Portage Lake Watershed Forever Plan

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Executive Summary

PURPOSE

The purpose of the Portage Lake Watershed Forever Plan is to engage all interests in the community in developing a *living document* that will ensure the wise use and enjoyment of the Portage Lake watershed for present and future generations. The plan will be used to guide and inform future monitoring, planning, management, and community and economic development efforts within the watershed. It is not regulatory in nature and its associated committees are non-political and do not have regulatory powers. While the Portage Lake Watershed Forever committees will provide coordination, the implementation of the plan largely depends on assistance from and the cooperation of numerous local, state, and federal partners.

VISION

The vision of the Portage Lake Watershed Forever Plan is that the Portage Lake watershed will be preserved *forever* by investing in protection and enhancement of natural and related cultural and historical resources in the watershed to provide economic benefit and to improve the quality of life for present and future residents and visitors.

STAKEHOLDER INVOLVEMENT

The Portage Lake Watershed Forever Plan is truly a community-driven effort, as evidenced by the numerous and diverse stakeholders that have been engaged throughout the three-year process. The process began in 2006, when more than 50 individuals, organizations, agencies, and businesses signed the *Portage Lake Watershed Forever Partnership Agreement.* This agreement contained principles to guide the plan as well as expected outcomes of the process. The Alliance for Economic Success (AES) (formerly the Manistee Economic Development Office) served as a nonprofit, 501 (c)(3) hub for financial, grant, and contract management for the planning process. In 2007, the AES engaged a neutral facilitator, Public Sector Consultants Inc. *(www.pscinc.com)* of Lansing, Michigan, to assist the community in developing the plan. The Portage Lake Watershed Forever Committee and its Executive Committee and Technical Advisory Committee, all of which include representation from diverse watershed interests, guided the planning process. Community citizens established a Portage Lake Watershed Forever Endowment Fund at the Manistee County Community Foundation *(www.manisteefoundation.org*) to provide support for the plan and its long-term implementation.

Public Sector Consultants engaged nearly 150 people through eight community conversations and a community forum and surveyed 250 households in the watershed by telephone to solicit information from all interests about water quality concerns, desired uses, and their vision for the future of the watershed. Numerous additional stakeholder meetings were conducted by members of the Portage Lake Watershed Forever Executive Committee.

DESCRIPTION OF WATERSHED

The Portage Lake watershed is located in the northwest portion of Michigan's Lower Peninsula in Manistee County and encompasses portions of Bear Lake, Brown, Manistee, and Onekama Townships as well as the Village of Onekama. The watershed is approximately 24.6 square miles, or 15,777 acres (MDIT/CGI, LP Watersheds). Portage Lake's surface area is 2,116 acres and comprises 13.4 percent of the total surface area of the watershed (MDIT/CGI, LP Watersheds). It is a natural lake formed by glaciers with maximum depths in two areas of up to 60 feet and a mean depth of 19 feet. Surface water courses drain to Portage Lake and eventually to Lake Michigan through a manmade channel (Portage Lake Channel) on the west side of Portage Lake that requires periodic dredging to maintain navigation between Portage Lake and Lake Michigan. Three other named lakes, seven named tributaries (including several small unnamed creeks and drains), numerous artesian wells, and significant groundwater all flow into Portage Lake.

The Portage Lake watershed is generally bowl shaped with elevations at the outer edges of the watershed reaching as high as 950 feet above sea level (289.6 meters) and sloping toward Portage Lake. The bedrock beneath the glacial deposits in Manistee County consists predominantly of sandstones and shale. The Portage Lake watershed is at the rim of the large geologic sedimentary rock feature covering most of the Lower Peninsula of Michigan that contains significant hydrocarbon deposits. The county ranks second in the state in the total production of both oil and natural gas that began in Michigan in 1925.

There are no state or federally-listed endangered species in the Portage Lake watershed. Three state-listed threatened species include the red-shouldered hawk, the pitcher's thistle, and the Lake Huron locust. The brown walker snail is a state-listed species of concern. There is one federally-listed threatened species in the watershed: the pitcher's thistle.

The Portage Lake Watershed has undergone significant change in land use and land cover since the area was first surveyed and platted in 1836. The beech-sugar maple-hemlock hardwood forests that once dominated the watershed prior to development are now limited primarily to the western portion of the watershed because of forestry and agricultural practices, residential and commercial development, and transportation corridors that have built over the last 170 years. Wetlands and associated conifers that once dominated significant portions of the south side of Portage Lake have been significantly reduced.

The shoreline areas of Portage Lake have been substantially altered by either historical timber-related activities or because of more recent commercial, residential, recreational, and related transportation development. More than 20 percent of the shoreline of Portage Lake has been altered by filling, dredging, seawall construction, and related activities to accommodate current and historical uses. The manmade current outlet of Portage Lake to Lake Michigan constructed in 1871 permanently lowered the water level of the lake by several feet. The new channel outlet provided commercial and recreational boating access to Lake Michigan, increased the productive littoral zone of Portage Lake, and accommodated access to Portage Lake by fish species and other aquatic organisms common to Lake Michigan.

Despite significant changes in land cover, the water quality in Portage Lake and tributary streams remains relatively good, in large part due to the glacial till that dominates the watershed. Direct runoff to watershed lakes and streams is minimized because of infiltration through permeable glacial soils and recharge of groundwater that provides a major source of cool water to Portage Lake and most of the tributary streams. Direct storm water and snowmelt point and nonpoint sources of potential pollutants in the watershed are generally limited to areas where intensive development, transportation corridors, and agricultural activities are immediately adjacent to surface water.

Portage Lake is very popular for fishing, sailing, cruising, waterskiing, and swimming. The Portage Lake Channel and protected harbor provide the opportunity for larger recreational boat owners to move back and forth between Portage Lake and Lake Michigan. Several Great Lake charter-fishing businesses operate out of Portage Lake that target Chinook salmon, Coho salmon, brown trout, and lake trout, and two public boat launches exist on Portage Lake.

Unlike many watersheds in the northern Lower Peninsula, there is very little state or federal public land within the watershed. Private land practices associated with forestry, agricultural, recreational, commercial, industrial, and residential uses have been and will continue to be the major influence on the condition of the subwatershed and the quality of its groundwater and surface water resources.

The estimated current population of the Portage Lake watershed is 2,059. There are approximately 1,351 total housing units including 474 seasonal housing units. Between 1990 and 2000 the population of Onekama Township (including the Village of Onekama), the most densely populated area of the watershed, increased by nearly 20 percent. This population growth rate is nearly three times the state's growth rate of 6.9 percent during the same period.

USES, THREATS, SOURCES, AND CAUSES

State water quality standards for all designated uses in the watershed are currently being met and no protected uses are impaired. The most likely future threats to designated uses, as well as the sources/causes of these threats, are as follows:

- **Public health** threats from
  - pathogens coming from failed septic systems, uncontrolled runoff from farm-raised animals, household pets, and waterfowl; and
  - contaminated fish from air deposition of toxic, bioaccumulative heavy metals and persistent organic compounds; as well as potential, but undocumented, historical industrial releases contained in Portage Lake sediments.

- **Ecosystem health** threats from
  - increased phosphorus loadings due to septic tile field leachate, riparian lawn fertilization, storm water discharges, agricultural practices and resulting excessive plant and algal growth, and associated impairments due to eutrophication[1]; and

[1] A process by which a water body becomes rich in dissolved nutrients, often leading to algal blooms, low dissolved oxygen, and an environment that does not readily support oxygen-dependant aquatic life.

- habitat degradation from wetland destruction, lakeside and streamside development, invasive species, and sedimentation from lake access areas, bridge crossings, and other land disturbance activities.

- **Recreational and fishing access** threats from
  - lack of maintenance dredging of the Portage Lake Channel and
  - lack of adequate and safe boat launching and docking facilities and public swimming and recreational areas due to the limited sites available and low water levels

- **Groundwater contamination** threats from
  - unlawful existing and potential releases of contaminants from spills and
  - leaking underground storage tanks and improperly plugged domestic and industrial wells

Several additional desired uses of the watershed were identified by the community beyond those uses specifically protected under surface water pollution control laws and regulations.

PRIORITY AREAS

Areas in the watershed that are either sources of pollution or are most susceptible to changes that would result in increased input of priority pollutants are defined as priority areas. These areas include:

- a 1,000-foot zone riparian to Portage Lake and a 100-foot zone riparian to all tributaries;
- the non-sewered portion of Portage Lake shoreline;
- the Village of Onekama (storm water runoff),
- and known sites of environmental contamination.

Priority areas in the watershed were identified and mapped to help inform development of goals and objectives and to guide future monitoring, planning, and management efforts.

GOALS AND OBJECTIVES

The following goals were developed, based on various modes of stakeholder input, past studies, and current water quality monitoring.

- **Goal 1—Public Health**: Ensure that participants in water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish, or wildlife with contaminants in excess of advisories.
- **Goal 2—Aquatic Ecosystem**: Protect the quality of water resources in the Portage Lake watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.

- **Goal 3—Water-Based Recreation**: Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake watershed for people of all ages and abilities.
- **Goal 4—Natural Resource and Cultural Assets**: Invest in protection and enhancement of land-based natural resources and related cultural assets that provide recreational and educational benefits unique to the watershed and contribute to the quality of life and economic well-being of local residents while expanding the vacation experiences of visitors.
- **Goal 5—Local Management and Implementation Institution:** Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.

To achieve these goals, 18 objectives and 57 actions were laid out covering a ten-year timeline. Potential partners and estimated costs are identified for each action.

LOCAL PROGRAMS, PROJECTS, AND PLANNING

Planning and zoning documents for each of the five jurisdictions in the watershed were reviewed to assess the effectiveness of each in helping to further watershed plan goals and objectives. Although each jurisdiction had some water quality protection provisions in place, best practices and recommendations for how to strengthen future planning and zoning were outlined. A description of mission statements of various other agencies and community-based organizations provided information on potential partners for plan implementation.

INFORMATION AND EDUCATION PLAN

An information and education plan, based on stakeholder input from community conversations and a household survey, was developed to help increase awareness and understanding about how actions on the land within the watershed can impact water quality. The purpose of the strategy is to establish and promote education programs that support effective implementation of watershed planning goals, objectives, and tasks.

MONITORING AND EVALUATION

Implementation of watershed plan goals and objectives will require routine monitoring. Monitoring is a key component of this plan since the focus is on sustaining current conditions that support designated and other beneficial uses. The proposed monitoring plan will help fill gaps on both habitat conditions and conformance with water quality standards. The intent of the monitoring plan is to identify changes in environmental conditions early enough to develop corrective actions before significant impairments occur. The monitoring plan focuses on the three priorities of the watershed plan: public health, aquatic ecosystem health, and groundwater protection.

Evaluation of monitoring activities will also be necessary to determine the progress and effectiveness of the proposed activities. A measure of success will be that all water quality standards continue to be met and designated uses are protected. Where state

standards are not available, the measure of success will be no evidence of significant deterioration of current environmental conditions.

Successful establishment of the institutional structure to assure implementation of the recommendations of this plan is critical. While volunteers can contribute substantially to the monitoring effort, the Portage Lake Watershed Forever organization needs to formalize its structure and operations to assure that it has staff that can organize and manage the elements in the monitoring plan and evaluate the results.

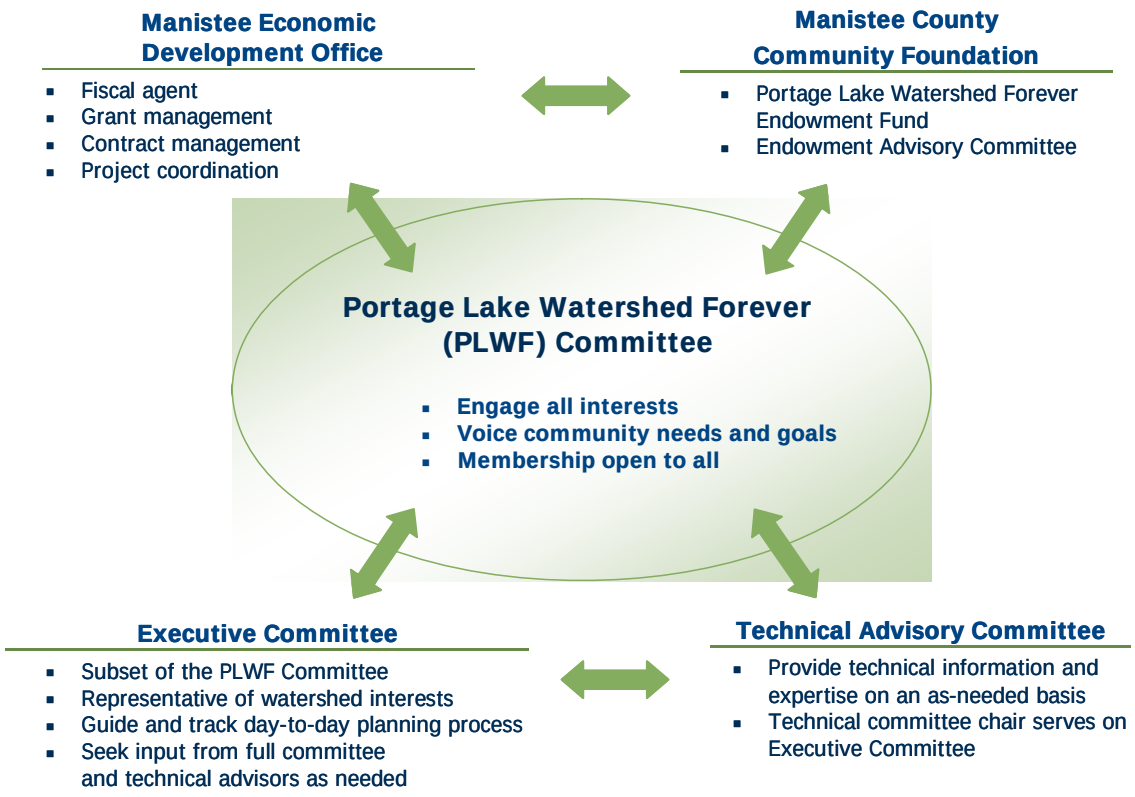
Stakeholder Involvement

The Portage Lake Watershed Forever Plan began in 2006 as a local initiative by residents, public officials, nonprofit organizations, and business leaders aided by the Manistee County Community Foundation and Manistee Economic Development Office, all of whom recognize the importance of protecting and enhancing this natural resource for the future quality of life and economic well-being of the area. At the beginning of the planning process, more than 50 individuals, organizations, agencies, and businesses signed the *Portage Lake Watershed Forever Partnership Agreement,* which contained principles that helped guide the development as well as the expected outcomes of the plan.

PLAN DEVELOPMENT ORGANIZATIONAL STRUCTURE

Several organizations and committees provided leadership in the development of this plan. The Manistee Economic Development Office (MEDO) served as a nonprofit, 501 (c)(3) hub for financial, grant, and contract management for the planning process. The MEDO engaged a neutral facilitator, Public Sector Consultants Inc. *(www.pscinc.com)* of Lansing, Michigan, to assist the community in developing the plan. The Portage Lake Watershed Forever Committee and its Executive Committee and Technical Advisory Committee, all of which include representation from all watershed interests, guided the planning process. A Portage Lake Watershed Forever Endowment Fund was established at the Manistee County Community Foundation *(www.manisteefoundation.org*) to provide support for the plan and its implementation. The plan organizational structure is illustrated in Exhibit 1.

EXHIBIT 1
Portage Lake Watershed Forever Plan Organizational Structure



SOURCE: Public Sector Consultants Inc., 2007.

COMMUNITY CONVERSATIONS

One of the first steps in the development of this watershed management plan involved identifying and convening stakeholders in the watershed through community conversations. Stakeholders were defined as individuals, groups, agencies, and organizations that make and carry out decisions, are affected by decisions, or have the ability to impede or affect decisions that impact the watershed. Stakeholders were involved at an early stage and throughout the development of this plan. Their participation was considered critically important to ensure the development of a community-driven watershed management plan and local commitment toward achieving goals through implementation of the plan.

The purpose of the community conversations was to:

- Educate participants about watersheds, the history and status of the Portage Lake watershed, the development of watershed management plans, and how a plan can benefit the local community
- Solicit information from all interests about water quality concerns and desired uses to provide a foundation for the development of the watershed plan and gather qualitative information that would help inform the development of a watershed household survey

- Build community ownership of and engagement in the plan

Public Sector Consultants engaged nearly 150 people through eight community conversations organized by stakeholder groups (see Exhibit 2) conducted between March and June 2007 and a community forum aimed at engaging the general public held in May 2007. A series of eight questions were asked during each facilitated meeting and responses were recorded. A summary table of questions and responses is provided in Exhibit 3. Responses from stakeholders indicate that they believe the health of the watershed is essential to their quality of life and economic well-being.

EXHIBIT 2
Stakeholder Groups and Number of Participants Engaged through Community Conversations and Community Forum

Stakeholder group	Number of participants
Year-round residents	11
Seasonal residents	35
Youth/students (Onekama High School)	15
Educators	4
Village, township, county, and tribal government	11
Recreation, tourism, business, and civic organizations	7
Agriculture and land developers/managers	13
Natural resource managers	14
Community Forum (general public)	38
Total	**148**

SOURCE: Public Sector Consultants Inc., 2007.

EXHIBIT 3
Combined Summary of Responses from Community Conversations and Community Forum

Question	Responses
What are some of the things you do in the watershed?	• Participate in numerous water and land-based recreational activities • Enjoy natural beauty; live; work; educate; manage/protect the health of the watershed
What do you consider to be some of the biggest problems facing the Portage Lake watershed right now?	• Lack of complete/accurate/current fact-based information about the watershed • Lack of understanding about how actions impact water quality • Development of sensitive areas • Loss of critical habitat • Invasive species • Nutrient loading from fertilizer application and improperly maintained septic systems • Lack of channel dredging • Not enough long-term planning • Lack of communication among local units of government or

Question	Responses
	collaborative planning • Lack of economic development • Decreasing number of students and young families
What are some possible solutions to these problems?	• Information, education and outreach • Leveraging additional financial, human and technical resources • Implementation of best management practices (BMPs); joint planning • Land use planning • Economic development planning • Dredging • Water quality monitoring
Have you ever had a conflict with other people who use the watershed differently than you do?	• Personal water crafts and other lake users • Development that impacts critical habitat and views • Users of road ends as public access sites and nearby property owners • Hunters and other watershed users • Various watercraft users and fisherman • Government regulations and property owners
Are there certain cultural, historic or environmental sites or resources that you think should be protected?	• Parks and public access sites • Camps • Beaches • Views and vistas • Trails • Farming/agriculture • Historical sites and structures • Rural character • Fair grounds • Critical habitat and sensitive areas (water quality, wetlands, dunes, feeder creeks, forests) • Fishery • School
How do you get most of your information about the Portage Lake watershed?	• Local newsletters and web sites • Federal, state, and local agencies and organizations • Word of mouth • Teachers • Past studies and plans
Are there certain sources of information you consider more trustworthy than others?	• Most are trusted • No central source for fact-based information about the watershed
Imagine the Portage Lake watershed 50 years from now—what do you want it to look like?	• Not a lot different from now • Enhanced and more parks and public access and trails • Views and vistas maintained • Abundant fish and wildlife • Lack of exotic and invasive species • Excellent water quality • Protected fragile environments • Outstanding schools with water curriculum • Protected and wisely planned community • Engaged community • Multiple generations live and work • Vibrant cultural focus

SOURCE: Public Sector Consultants Inc., 2007.

Additional stakeholder meetings were conducted by members of the Portage Lake Watershed Forever Executive Committee, including meetings with the Lions Club, Onekama Guild, Portage Lake Association, Portage Point Summer Resort Corporation, joint meeting of Onekama Township and the Village of Onekama, and numerous individuals and business owners.

The information collected through the community conversations, community forum, and additional stakeholder meetings provided a valuable foundation for the development of the watershed management plan and helped to inform the development of the household survey. These meetings also provided an excellent way to educate and engage various stakeholders in the development of the plan.

HOUSEHOLD SURVEY

Development of this watershed management plan included a survey of 250 households in the watershed. Conducted in August 2007 by Public Sector Consultants, the survey was designed to learn how residents use the watershed, how they want it to look in the future, their perceptions of and priorities for improving water quality, and to provide general information about the households that could impact the watershed. The survey also helped shape the information and education section of this plan by shedding light on the perceived use and trustworthiness of different sources of information, uncovering false perceptions, identifying targets for outreach efforts, and establishing a baseline of information that can be used to evaluate the success of future watershed management activities.

Because this survey was designed to include seasonal residents, the total number of housing units (1,351), which includes rental properties, was used to calculate the margin of error, which is ±5 percent at the 95 percent confidence interval. A complete report containing the survey instrument and results can be found at *http://www.pscinc.com/documents/PLWF*. The following sections provide a summary of the report findings.

Activities

When creating a watershed management plan, it is important to know how residents use the watershed and how they want it to look. This information is important because it helps guide and prioritize protection and restoration efforts. To identify how residents in the Portage Lake area use the watershed, respondents were asked to report how frequently they participate in certain activities, weather permitting. The activities that respondents **most frequently** engage in are:

- Boating: 45 percent participate once a week or more often
- Swimming, snorkeling, or scuba diving: 42 percent participate once a week or more often
- Fishing: 37 percent participate once a week or more often

The activities that respondents report **never** participating in include:

- Waterfowl hunting (94 percent)
- Winter snowmobiling or ATV riding (84 percent)

- Water skiing, tubing, wakeboarding, or kneeboarding (68 percent)
- Canoeing, kayaking, or tubing on a river (58 percent)

Among respondents who report fishing, 66 percent rate the fishing as *excellent* (13 percent) or *good* (53 percent). Nearly half (46 percent) report that the fishing has stayed *about the same* over the past few years. Among respondents who report boating, motor boats are the most frequent type of boat used. Within this category, 40 percent use a motor boat 20 feet in length or smaller, and 24 percent use a motor boat over 20 feet. Jet ski/waverunner/personal watercraft represent the least frequent type of boating among residents.

It appears that residents in the watershed use different boating access points to Portage Lake in fairly equal proportions. One-third (33 percent) of respondents who report boating access Portage Lake by a dock, mooring, or launch from their own property; 31 percent from a Michigan Department of Natural Resources (MDNR) state public access site; and 23 percent from Village Park.

Conflicts

For watershed planning purposes, it is important to know if any of the ways in which residents use the watershed are in conflict. To answer this question, respondents were asked if they had personally observed any conflicts between users of Portage Lake, such as personal watercraft interfering with fishing. About two-thirds (67 percent) of respondents say that they have not seen conflicts between various users of Portage Lake. Respondents who have personally observed conflicts most frequently mentioned personal watercraft being involved (39 percent), even though personal watercraft represent just 6 percent of boating reported on Portage Lake by those surveyed. Other conflicts include issues involving access to the lake (19 percent), conflicts between those fishing and those boating on the lake (14 percent), and among boaters on the lake (10 percent). Half of those reporting conflicts (51 percent) say that the conflicts occur at peak times only (that is, holiday and summer weekends), 39 percent say both peak and non-peak times, and 10 percent say non-peak times only. Nearly half (47 percent) say that these conflicts are not very frequent.

Water Quality Perceptions and Improvement Actions

To begin to understand potential water quality problems in the watershed, survey respondents were asked about their perceptions of the water quality of Portage Lake. Overall, respondents give the water quality of the Portage Lake high marks.

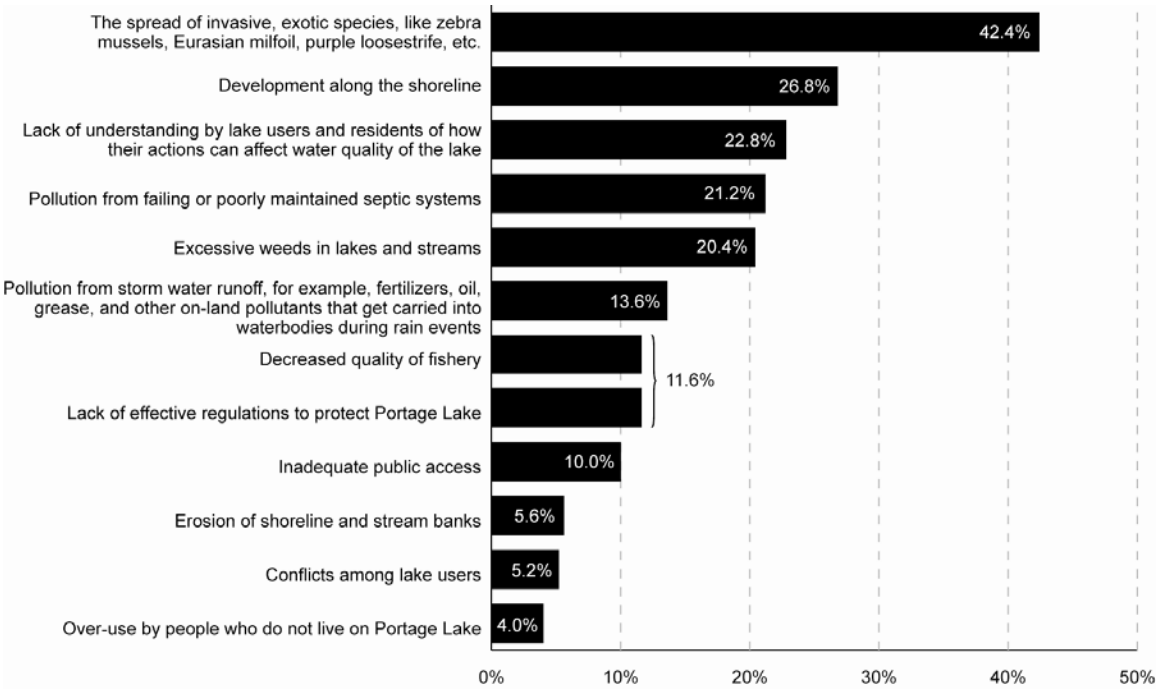
- 82 percent of respondents rate the overall water quality of Portage Lake as excellent (25 percent) or good (57 percent).
- The majority (64 percent) feel that the water quality of Portage Lake is somewhat (39 percent) or significantly (25 percent) better than the water in other inland lakes.
- About half (55 percent) say the water quality has stayed about the same over the past few years; another 18 percent say that it is either somewhat (16 percent) or much (2 percent) better.

Respondents were also asked to indicate how much of a problem is posed by certain issues regarding water quality and recreational opportunities. As shown in Exhibit 4, the following were most frequently identified by respondents as **major problems**:

- The spread of invasive, exotic species (42 percent)
- Development along the shoreline (27 percent)
- Lack of understanding by lake users and residents of how their actions can affect water quality (23 percent)
- Pollution from failing or poorly maintained septic systems (21 percent)

Another telling statistic is the number of respondents who say they "don't know" if the issues are a problem: 27 percent don't know if the decreased quality of the fishery is a problem, 24 percent don't know if lack of effective regulations on Portage Lake are a problem, and 18 percent don't know if pollution from failing or poorly maintained septic systems is a problem.

EXHIBIT 4
Issues Considered Major Problems by Watershed Residents



SOURCE: Public Sector Consultants Inc., Survey of Portage Lake Residents, 2007.

Respondents were also asked to rate the priority for protection of certain places in the Portage Lake watershed. The sites most frequently mentioned as the **highest priority** for protection include:

- Lake Michigan sand dune areas and beach areas (74 percent)

- Natural features that help maintain water quality, such as wetlands and natural vegetation along lakes and streams that help filter pollution and prevent erosion (73 percent)
- Scenic vistas (58 percent)

Respondents were also given the opportunity to list other priorities that were not included in the provided list. Keeping the Portage Lake Channel dredged was most commonly mentioned, followed by avoiding overdevelopment in the area and protecting wildlife habitat.

Respondents were also asked to rate how strongly they would support certain actions to improve water quality. Actions that respondents **strongly support** include:

- Addressing unplugged and abandoned oil, gas, and mineral wells to prevent groundwater pollution (71 percent)
- Getting more students involved in watershed activities (68 percent)
- More effective planning for future growth by local leaders (60 percent)

Sources of Information

To help inform future public education efforts, several questions were asked about where residents get their information about the watershed and which sources of information they trust. Respondents obtain information about Portage Lake from a variety of sources. Local newspapers, such as the *Manistee News Advocate* or *Traverse City Record Eagl*e, were the most cited, with one out of three respondents (36 percent) saying they get most (22 percent) or a lot (16 percent) of their information from this source.

The top three sources from which respondents report getting **none** of their information are:

- Local cable access television (72 percent)
- Public service announcements on the radio (70 percent)
- Internet sources such as e-mails, newsletters, listservs, blogs, etc.(68 percent)

Respondents were also asked how much they would trust information from a variety of local, state, and federal sources. The sources of information considered the **most** trustworthy include:

- Neighborhood or lake associations: 67 percent (trust all of the time, 17 percent; trust most of the time, 50 percent)
- Manistee County Health Department: 67 percent (trust all of the time, 15 percent; trust most of the time, 52 percent)
- University Extension, professors, and scientists: 66 percent (trust all of the time, 19 percent; trust most of the time, 47 percent)

The sources of information considered **least** trustworthy include:

- U.S. Environmental Protection Agency: 61 percent (trust none of the time, 11 percent; some of the time, 50 percent)

- Local township, village, or tribal officials: 61 percent (trust none of the time, 7 percent; some of the time, 54 percent)

In addition, respondents were asked to list other organizations, people, or groups that they would trust or look to for information about the Portage Lake watershed. The Portage Lake Watershed Forever Committee was the most frequently mentioned group (37 percent), followed by homeowners or local businesses (23 percent) and the Nature Conservancy (12 percent).

Property Characteristics

Respondents were also asked about different amenities they have on their property that could impact the Portage Lake watershed. Respondents report having a:

- Washing machine (93 percent)
- Grass lawn (81 percent)
- Dishwasher (71 percent)
- Garbage disposal (42 percent)

The majority of respondents (67 percent) have either two (47 percent) or three (20 percent) bathrooms at their residence.

Eighty-two percent of respondents are served by a septic system. As shown in Exhibit 5, nearly half (42 percent) of these septic systems are less than ten years old. Regardless of the age of the septic system, the vast majority of respondents (85 percent) indicated that they have had their system inspected and/or pumped out in the last five years.

EXHIBIT 5
Age and Maintenance of Septic Systems

Age	% of Respondents	% Maintained in last 5 years
1 to 5 years	20%	90%
6 to 10 years	22	84
11 to 20 years	25	80
21 years or older	33	85

SOURCE: Public Sector Consultants Inc., Survey of Portage Lake Residents, 2007.

More than one-third of respondents (38 percent) live on Portage Lake or on a river or stream flowing into Portage Lake. As shown in Exhibit 6, regardless of whether they live on the water, respondents' behavior is consistent, that is, about three-quarters or more of each group report maintaining a lawn, being served by a septic system, and owning a dishwasher and washing machine.

EXHIBIT 6
Distribution of Amenities with Possible Impact on Watershed

		Is your property on Portage Lake or on a river or stream flowing into Portage Lake?	
		Yes	No
Do you maintain a grass lawn at your residence?	Yes	89.2%	76.1%
	No	10.8	23.9
Do you have a washing machine?	Yes	89.2	94.8
	No	10.8	5.2
Do you have a garbage disposal?	Yes	52.7	36.8
	No	47.3	63.2
Do you have a dishwasher?	Yes	66.7	72.9
	No	33.3	27.1
Is your residence served by a septic system?	Yes	76.3	85.2
	No	23.7	14.8

SOURCE: Public Sector Consultants Inc., Survey of Portage Lake Residents, 2007.

Seasonal and Full-Time Resident Differences

Three-fourths of respondents (74 percent) are full-time residents, 26 percent are seasonal residents, and 1 percent are vacation renters for more than 30 days. Statistically significant differences between seasonal and full-time residents occur in only a few instances.

- Seasonal residents are more likely **not** to have a washing machine or maintain a grass lawn.
- Seasonal residents are more likely to get only some or none of their information about the Portage Lake watershed from local newspapers.
- Seasonal residents tend to be older than full-time residents, with 55 percent aged 65 years or older and 83 percent aged 55 years or older.
- Seasonal residents are also much more likely to have completed college or postgraduate study (70 percent) than full-time residents (45 percent).

Conclusion and Recommendations

Boating, fishing, and swimming/snorkeling/scuba are the most frequent activities, with most respondents unable to recall observing any conflicts between different types of lake users. Of those who had seen a conflict, conflicts mostly involved jet skiers or other boaters interfering with fishing and swimming at peak use times. As in other inland lakes in Michigan, personal watercraft are a source of tension between users of the lake and residents. This survey indicates that most personal watercraft users are day users and not residents of the watershed (only 6 percent of respondents say they use personal watercraft). Given the tension apparent in resident comments (included in the Appendix to the complete survey report, available at *http://www.pscinc.com/documents/PLWF*), communication and outreach for personal watercraft users should be considered. Motorboats were the most frequent type of boating, and respondents specifically mention

the need to dredge the Portage Lake Channel, indicating that Portage Lake is used as a means to access Lake Michigan.

Respondents have a favorable opinion of the current water quality in the Portage Lake watershed and feel that it compares favorably to other inland lakes. They consider the spread of invasive species and a lack of knowledge on the part of residents and other users as to how their actions impact water quality to be the two biggest problems facing the watershed. These results indicate the need for education and coordinated dissemination of information to residents and other users.

Another concern identified as a major problem by respondents is pollution from failing or poorly maintained septic systems. While 85 percent of respondents with septic systems report having their tanks serviced in the last five years, the number appears to be extremely high. In retrospect, the survey question may have prompted a positive response that resulted in an over-estimate of the frequency of septic tank maintenance.

Respondents trust information from their neighborhood lake association, the Manistee County Health Department, and university extension personnel more than they trust local or federal government officials. At the same time, organizations like the Portage Lake Watershed Forever Committee, the Nature Conservancy, and other property owners or local business owners were specifically mentioned by respondents as trustworthy sources. This indicates that communication and coordination of information about the watershed could be effectively disseminated by grassroots organizations such as these, and that residents are more likely to trust the information and efforts of these groups.

The vast majority of respondents have a washing machine and a dishwasher and maintain a grass lawn at their residence in the Portage Lake watershed. While the survey results provide baseline data for these property characteristics, the survey does not examine the frequency of use of these appliances or the specific types of fertilizers used to maintain lawns, if any. PSC recommends additional follow-up with residents to communicate and educate them about the potential impact of these appliances and lawn care on the Portage Lake watershed.

Description of Portage Lake Watershed

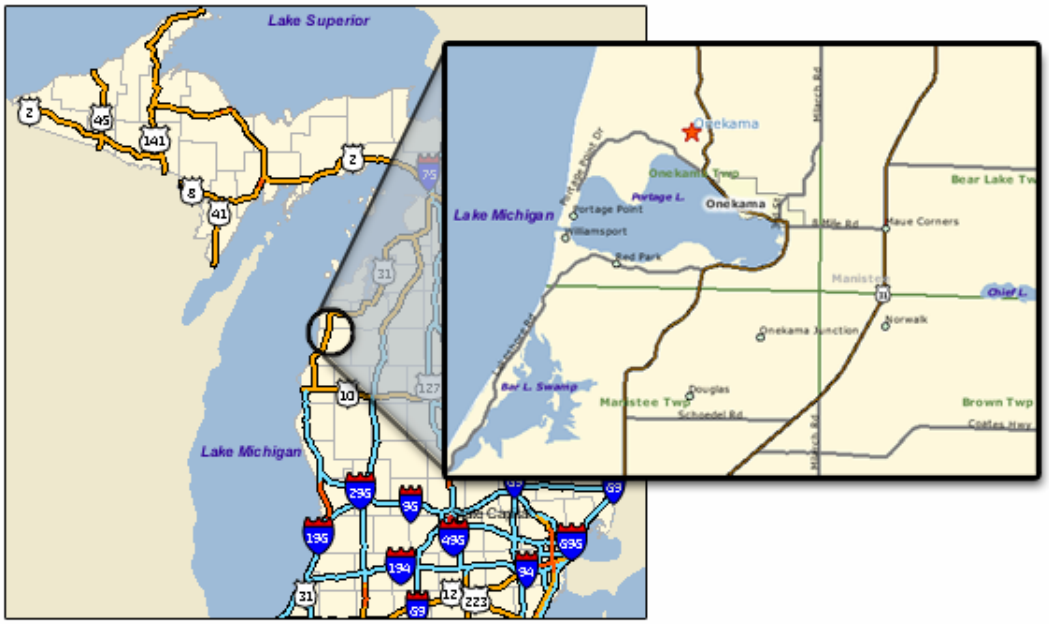
This section provides a comprehensive description of the Portage Lake watershed, including its physical, political, and environmental setting.

PHYSICAL AND NATURAL FEATURES

Location, Size, and Boundaries

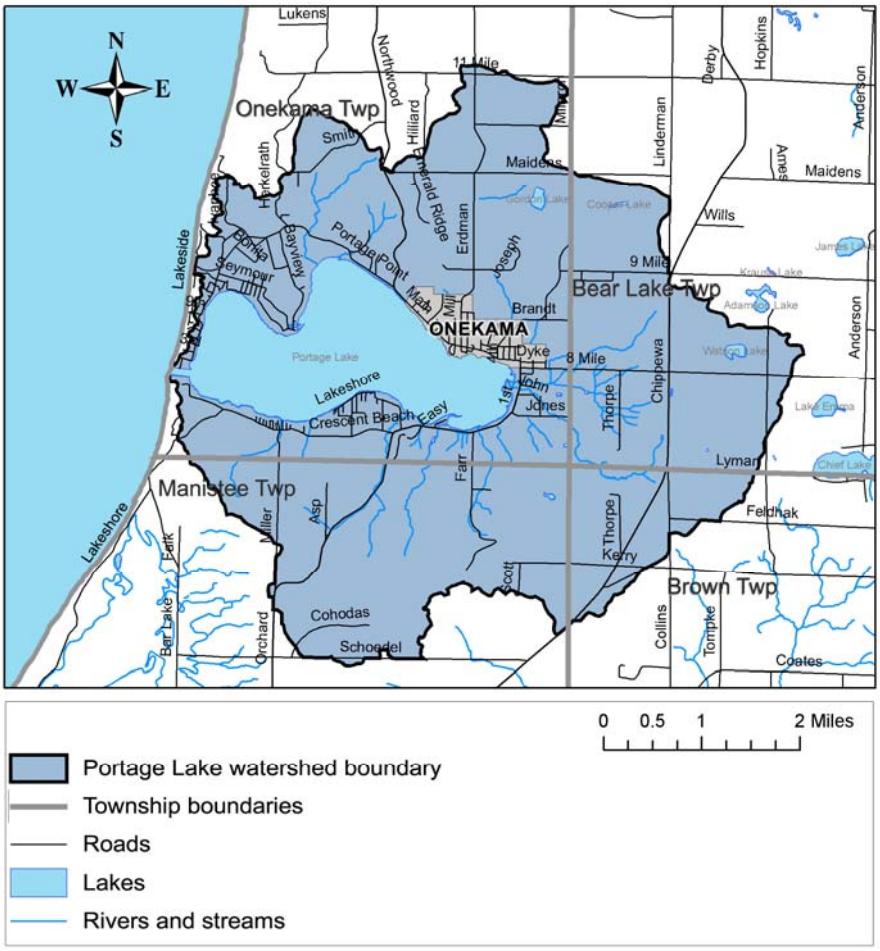
The Portage Lake watershed is located in the northwest portion of Michigan's Lower Peninsula in Manistee County (see Exhibit 7). As shown in Exhibits 8 and 9, the boundaries of the Portage Lake watershed encompass portions of Bear Lake, Brown, Manistee, and Onekama Townships as well as the Village of Onekama. The watershed covers approximately 24.6 square miles, or 15,777 acres (MDIT/CGI LP Watersheds).

EXHIBIT 7
General Location, Portage Lake Watershed



SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI, Map Michigan.

EXHIBIT 8
Portage Lake Watershed



SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI (LP Watersheds).

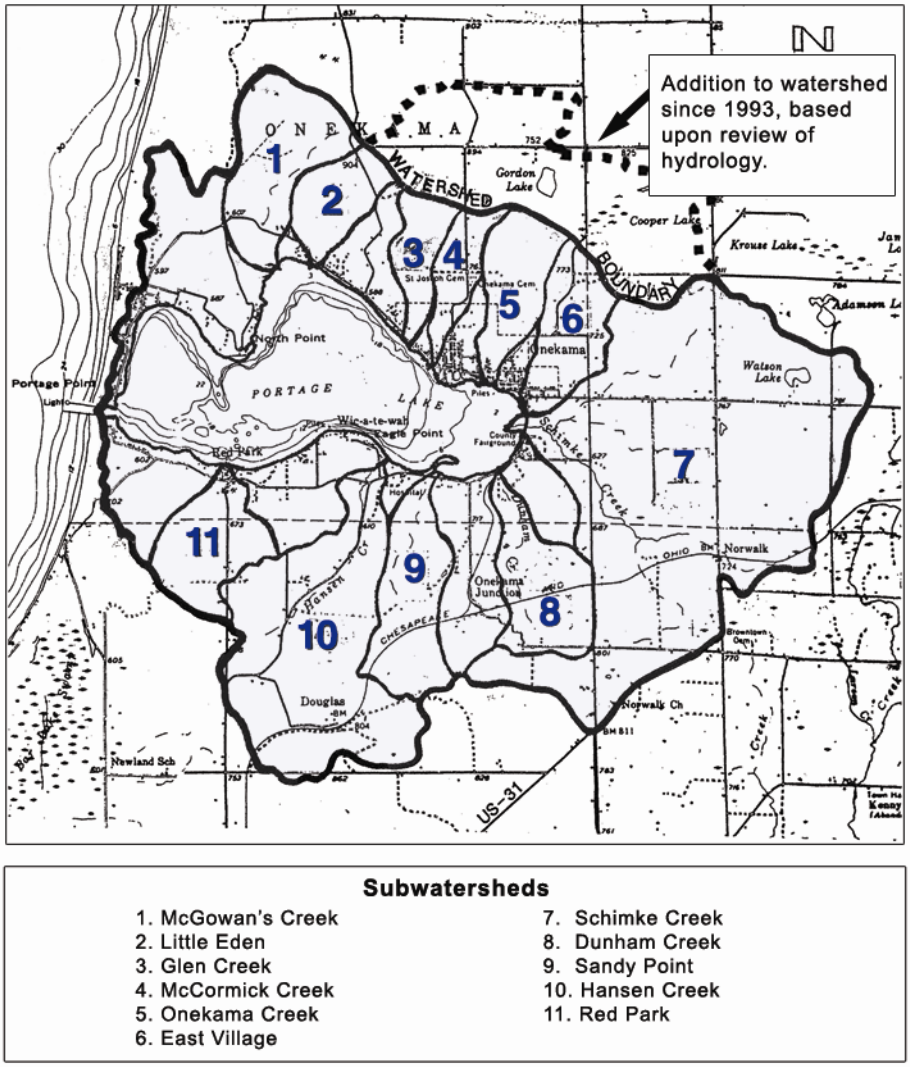
EXHIBIT 9
Communities in the Portage Lake Watershed

Jurisdiction	Acres within watershed	Square miles within watershed	% of jurisdiction within watershed	% of watershed within jurisdiction
Bear Lake Township	3,019	4.7	13%	19%
Brown Township	1,085	1.7	5	7
Manistee Township	3,476	5.4	12	22
Onekama Township	7,821	12.2	56	50
Village of Onekama	375	0.6	100	2

SOURCE: Public Sector Consultants Inc., 2007.

In the *Portage Lake EPA Phase I Diagnostic/Feasibility Study* (Phase I Study), published in 1993 (SEG 1993), the major subwatersheds were established to include drainage areas for each of the lake's named tributaries plus three areas that do not contain a named surface tributary (Red Park, East Village, and Sandy Point). Unfortunately, the 1993 study did not include a significant part of the area that now is recognized as within the watershed's hydrologic boundary (see Exhibit 10).

EXHIBIT 10
Major Subwatersheds of Portage Lake



Subwatersheds

1. McGowan's Creek
2. Little Eden
3. Glen Creek
4. McCormick Creek
5. Onekama Creek
6. East Village
7. Schimke Creek
8. Dunham Creek
9. Sandy Point
10. Hansen Creek
11. Red Park

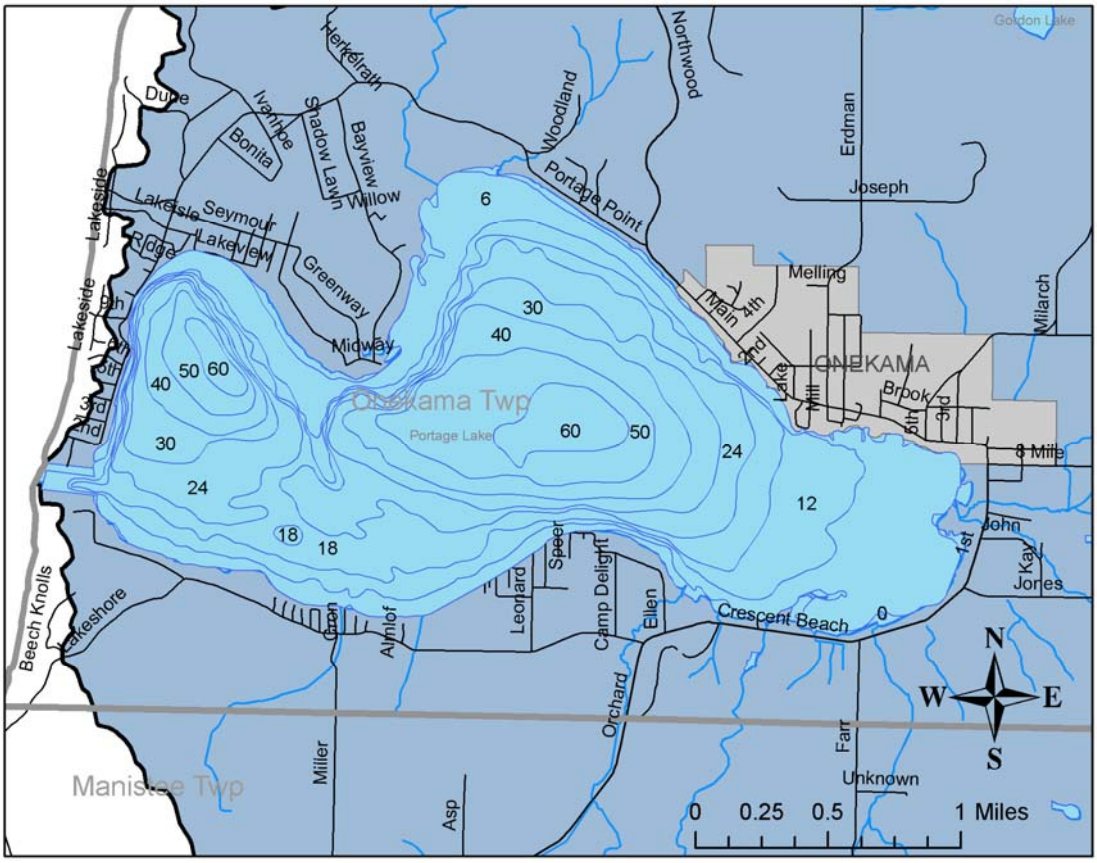
SOURCE: SEG, 1993.

Water Resources and Hydrology

The largest surface water feature in the watershed is Portage Lake, whose area is 2,116 acres and comprises 13.4 percent of the total surface area of the watershed (MDIT/CGI LP Watersheds). It is a natural lake formed by glaciers with maximum depths in two areas of up to 60 feet (see Exhibit 11). The littoral zone (areas less than 15 feet in depth)

makes up just over half the lake area, and the mean depth is approximately 19 feet. The total volume of the lake is estimated to be 39,449 acre-feet (48,706,500 cubic meters) with a projected water retention time (or residence time) of 3.5 years.

EXHIBIT 11
Portage Lake Map and Depth Contours



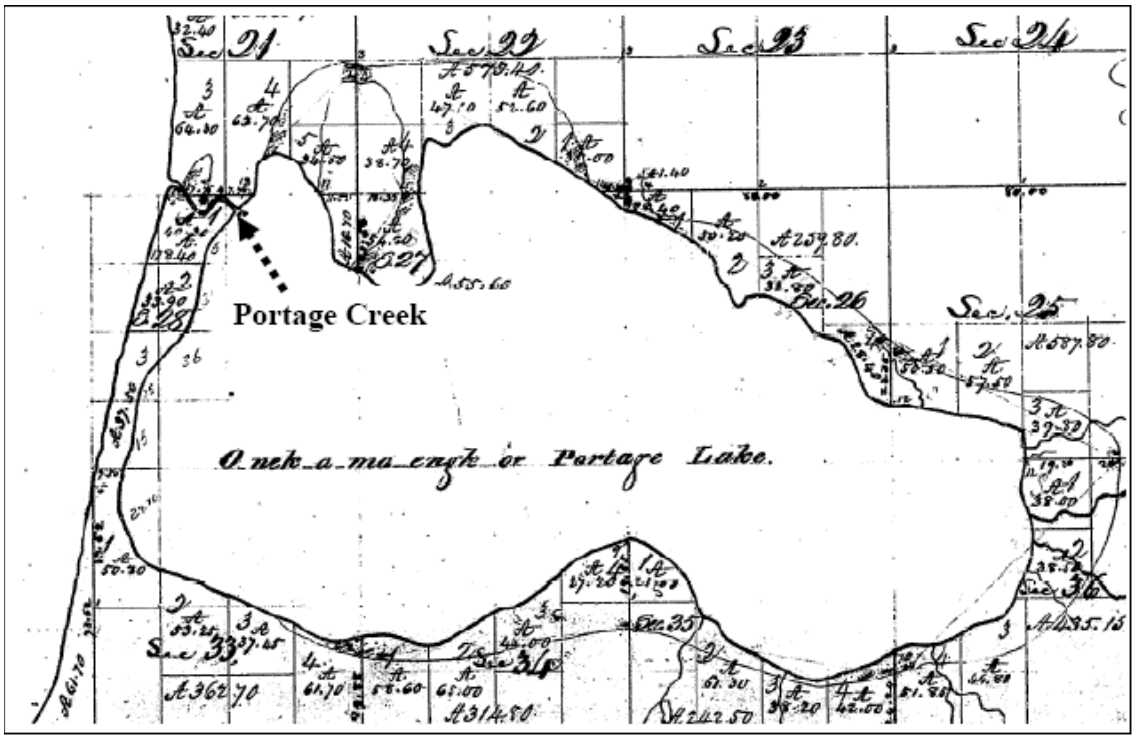
SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI (Inland Lake Contours).

Surface water courses drain to Portage Lake and eventually to Lake Michigan through a manmade channel (Portage Lake Channel) on the west side of Portage Lake that, in 1871, replaced the natural outlet to Lake Michigan located north of the current channel. Prior to 1871, Portage Lake was connected to Lake Michigan by Portage Creek, described at the time as a "winding, fast-flowing stream" located approximately one mile north of the current Portage Lake Channel. A water-powered sawmill and associated dam structure was located on Portage Creek, which elevated Portage Lake up to an additional six feet above natural levels. This prompted local property owners faced with flooded shoreline property in 1871 to dig through the dunes to construct a permanent channel to Lake Michigan in order to lower the lake level. The channel eventually eroded to the point that the existing water level is more than ten feet below where it was prior to 1871 when the sawmill dam on Portage Creek was operating under peak head conditions.

Exhibit 12 shows the original location of Portage Creek as depicted on the 1836 General Land Office Plat of Manistee County. The natural elevation of Portage Lake was four to five feet above that of Lake Michigan prior to the opening of the current channel. Now the level of Portage Lake is essentially determined by the level of Lake Michigan. The former Portage Creek outlet to Lake Michigan no longer exists. Since the early 1900s the Portage Lake Channel has been periodically dredged to maintain navigation between Portage Lake and Lake Michigan.

EXHIBIT 12

Portage Lake Portion of 1836 General Land Office Plat of Manistee County (Adapted)



SOURCE: Public Sector Consultants Inc., 2007, using Portage Lake portion of MDNR 1836 General Land Office Plat of Manistee County.

While Portage Lake is by far the largest lake in the watershed, there are three other named lakes: Watson Lake in the far eastern edge of the watershed and Gordon and Cooper Lakes in the northeastern portion of the watershed. The latter two lakes and their drainages were not included in the watershed boundary when the boundary was described as part of the Phase I Study, but these lakes were subsequently added as part of the watershed based upon a closer examination of the topography and hydrology. Gordon and Cooper Lakes lie in a shallow basin between two ridge lines and their surface water, and presumably the groundwater, moves in a generally southeast direction before moving south and west to enter Portage Lake.

Seven named tributaries feed Portage Lake—Dunham, Glen, Hansen, McCormick, McGowan's, Onekama, and Schimke Creeks—along with several small unnamed creeks and drains. Schimke Creek is the largest tributary, with a base flow of 17 cubic feet per

second (cfs.), followed by Hansen Creek (4 cfs.). All the remaining tributaries contribute less than 3 cfs. each during base flow conditions.

Residence time is an indication of how long it takes for all the water in a lake to be replaced and a measure of how long the lake needs to flush itself out. The shorter the residence time, the faster changes will occur in water quality when controlled sources of nutrient input are reduced. It is estimated that Portage Lake has a relatively fast residence time for a lake its size: 3.5 years (Phase I Study). However, the unknown influence of Lake Michigan, through the outlet channel, may be a source of variability that would significantly alter this estimate. A detailed water budget for Portage Lake has not been calculated and relative impacts from various influences, including precipitation, evaporation, surface inflow, outlet outflow, and groundwater input, are not known.

Groundwater Resources

Groundwater is an important resource in the Portage Lake watershed. It is a major source of cool water to Portage Lake and most of the tributary streams. Numerous artesian wells are found throughout the watershed. There is no public water supply in the Portage Lake watershed and residents and businesses rely on groundwater from wells for drinking water and irrigation. Groundwater quality and quantity are particularly important to safeguard current human uses of surface water and groundwater as well as to protect fish and wildlife habitat in the watershed. It is estimated that influences from groundwater are much more significant to the water quality of Portage Lake than surface water or runoff, due to the low proportion of surface water area and volume (few small lakes, short length and low flow of tributary streams) and primarily well-drained soils in the watershed.

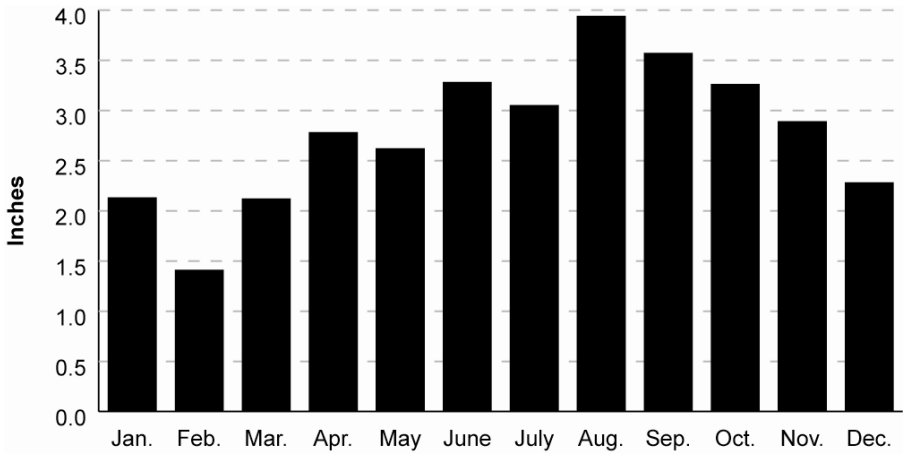
Unlike many watersheds in the northern Lower Peninsula, there is very little state or federal public land within the watershed. Private land practices associated with forestry, agricultural, recreational, commercial, industrial, and residential uses have been and will continue to be the major influence on the state of the watershed and the quality of its groundwater and surface water resources. Groundwater is highly susceptible to contamination from septic tanks, agricultural runoff, highway de-icing, landfills, and pipe leaks.

The Michigan Department of Environmental Quality (MDEQ), under state law and under federal law delegated to the state by the U.S. Environmental Protection Agency (USEPA), protects groundwater resources from pollution in a number of ways: it establishes and enforces groundwater discharge requirements; regulates the storage, transportation, treatment, and disposal of liquid and solid waste as well as other hazardous substances, offers guidance to owners of domestic wells, regulates underground storage tanks, and responds to accidental spills of hazardous materials or other losses of potential pollutants into or on the ground. The MDEQ Wellhead Protection Program, in coordination with local health departments, promotes management practices to protect potable groundwater supplies from contamination as provided under state and federal safe drinking water laws and regulations.

Climate/Precipitation

An average of 33 inches of total precipitation falls annually at the Manistee County Blacker Airport, the nearest weather station to the Portage Lake watershed (NOAA 2000). The maximum average precipitation occurs in August (3.94 inches) and the lowest in February (1.41 inches). See Exhibit 13 for monthly precipitation averages.

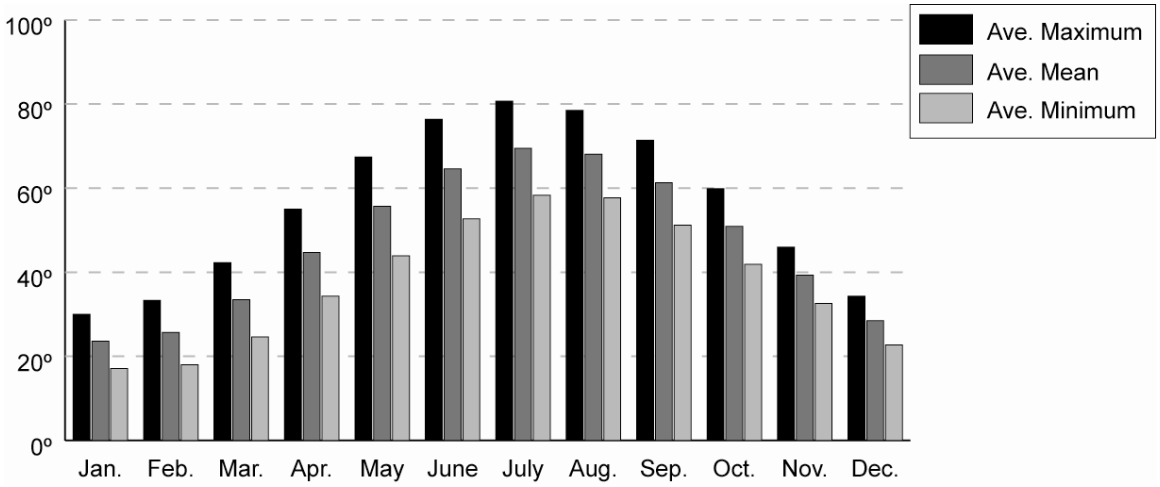
EXHIBIT 13
Monthly Precipitation Average at Manistee County Blacker Airport, 1971–2000



SOURCE: Public Sector Consultants Inc., 2007, using data from NOAA, 2000.

During January, typically the coldest month of the year, the temperature averages 30 to 17.1 degrees Fahrenheit (°F). During July, typically the warmest month of the year, temperatures average between 80.7 and 58.3 °F (NOAA, 2000). See Exhibit 14 for monthly temperature averages.

EXHIBIT 14
Monthly Temperature Average at Manistee County Blacker Airport, 1971–2000



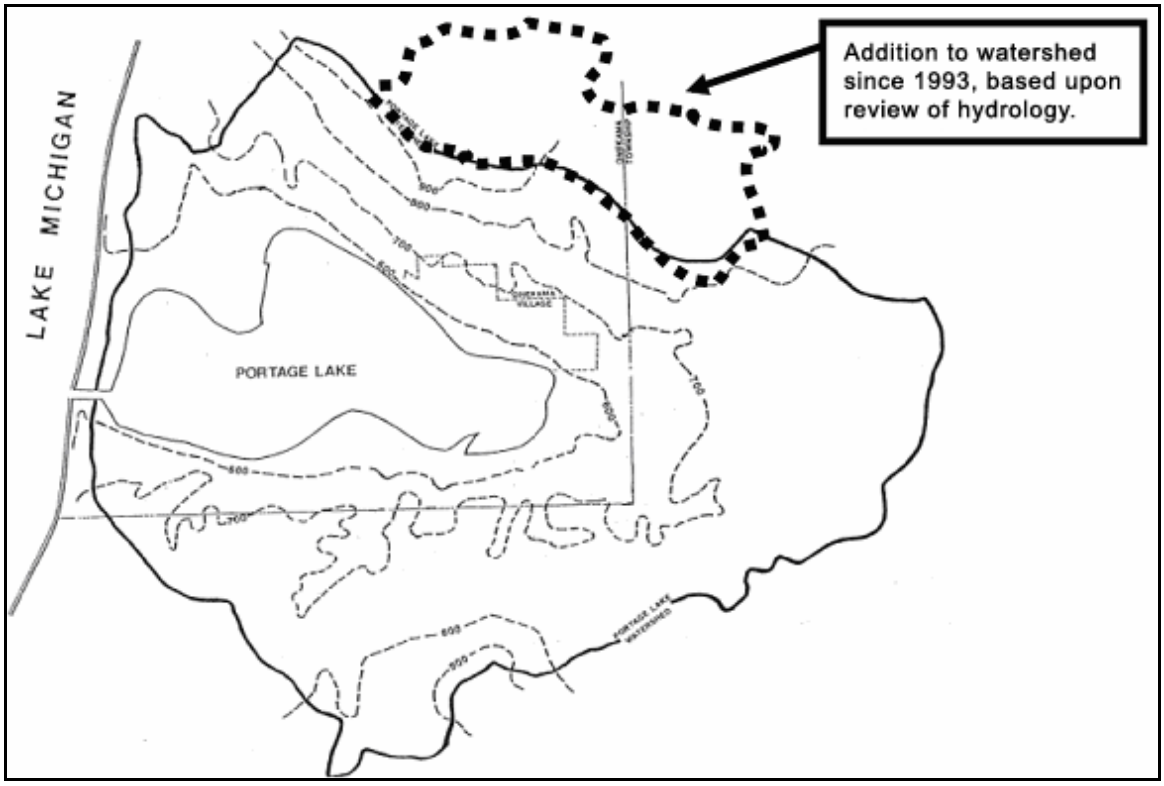
SOURCE: Public Sector Consultants Inc., 2007, using data from NOAA, 2000.

Topography/Elevation

The Portage Lake watershed is generally bowl shaped with elevations at the outer edges of the watershed reaching as high as 950 feet above sea level (289.6 meters) and sloping toward Portage Lake. The lowest point of land is approximately 580 feet (176.8 meters) above sea level. The eastern side of the watershed is relatively flat with grades less than 3 percent, while the area north of Portage Lake has steep slopes with grades as much as 20 percent. The northeast portion recently determined to be within the watershed boundary is a shallow basin surrounded on three sides by relatively high ridges that taper off to the south and west, eventually allowing groundwater to drain toward Portage Lake. The western portion of the watershed is bounded by coastal dunes that reach heights of over 80 feet (24.4 meters), with grades as great as 40 percent on the Lake Michigan side (see Exhibit 15).

EXHIBIT 15

Portage Lake Watershed Topography Shown in Feet above Sea Level



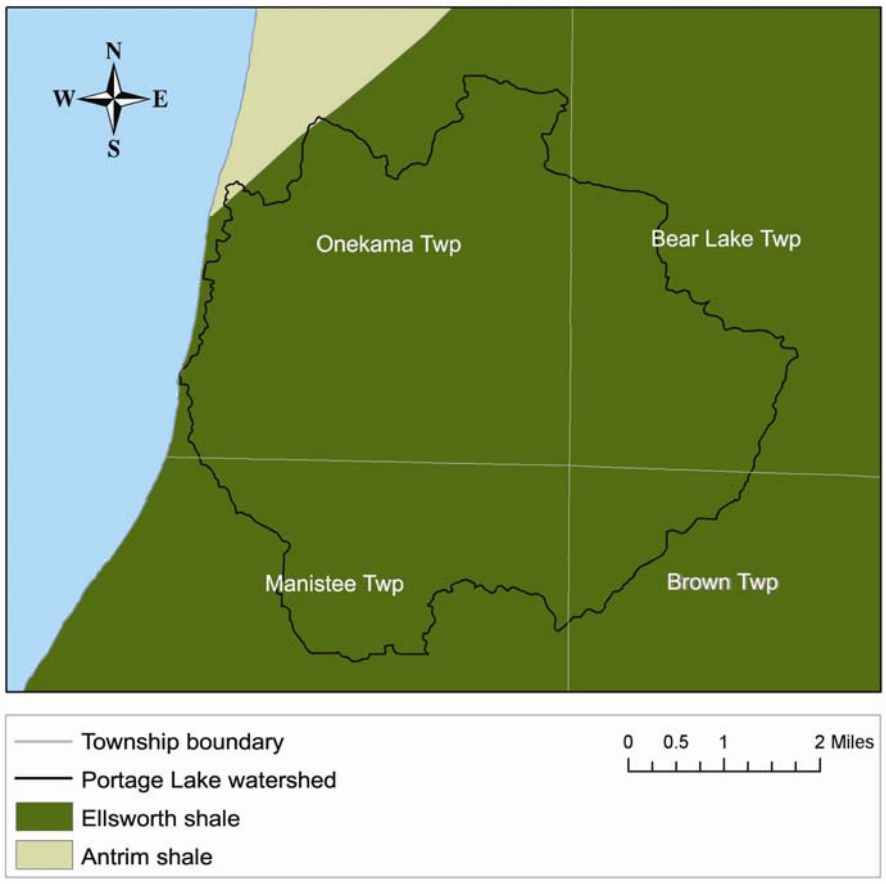
SOURCE: SEG, 1993.

Geology

The bedrock beneath the glacial deposits in Manistee County consists predominantly of sandstones (i.e., Marshal Formation) and shale (i.e., Antrim, Coldwater, and Ellsworth formations). The Portage Lake watershed is underlain almost entirely by Ellsworth shale, with only a small portion underlain by Antrim shale (see Exhibit 16). The Portage Lake watershed is at the rim of the large geologic sedimentary rock feature covering most of the Lower Peninsula of Michigan (described as the Michigan Basin) that contains

significant hydrocarbon deposits. Manistee County has had considerable oil and gas exploration and development activity, particularly since the 1970s. The county ranks second in the state in the total production of both oil and natural gas that began in Michigan in 1925 (see Exhibit 54).

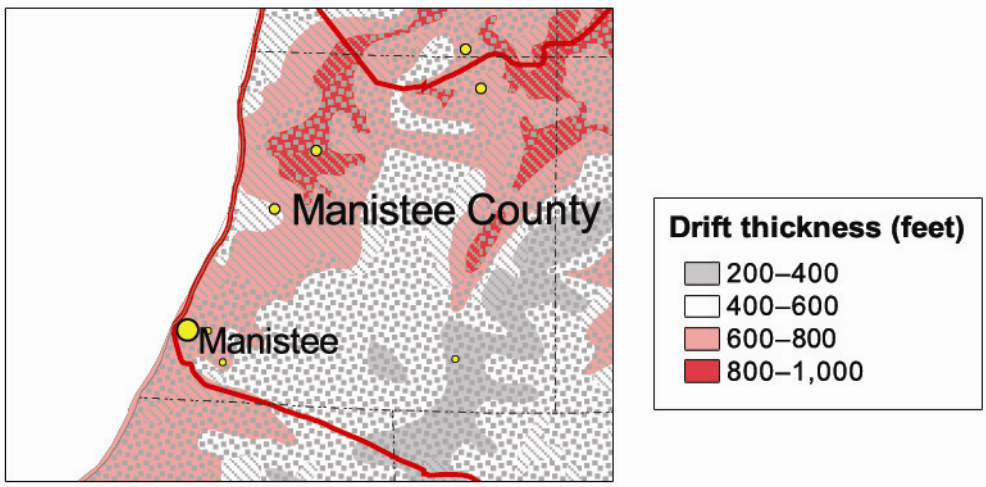
EXHIBIT 16
Bedrock Geology of Portage Lake Watershed



SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI (Bedrock Geology).

Glacial deposits (drift thickness) vary from 200 to 1,000 feet above the bedrock formations in Manistee County (see Exhibit 17).

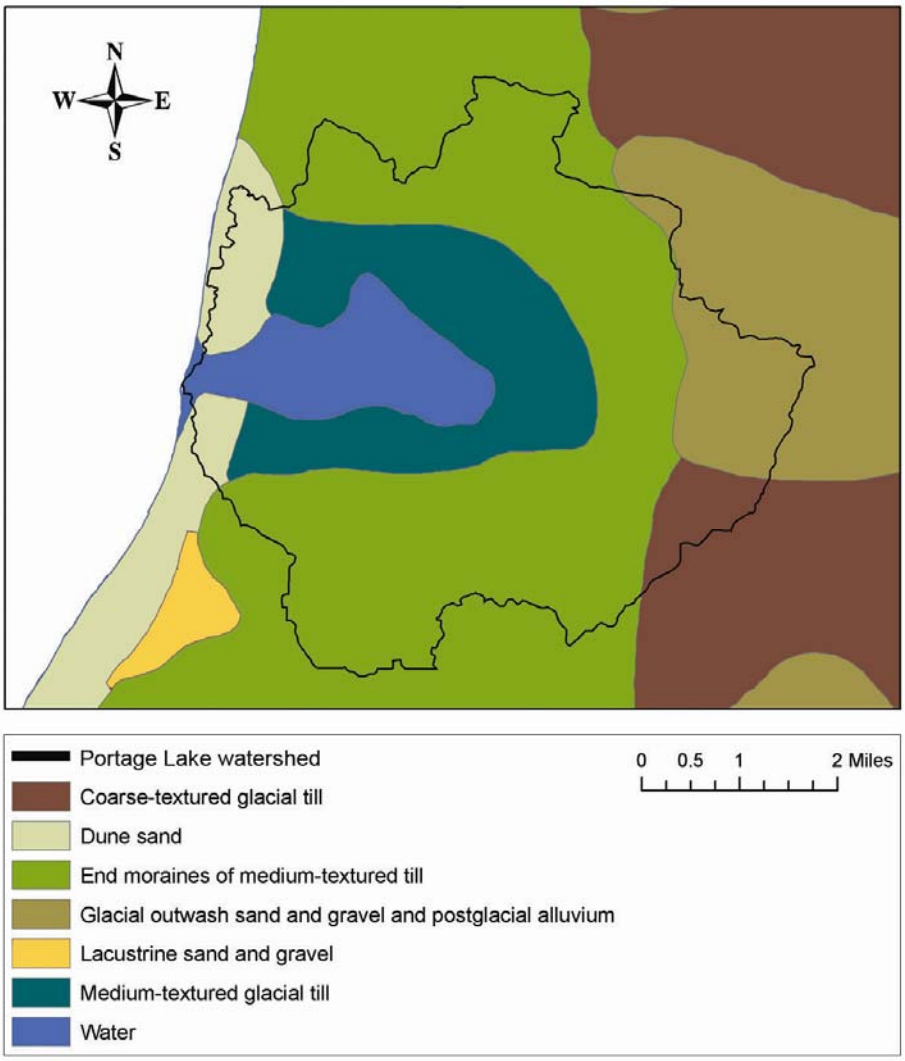
EXHIBIT 17
Thickness of Glacial Deposits (Drift) in Manistee County



SOURCE: U.S. Geological Survey, ND.

A mixture of lacustrine sand and gravels; glacial outwash sand and gravel, and post-glacial alluvium; as well as various coarse-, medium-, and fine-textured tills associated with moraines and other glacial features characterize the near-surface geologic conditions within the Portage Lake watershed (see Exhibit 18).

EXHIBIT 18
Portage Lake Watershed Area Quaternary Geology (Recent Glacial Deposits)

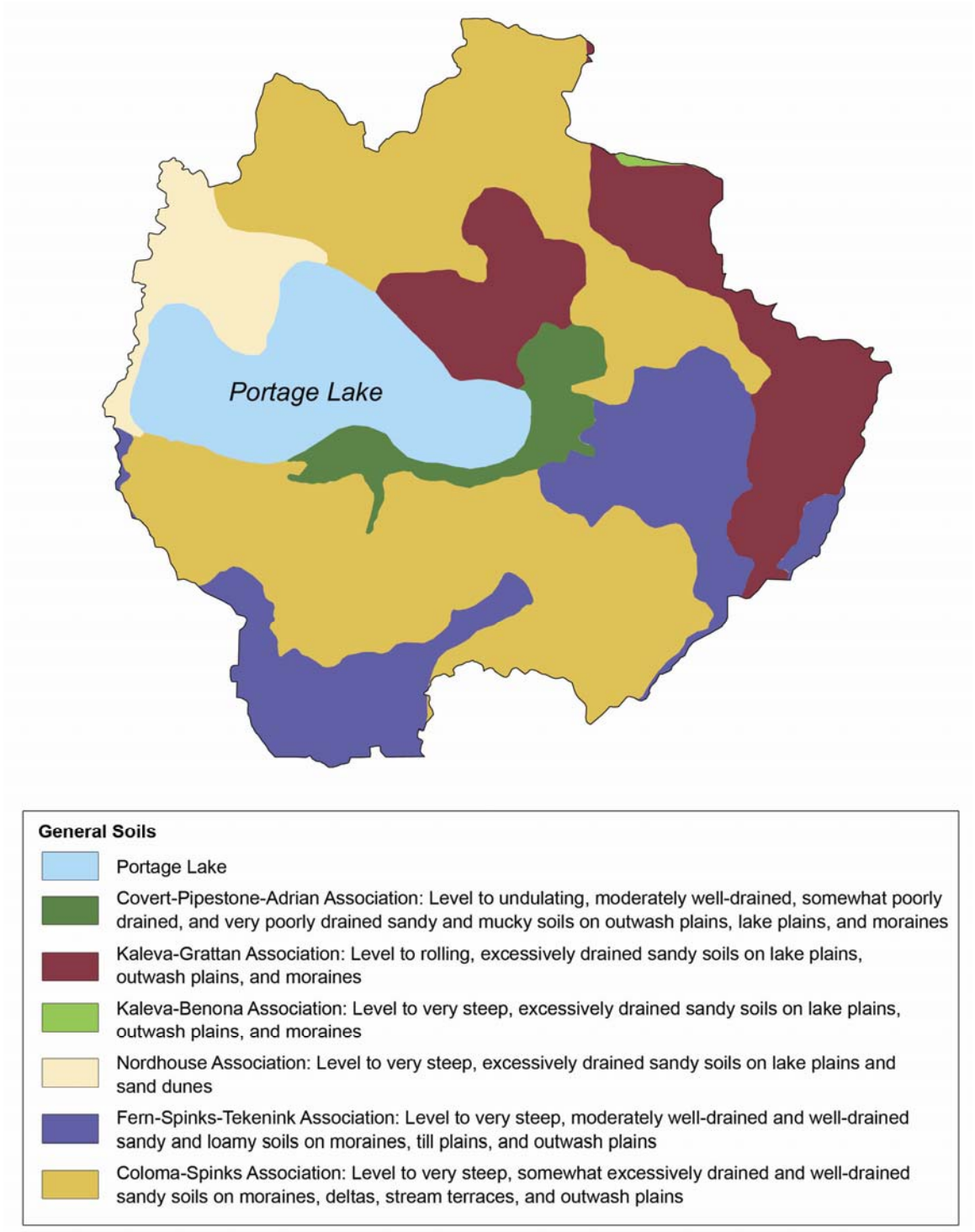


SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI (Quaternary Geology).

Soils

The surface soils of the watershed reflect the glacial origins of this area of the Lake Michigan shoreline. In general the soils are well drained sand or sandy loam, with interspersed, smaller areas of less-well-drained mineral and organic soils (see Exhibit 19). In general, surface runoff is minimized by the permeability of the soils in the watershed and both Portage Lake and its tributaries have significant contributions of groundwater inputs.

EXHIBIT 19
Portage Lake Watershed General Soils



SOURCE: USDA, Natural Resource Conservation Service, Grayling Area Office, 2007.

Threatened, Endangered, and Species of Concern

Michigan's endangered and threatened species are protected under the Natural Resources and Environmental Protection Act, Public Act 451 of 1994. The Michigan Department of Natural Resources designates and maintains information on the status and location of threatened and endangered species. This work is coordinated by the Michigan Natural Features Inventory (MNFI), a part of Michigan State University Extension. Federally listed species are protected under the Endangered Species Act of 1973. The U.S. Fish and Wildlife Service (USFWS) is the federal agency responsible for federally listed species in Michigan.

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

Based on information from the MNFI, there are no state or federally listed endangered species in the Portage Lake watershed. There are three state-listed threatened species (T) within the watershed—the red-shouldered hawk, the pitcher's thistle, and the Lake Huron locust—and one state-listed species of concern (SC), the brown walker snail. There is one federally listed threatened species in the watershed: the pitcher's thistle. Exhibit 20 includes the species of plants and animals found in the watershed that are state and federally listed as threatened or of special concern.

EXHIBIT 20
Portage Lake Area Threatened Species and Species of Concern

Scientific name	Common name	Federal status	State status
Buteo lineatus	Red-shouldered hawk	—	T
Cirsium pitcheri	Pitcher's thistle	T	T
Trimerotropis huroniana	Lake Huron locust	—	T
Pomatiopsis cincinnatiensis	Brown walker	—	SC

SOURCE: MNFI-MSUE, Watershed Element Data for Watershed ID 4060104 20L 2.

While the specific locations of these species are not publicly disclosed in order to protect the species, the MDNR uses the information to evaluate state or federal permits required for land or water uses. The threatened species and species of concern in the Portage Lake watershed and their habitat requirements are described briefly in the following sections.

Red-shouldered Hawk

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

Red-Shouldered Hawk
Photo by Michael R. Penskar
MSU Extension
http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=10942

The primary threat to this species in Michigan is habitat alteration and destruction due to timber harvest, road construction, and residential development. Habitat manipulation impacts the species directly by alteration of suitable structure around the nest site and indirectly by influencing the abundance, distribution, and vulnerability of prey species. Fragmentation of forest stands and the creation of larger openings favor the immigration of nest competitors and predators such as the red-tailed hawk (*Buteo jamaicensis*) and great horned owl (*Bubo virginianus*). Currently, management has focused on maintaining the critical components of individual home ranges such as the nest area, post-fledgling area, and foraging area (Rabe 1999).

Pitcher's Thistle

Pitcher's thistle is a perennial thistle of open Great Lakes dunes. This plant typically grows on open sand dunes and occasionally on lag gravel associated with shoreline dunes. Critical habitat for this species is along the Great Lakes shores, or in very close proximity.

Pitcher's Thistle
Photo by Susan R. Crispin
MSU Extension
http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=13485

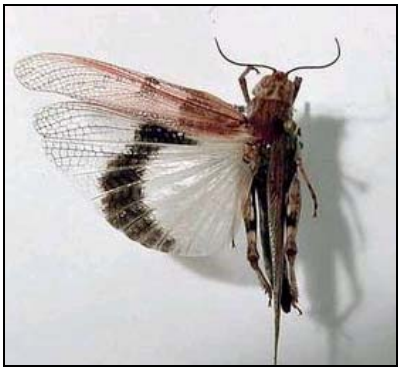
Though Pitcher's thistle can be locally extirpated by destruction or major disturbance of its habitat (e.g., by shoreline development or intensive recreation), it is somewhat tolerant of disturbance from pedestrians and limited off-road vehicle (ORV) traffic. However, vehicular traffic and regular foot traffic tend to unduly destabilize dune sands by mechanically destroying vegetation; this increases erosion and stresses Pitcher's thistle plants. An indirect effect of artificial disturbance is that it enables non-native species such as the invasive spotted knapweed (*Centaurea maculosa*) to invade dune habitats and displace native vegetation, resulting in further habitat degradation.

Because of the extreme development pressure along the Great Lakes shoreline, the potential cumulative impact to Pitcher's thistle populations is high. Two of the world's largest populations of *Cirsium pitcheri* lie within Sleeping Bear Dunes National Lakeshore and Ludington State Park/Manistee National Forest (Nordhouse Dunes) (Higman 1999).

Lake Huron Locust

The Lake Huron locust is a small, ash-gray grasshopper with darker brown and white markings and wings with a prominent dark band.

In Michigan, the Lake Huron locust is restricted to sparsely vegetated, high-quality coastal sand dunes. In these areas, it typically occurs in high numbers and is usually the dominant species. Unfortunately, significant parts of the locust's high-quality dune habitat have been degraded or destroyed by shoreline home and recreational development throughout the Great Lakes region.



Lake Huron Locust
Photo by David Cuthrell
MSU Extension
http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=12268

Although this species is dependant on the dune environment for survival, the Lake Huron locust apparently can persist with low to medium levels of human-related disturbance. Healthy locust populations have been maintained on private lands in several places on Lake Michigan and Lake Huron, as long as the basic dune system is kept intact (Cooper 1999).

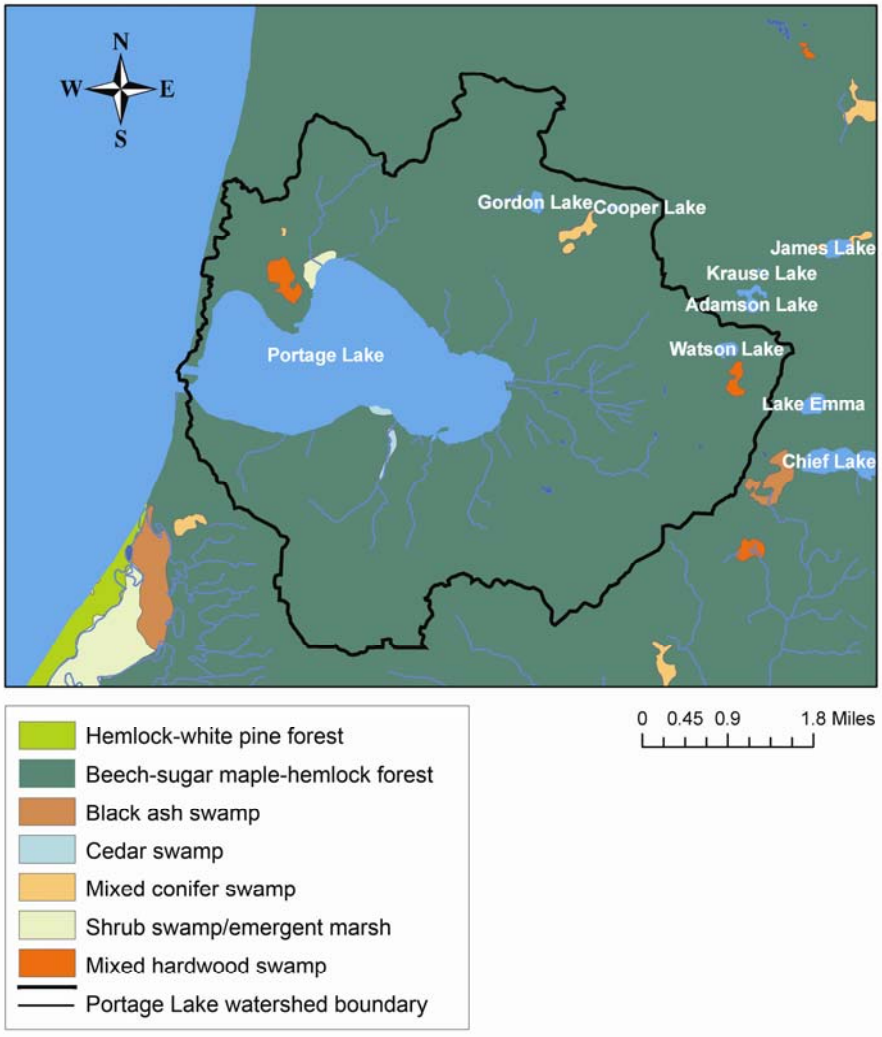
Brown Walker

The brown walker is a small freshwater snail with a broadly conic shell that is 4.5 mm in height and 3.5 mm wide with rounded whorls gradually increasing in size and a small rounded aperture (main opening) one-fourth the height of the shell. The brown walker inhabits the banks of medium to large rivers. It is thought to prefer clay river banks and may hibernate on moist banks above water, under leaf litter and dormant grassy vegetation. The brown walker likely depends on maintaining natural vegetative canopy cover along stream banks. The species also is likely susceptible to water pollution in the form of pesticides as well as urban runoff and municipal discharge (MNFI 2007a).

LAND USE AND LAND COVER

Original land surveys in the 1800s show that the entire Portage Lake watershed was dominated by a beech-sugar maple-hemlock forest with conifers limited to a significant cedar swamp located on the south shore of Portage Lake and a few mixed conifer swamps in other isolated locations (see Exhibit 21).

EXHIBIT 21
Portage Lake Watershed Land Cover, circa 1800



SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI (Manistee Land Use circa 1800).

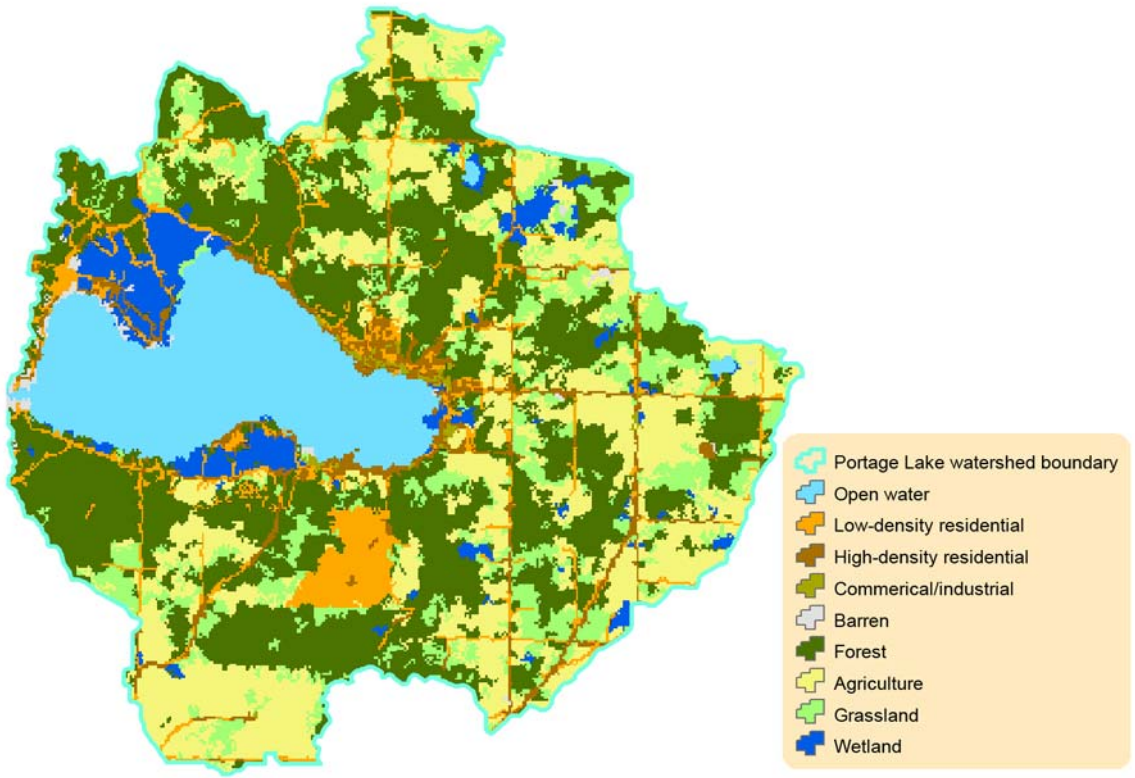
The most recent land use/land cover data available for the Portage Lake watershed is from 2001 (see Exhibits 22 and 23). Forested (hardwoods, conifers, mixed forest, and shrub land), agricultural (pasture/hay, row crops and small grains, orchards), and non-forested, non-agricultural vegetated lands dominate the landscape. Wetlands and urbanized areas (low- and high-density residential and commercial/industrial/ transportation) are limited primarily to shoreline areas adjacent to Portage Lake, particularly in the Village of Onekama on the east end of the lake; along the eastern half of the south shore; in the central portion of the north shore; and along the west shore near the outlet channel to Lake Michigan. The few remaining wetlands are located in these same areas adjacent to Portage Lake and in portions of tributary streams.

EXHIBIT 22
Portage Lake Watershed Land Use/Land Cover, 2001

Land use class	Acres	% of watershed
Commercial/Industrial	59	0.4%
High-density residential	672	4.3
Low-density residential	1,043	6.7
Forestland	5,494	35.1
Wetland	722	4.6
Grassland	1,946	12.4
Agriculture	3,593	22.9
Surface water	2,139	13.7

SOURCE: MSU CEVL and LPI, 2007, using data from MRLCC, 2001.

EXHIBIT 23
Portage Lake Watershed Land Use/Land Cover Map, 2001



SOURCE: MSU CEVL and LPI, 2007, using MRLCC data, 2001.

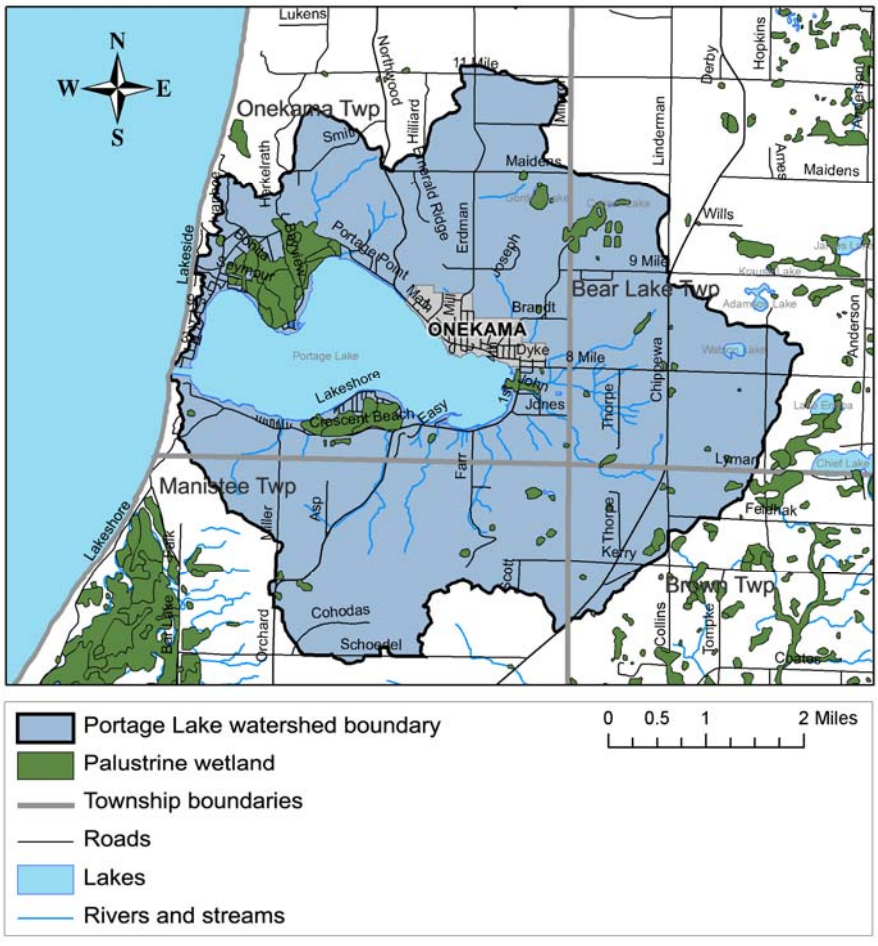
Current Wetlands of Potential Significance and Wetland Losses

The MDEQ has recently completed maps of all Michigan counties that identify potential and approximate locations of wetlands, using overlays of data from the following sources:

- The National Wetland Inventory (NWI), conducted by the U.S. Fish and Wildlife Service through interpretation of topographic data and aerial photographs
- Land cover, as mapped by the Michigan Department of Natural Resources Michigan Resource Inventory System (MIRIS), through interpretation of aerial photographs
- Soils, as mapped by the U.S. Department of Agriculture (USDA), Natural Resource Conservation Service

The Portage Lake watershed wetland map identifies areas of potential significance on the northwest side and adjacent to the south shore of Portage Lake, where there are significant areas of palustrine (freshwater) wetlands (see Exhibit 24). The map also identifies wetland areas along the length of Schimke Creek and in the headwaters of several other tributaries to Portage Lake.

EXHIBIT 24
Potential and Approximate Location of Wetlands in Portage Lake Watershed

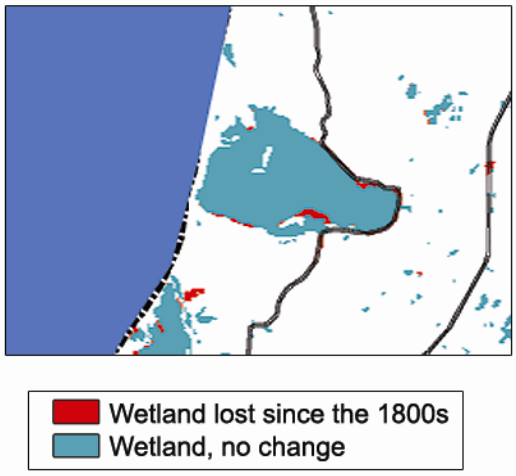


SOURCE: Public Sector Consultants, 2007, with data from MDIT/CGI (Manistee Final Wetland Inventory).

Based upon wetland maps developed by the Michigan Natural Features Inventory of land cover conditions in the 1800s, Exhibit 25 illustrates the areas of wetland loss in the

watershed. Most of the losses have been associated with the shore areas of Portage Lake, where residential and commercial development and related transportation corridors have been most intense over the last 150 years. Nearly 15 percent of the shoreline of the lake has been modified by bulkheads or breakwalls, with less than 25 percent remaining in natural wetland habitat.

EXHIBIT 25
Portage Lake Area Wetland Loss since 1800s

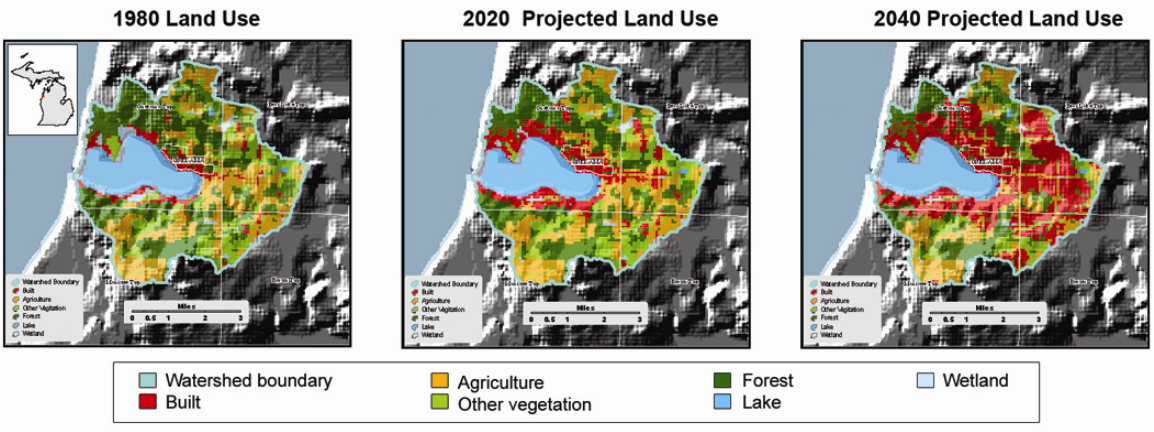


SOURCE: Michigan Natural Features Inventory, MSU Extension, 1995.

Land Use Projections

Researchers at Michigan State University have developed a spatialized trend model to project what Michigan's landscape might look like in the future if present trends continue. The analysis was conducted on the Michigan base (1980), provided by the MIRIS, the projected land use in 2020, and the projected land use for 2040. The digital maps for these three time periods are shown in Exhibit 26.

EXHIBIT 26
Portage Lake Basin Land Use in 1980 and Projections for 2020 and 2040



SOURCE: MSU CEVL and LPI, 2007.

By 2040, the built areas of the Portage Lake watershed are projected by the model to increase by 409 percent. The other vegetation, agriculture, forest, and wetland areas are expected to decline in acreage. Exhibit 27 summarizes the results from the analysis. This trend indicates that growth comes at the price of forestland, wetland, and agricultural land loss. Given past trends and future projections, the need for structured land use planning and protection becomes evident.

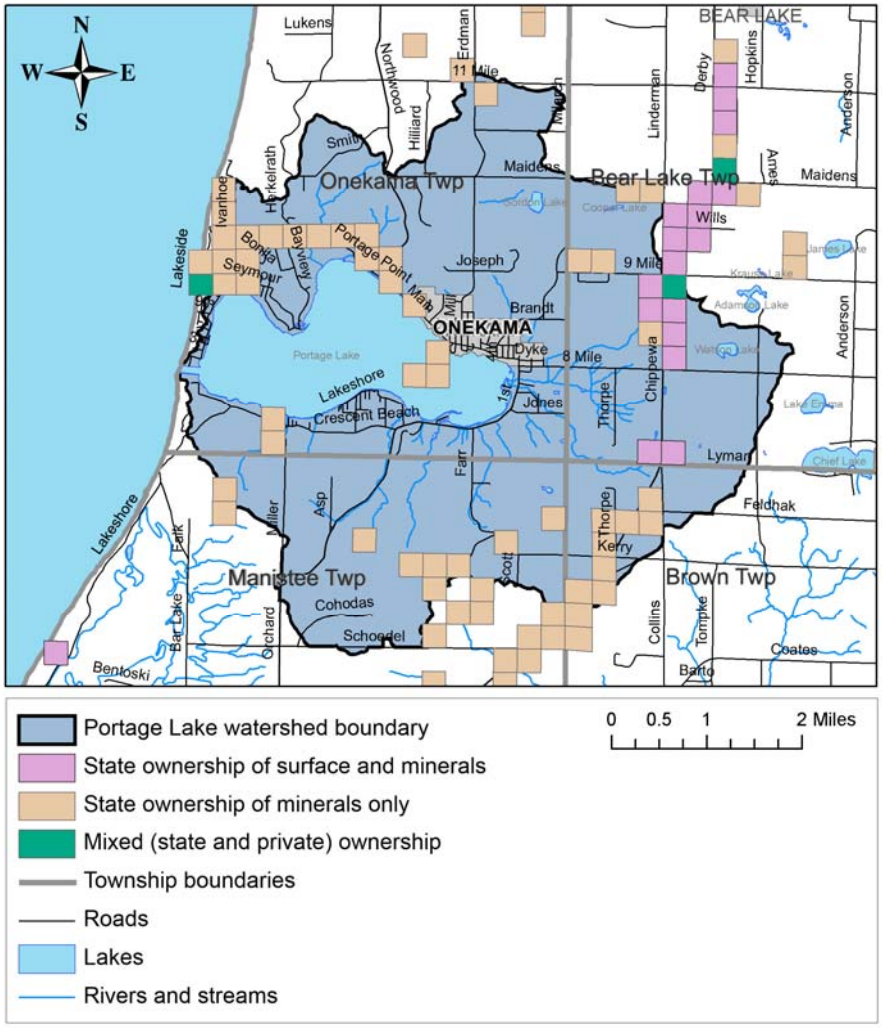
EXHIBIT 27
Land Use Changes, 1980–2040, Acres

Class	1980	2040	Change	% Increase/ decrease
Agriculture	4,043	2,701	–1,342	–33%
Built	1,137	5,790	4,653	409
Forestland	5,508	3,408	–2,100	–38
Wetland	425	175	–250	–59
Other vegetation	2,493	1,532	–961	–39

SOURCE: MSU CEVL and LPI, 2007.

The State of Michigan owns approximately 1,700 acres of subsurface minerals within the Portage Lake watershed, mineral ownership retained by the state mostly from tax-reverted lands whose surface ownership was subsequently sold. The state holds title to fewer than 400 acres of surface land within the watershed. With the exception of small acreage owned by local government, more than 95 percent of the subsurface minerals and over 98 percent of the surface lands within the watershed are privately owned (see Exhibit 28). There is no or very limited federally owned property within the watershed.

EXHIBIT 28
Portage Lake Watershed Area State Ownership of Surface and Minerals, Minerals Only, and Mixed (State and Private) Ownership



SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI (Manistee DNR Land and Mineral Ownership).

Recreation

Portage Lake is very popular for fishing, sailing, cruising, water skiing, and swimming. Its Great Lakes access and protected harbor provide the opportunity for larger recreational boat owners to sail, cruise, or fish in the Great Lakes. Several Great Lakes salmon and trout charter-fishing businesses operate from a base on Portage Lake. There are two public boat launch sites on the lake: one is operated by the state and one by the Village of Onekama. During peak fishing periods in the fall, the launch facilities are used to capacity. A large number of permanent and seasonal residences on and near the lake dock or moor their fishing and recreation boats on the lake during the open water season. In the winter months the lake supports an intensive ice fishery for a variety of species.

DEMOGRAPHICS

Because the Portage Lake watershed boundary does not directly correspond to established census boundaries, it is difficult to analyze demographic characteristics of the population situated within the watershed boundary. Geographic Information System (GIS) software and data from the 2000 U.S. Census (U.S. Census Bureau 2000) were used to develop approximate boundaries to allow for estimated demographic information. This was done by inputting the watershed boundary into ArcMap GIS software and then comparing it to the Census 2000 block boundaries. Census blocks within the watershed boundary or immediately bordering the watershed boundary were isolated and demographic information was gathered based on this boundary.

Exhibit 29 reveals the demographic information for the watershed using this approach. The approximate population of the Portage Lake watershed is 2,059, with the most densely populated areas around Portage Lake (see Exhibit 30). Of this population, 449 people (22 percent) are over 65 years of age. There are approximately 1,351 housing units: 809 occupied housing units and 542 vacant units (among the vacant units, 474 were classified for occasional, seasonal, or recreational use). There are 809 households in the watershed.

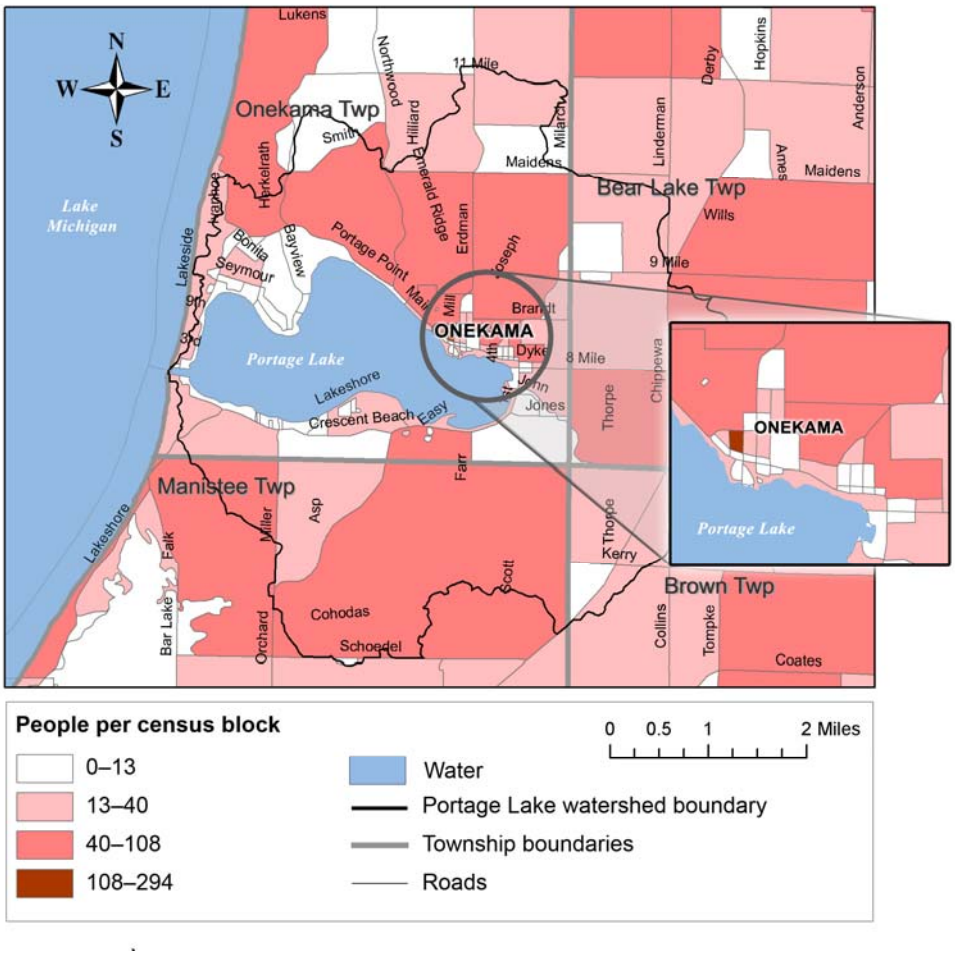
EXHIBIT 29

2000 Demographic Information for the Portage Lake Watershed

Characteristic	2000 Census
Population	2,059
Population over 65 years of age	449
Total housing units	1,351
Occupied housing units	809
Vacant housing units (not seasonal)	68
Seasonal housing units	474
Number of households	809

SOURCE: U.S. Census Bureau, 2000.

EXHIBIT 30
Population Density (People per Census Block Group) for Portage Lake Watershed and Surrounding Areas



SOURCE: Public Sector Consultants Inc., 2007, using data from U.S. Census Bureau, 2000 (TIGER/Line data (Manistee County, Michigan).

To get a sense for demographic trends in the watershed, the indicators mentioned above were compared from 1990 to 2000. Unfortunately, census block data was not available for certain demographic characteristics in the 2000 census, and was not available for any demographic characteristics in the 1990 census. Therefore, the census-friendly geographic boundary of Onekama Township (including the Village of Onekama) was used to determine trend information. This area comprises much of the most densely populated areas of the watershed (see Exhibit 30).

Between 1990 and 2000, the population in Manistee County increased by 3,262 to a total of 24,527 based upon U.S. Census information. This represents a growth rate of 15.3 percent during this ten-year period, more than double the state's growth rate of 6.9 percent during the same period.

Exhibit 31 illustrates the significant changes that occurred in Onekama Township during the same period. Total population increased by nearly 20 percent, and the number of residents 65 years of age and older increased by 25.3 percent. This population growth rate is slightly greater than growth in Manistee County and much greater than the state increase.

The total number of housing units in the township increased slightly, as did the number of seasonal housing units. Although this represents only a 2.9 percent increase in total housing units over the ten-year period, there was a 58.9 percent *decrease* over the ten years in the number of *vacant* housing units. The average household size for both owner-occupied and rental housing decreased slightly.

The proportion of seasonal housing units in the township is very high and in 2000 represented approximately 42 percent of all housing units. This is consistent with the outstanding quality of the area's water and related outdoor summer activities. It is likely that in the period from Memorial Day through Labor Day of each year the number of people living in the township, and in the watershed, increases significantly. During peak summer weekends the overnight population in the watershed is likely to be two to three times that of the permanent winter population.

Economic indicators in the township are remarkable. Median and per capita income nearly doubled from 1990 to 2000 while the number of impoverished families decreased by 19.4 percent.

EXHIBIT 31

Demographic Information for Onekama Township (including the Village of Onekama), Manistee County, 1990 and 2000

Characteristic	1990 Census	2000 Census	% Increase/ decrease
Population	1,266	1,514	19.60%
Population over 65 years of age	292	366	25.3
Total housing units	1,086	1,117	2.9
Occupied housing units	519	603	16.2
Vacant housing units (not seasonal)	112	46	-58.9
Seasonal housing units	455	468	2.9
Average household size (owner occupied)	2.4	2.3	-4.2
Average household size (renters)	2.3	2.1	-8.7
Median family income	$26,406	$51,042	93.3
Per capita income	$10,601	$20,919	97.3
Families below poverty level	31	25	-19.4

SOURCE: U.S. Census Bureau, 1990 and 2000.

WATERSHED CONDITIONS

This section describes the current watershed conditions in terms of water quality, flow, and biology.

Available Monitoring/Resource Data

What is known about the condition of the Portage Lake watershed is derived from the following studies and reports. Various water quality parameters were measured and are reported on in the following sections.

Michigan Department of Natural Resources Water Quality Data

(MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data)

As part of the then-routine monitoring program of Great Lakes tributaries by the MDNR, water quality samples were collected at various depths at the two deepest locations (60 feet) in the central and western basins of Portage Lake in July and again in September of both 1974 and 1985. At the time the MDNR included water quality monitoring that is now the responsibility of the MDEQ.

A Shoreline Algal Survey, NW Michigan Regional Planning and Development Commission

(Northwest Michigan Regional Planning and Development Commission, 1983)

This is a USEPA-supported project to evaluate the need for sanitary sewers completely around Portage Lake originally proposed in a 1976 plan. The survey encompassed all shoreline areas of the lake and focused on the use of *Cladophora* as an indicator algal species in combination with models to evaluate phosphorus loadings and sources.

Portage Lake EPA Phase I Diagnostic/Feasibility Study 1991

(SEG, 1993)

The most recent comprehensive water quality study of Portage Lake and its watershed is the *Portage Lake EPA Phase I Diagnostic/Feasibility Study* (Phase I Study), prepared by the Snell Environmental Group Inc. It was completed in 1993 with funding support from Onekama Township and a 50 percent matching grant from the USEPA, Region V, through the then MDNR Clean Lakes Program. The study describes the physical properties of the lake and watershed and its historic and present uses, and summarizes previous information collected on the status of the lake and the watershed. SEG collected water samples beginning in January 1991 and continuing through February 1992. Samples were collected monthly at three lake locations at multiple depths for the periods March through April and September through February. The same locations were sampled twice a month from May through August. Six additional lake littoral zone areas were also sampled at the surface each month from May through October.

A variety of parameters were measured for water samples collected from Portage Lake including temperature, pH, conductivity, dissolved oxygen (DO), nitrate and nitrite nitrogen, ammonia, Kjeldahl nitrogen, orthophosphate, total phosphorus, suspended solids, chlorophyll *a*, and Secchi disk transparency. The analyses of the data collected focused on four primary parameters: total phosphorus; chlorophyll *a*; Secchi disk

transparency; and DO. These parameters are typically used to evaluate the trophic status[2] of lakes and in combination can be used to detect significant changes that may be occurring due to human activity.

Four streams (Dunham, Glen, Schimke, and Onekama Creeks) were sampled at their lake outlets twice a month during April and May and once a month during the 12-month study period. Eleven smaller streams and drain outlets were sampled at their lake outlets in May, August, and November. Parameters measured on tributaries included flow, temperature, pH, conductivity, DO, nitrite, orthophosphate, total phosphorus, and suspended solids. The analysis of stream data collected focused on three primary parameters: flow, total phosphorus, and suspended solids.

Michigan Department of Natural Resources Fish Contaminant Monitoring 1991
(as cited in SEG, 1993)

The MDNR reported on various heavy metals and organic compounds measured in fish taken from Portage Lake in 1991 and the results were reported in the 1993 Phase1 Study.

Onekama Township Bacteriological Sampling 1985–1990
(as cited in SEG, 1993)

From 1985 through 1990, representatives of Onekama Township collected lake water samples for fecal coliform analyses to determine compliance with then State Health Department standards for safe total body contact.

Onekama High School Water Quality Monitoring 1993–2007
(Onekama High School, 2007)

Onekama High School students have tracked water quality in Portage Lake from 1993 through the present including monitoring temperature, pH, DO near the surface, Secchi disk transparency, chlorophyll *a*, and total phosphorus at three lake locations (same locations sampled during Phase I Study) in both the spring and the fall of each year.

Department of Natural Resources Water Quality Monitoring 1999 and 2007
(MDNR, 1999 and 2007)

The Fisheries Division of the MDNR collected water quality samples and determined the dissolved oxygen concentration at various depths in one-day sampling events during 1999 and 2007.

Status of the Fishery Resource Report 2000
(MDNR, 2000)

The last intensive survey of the fisheries of Portage Lake was completed in June of 1999 and reported in the MDNR *Status of the Fishery Resource Report 2000-9*. The Fishery Resource Report outlined the history of the lake, land use in the watershed, development along the shoreline, basic water chemistry, and the status of the fish population.

[2] Classification of the condition of a water body is based on the degree to which sun energy is converted to aquatic plant and algal growth (i.e., productivity). Generally, lakes are classified as oligotrophic (unproductive) or eutrophic (very productive), and those in-between are called mesotrophic.

Little River Band of Ottawa Indians (LRBOI) Walleye Recruitment Assessments of Portage Lake
(LRBOI, 2005 and 2006)

The Little River Band of Ottawa Indians, as part of a larger study of fish populations in their tribal area of interest, conducted field investigations during 2005 and 2006 to determine the status of walleye recruitment and growth in Portage Lake.

A Biological Survey of McGowan's and Schimke Creeks, Manistee County
(MDEQ, 2007d)

During August of 2003, the MDEQ Water Bureau, Surface Water Quality Assessment Section conducted field investigations on McGowan's and Schimke Creeks. The focus of the studies was to determine the biological integrity and physical habitat in these two largest tributaries to Portage Lake.

Onekama Township Bacteriological Sampling 2007
(Onekama Township, 2007)

Five popular swimming beaches were sampled during July and August 2007 for *E. coli* bacteria to determine compliance with state water quality standards for total body contact.

Surface Water Quality

Water Quality Data for Many Parameters

As part of the same MDNR monitoring program mentioned above, samples were collected at various depths at the two deepest locations (60 feet) in the central and western basins of Portage Lake in July and again in September of both 1974 and 1985. Exhibit 32 compares the sample results for the major parameters measured. No significant differences occurred in the range of water quality parameters measured in Portage Lake over the 11-year period between 1974 and 1985. In general, the results were consistent with what was expected in a hard water lake in this area of the state. No major water quality issues were apparent with the exception of the low dissolved oxygen levels at depths greater than 20 feet during summer stratification.

EXHIBIT 32
Water Quality Sampling Results at Various Depths from Central and Western Basins of Portage Lake, 1974 and 1985

Parameter	Western basin September 1974 0–60 feet	Central basin Sep-74 0–60 feet	Western basin Jul-85 0–60 feet	Central basin Jul-85 0–60 feet
Dissolved oxygen (mg/L)	9.4–8.2	8.2–2.3	9.0–< 0.1	9.2–0.4
pH	8.7	8.7–7.7	8.2–7.9	8.0–8.0
Total alkalinity mg/L	110	110–138	105–125	101–121
Secchi disk in feet and meters from surface	10.1 ft. (3.08 m)	12.5 ft. (3.81 m)	13.0 ft. (3.96 m)	12.5 ft. (3.81 m)
Chlorophyll *a* micrograms/L	4.6	4.6	2.2	2.6
Total phosphorus mg/L	0.03–0.01	0.02–0.04	0.01–0.02	<0.01–0.01
Total phosphorus micrograms/L	30–10	20–10	10–20	<10–10
Total N02&NO3 mg/L	0.02–0.09	0.02–<0.02	0.02–0.09	0.02–0.65
Total NH3&NH4 mg/L	0.02–0.01	0.02–0.31	0.01–0.69	0.14–0.27

SOURCE: MDNR, Michigan/USEPA STORET Water Quality Data, Manistee County, Site Numbers 510123 and 510090, 1974 and 1985.

Total Phosphorus, Chlorophyll a*, and Secchi Transparency*

Phosphorus is often the primary factor limiting the productivity of lakes in Michigan. Total phosphorus measurements can be used to evaluate the potential impacts of increased phosphorus loadings from septic tanks, and runoff from various land uses and from atmospheric deposition. Sampling conducted for the Phase I Study during the first four months of 1991 indicated a total nitrogen-to-phosphorus ratio in the range of 22:1, confirming that phosphorus is most likely the limiting nutrient in Portage Lake.

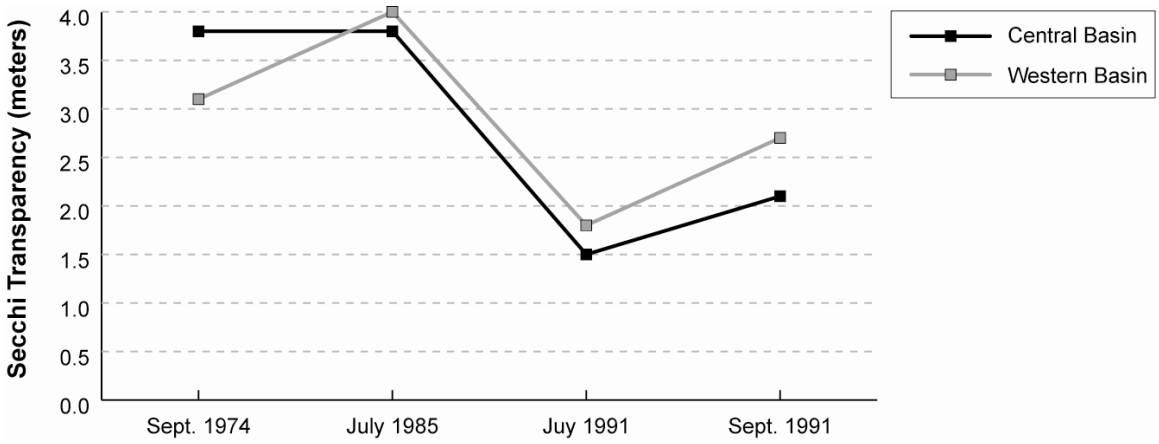
Chlorophyll *a* measurements provide an index of algal growth, and high levels, particularly in shallow areas, can indicate significant nutrient loadings from riparian properties. Secchi disk transparency readings indicate the depth of light penetration from the surface and in many instances can be used to indirectly measure algae growth, which decreases the depth of light penetration (i.e., lower Secchi readings may indicate higher productivity). In addition to algal growth, Secchi disk transparency can be decreased by wind turbulence that resuspends sediments, by suspended solids from lake tributaries and, in some cases, by high levels of dissolved solids in the form of calcium carbonate.

All three parameters vary depending upon time of year, location in the lake, weather conditions, and the depth of the water sample. Comparisons of these three parameters from one year to the next or over a longer period can be difficult unless samples are collected under similar conditions, at the same time of year, and at the same depth. To assess the water quality for these parameters, the MDNR and Phase I Study results were used. Exhibits 33, 34, and 35 provide a comparison of these selected parameters in 1974, 1985, and 1991 at the western and central basins where water depths reach 60 feet. The

MDNR sampling occurred only at these two stations for one day in September of 1974 and July of 1985, while the Phase I Study sampled both locations throughout 1991.

EXHIBIT 33

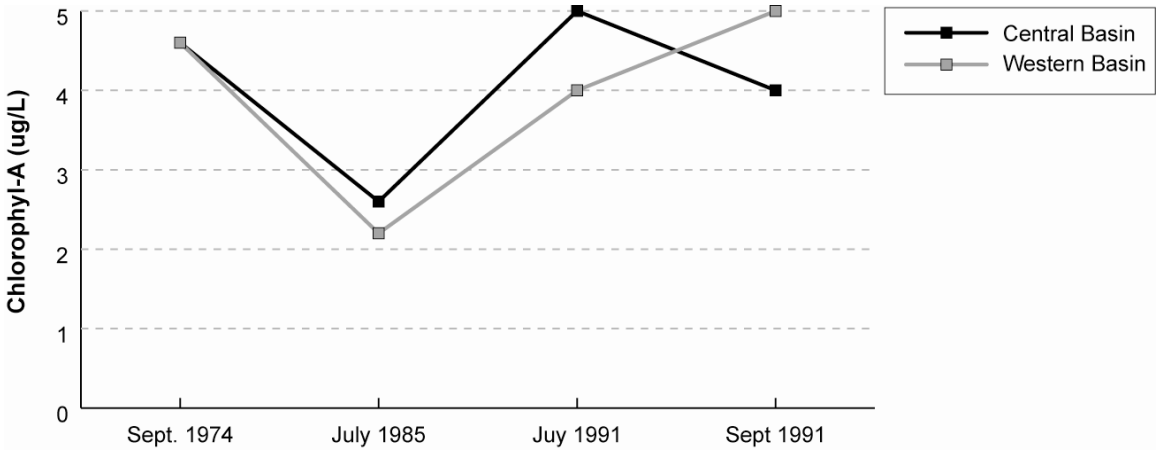
Secchi Transparency Measured in Portage Lake at the Western and Central Basin Sampling Locations in September 1974, July 1985, and July and September 1991



SOURCE: Public Sector Consultants Inc., 2007, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Data Files 1975 and 1985 and SEG, 1993.

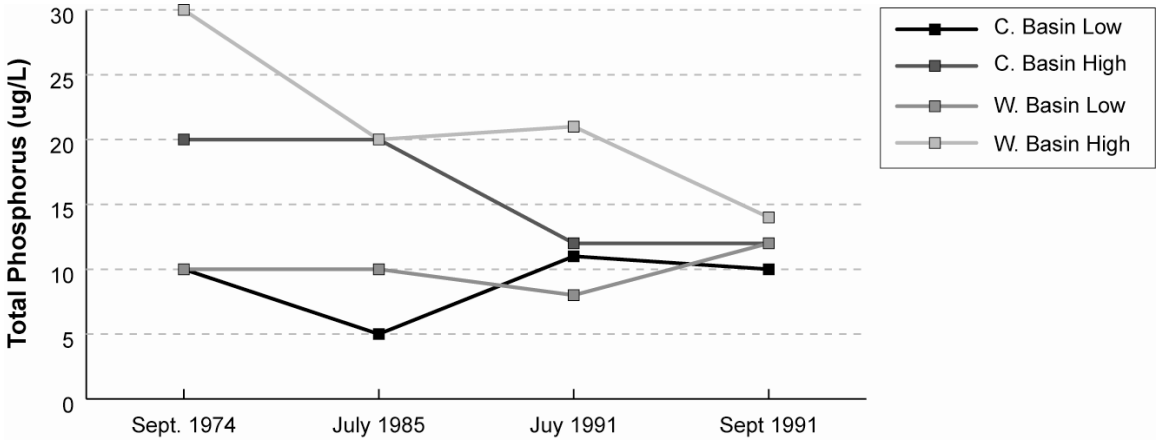
EXHIBIT 34

Chlorophyll *a* in Portage Lake at the Western and Central Basin Sampling Locations in September 1974, July 1985, and July and September 1991



SOURCE: Public Sector Consultants Inc., 2007, using data from MDNR, Michigan/USEPA STORET Data Files, 1974 and 1985, and SEG, 1993.

EXHIBIT 35
Range of Total Phosphorus at Various Depths in Portage Lake at the Western and Central Basin Sampling Locations in September 1974, July 1985, and July and September 1991



SOURCE: Public Sector Consultants Inc., 2007, using data from MDNR, Michigan/USEPA STORET Data Files, 1974 and 1985, and SEG, 1993.

Exhibit 35 shows the range of total phosphorus recorded in samples taken at various depths at the same two locations during the same three years. Total phosphorus results ranged between approximately 10 and 20 micrograms per liter (ug/L) at both locations during both months with the exception of the reading in September 1974 in the western basin that was approximately 30 ug/L and the level in the central basin in July 1985 that was close to 5 ug/L.

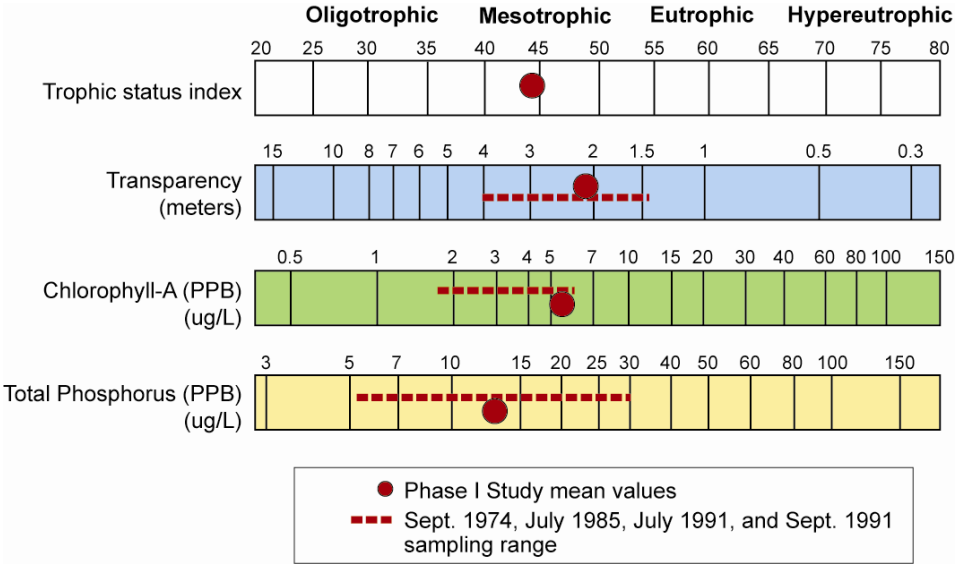
The Phase I Study reported annual mean water quality values for Secchi disk transparency of 2.44 meters, 4.6 ug/L for chlorophyll *a*, and 14.0 ug/L for total phosphorus. Based on mean water quality values, Portage Lake's trophic level fell within the ranges for a mesotrophic lake[3] classification (i.e., 2.29 to 4.57 meters Secchi disk transparency, 2.2 to 6 ug/L chlorophyll *a*, and 10–20 ug/L total phosphorus). With minor exceptions, the levels recorded in September 1974, July 1985, and July and September 1991, shown in Exhibits 33, 34, and 35, fall within the ranges normally associated with mesotrophic lakes.

Trophic Status Index

Exhibit 36 illustrates how the annual mean values from 1991, and the range of values from the central basin of Portage Lake in September 1974, July 1985, and July/September 1991 for these three parameters, compare to the Trophic Status Index (TSI) (Carlson 1977) as adapted by the Minnesota Pollution Control Agency (MPCA, 1991) and used by the MDEQ to guide interpretation of data collected under its Cooperative Lakes Monitoring Program (MDEQ 2003).The TSI is a good measurement for phosphorus-limited water bodies such as Portage Lake; this index was developed for lakes in the Great Lakes region and uses a combination of transparency (Secchi disk readings), chlorophyll *a* measurements, and phosphorus concentrations to classify lakes

with respect to their trophic or productivity levels[3]. The Phase I study established mean values for these three parameters using measurements over the entire open water season. The results indicated that Portage Lake was within the range of a mesotrophic lake[3]—between a eutrophic lake[3] and an oligotrophic lake.[3] Limited data from studies before 1991 and data collected in 2001, 2004, 2005, 2006, and 2007 indicate that the trophic status of Portage Lake, based upon these three parameters, has not changed significantly since 1974.

EXHIBIT 36
TSI of Portage Lake in Central Basin



SOURCE: Public Sector Consultants Inc., 2007, using data from MDNR, Michigan/USEPA STORET Data Files, 1974 and 1985, and SEG, 1993

Exhibit 37 summarizes the Onekama High School Portage Lake monitoring program for 1993–2007 as it relates to the three parameters.

EXHIBIT 37
Portage Lake Water Quality Monitoring Data, 1993–2007

Year	Range of Secchi disk transparency (meters)	Range of Chlorophyll *a* (ug/L)	Range of total phosphorus (ug/L)
1993	4.27–2.74	6.1–3.4	9.5–6.1
1994	7.62–1.83	9.8–2.5	12.9–6.3
1995	9.45–3.05	2.8–0.9	10.2–5.7

[3] The biological productivity of a lake is based on the availability of plant nutrients and is referred to as the lake's "trophic" condition. Extremely high or low productivity usually limits aquatic life. High productivity leads to a lot of algae and other aquatic plants. Low productivity leads to very little aquatic life. The trophic condition of lakes ranges from the least productive (oligotrophic) to moderately productive (mesotrophic) to highly productive (eutrophic). Hypereutrophic lakes are the most productive of all.

Year	Range of Secchi disk transparency (meters)	Range of Chlorophyll *a* (ug/L)	Range of total phosphorus (ug/L)
1996	7.62–3.35	13.3–1.2	8.8–4.6
1997	8.53–3.66	3.3–1.0	6.7–5.1
1998	5.79–3.66	4.4–1.6	7.2–5.4
1999	6.71–3.66	21.4–1.2	11.4–5.3
2000	6.71–3.66	4.9–1.1	10.1–5.7
2001	6.40–3.05	8.1–0.9	13.0–5.8
2002	7.93–3.05	3.1–2.3	6.8–5.6
2003	10.67–3.05	2.3–1.7	8.3–3.5
2004	8.53–3.05	4.2–1.0	10.6–8.0
2005	8.53–3.66	4.2–0.8	10.2–4.9
2006	8.23–3.66	4.3–1.7	9.3–3.7
2007 (Spring data only)	8.23–3.96	1.7–1.1	4.1–3.9

SOURCE: Onekama High School, 2007

The range of values for transparency, chlorophyll *a*, and total phosphorus overlap the range of data for the same parameters measured in earlier studies. The measurements recorded in the Onekama High School 1993–2007 monitoring tend to indicate that the lake is somewhat less productive than estimated in the previous studies (i.e., greater transparency, less chlorophyll *a*, and less total phosphorus). The mean values from the earlier Phase I Study, shown in Exhibit 36, were based upon measurements collected monthly from several locations in the lake and may not be directly comparable to the 2004–2006 monitoring data collected and reported by Onekama High School from one sample period in the spring and one in the fall. Nonetheless, annual monitoring of the type performed by Onekama High School students can provide a baseline upon which long-term trends in Portage Lake productivity can be measured.

Dissolved Oxygen

Another measure of lake productivity is the variation in dissolved oxygen (DO). The level of DO in natural water bodies is determined by a number of factors. In lakes, DO concentrations can vary depending upon time of year, depth, level of plant productivity, time of day, water temperature, weather conditions, oxygen demand from organisms, decomposition of organic matter, and/or oxidation of chemicals in the water or sediments. Temperature determines the amount of DO that water will contain at 100 percent saturation—the lower the water temperature the higher the dissolved oxygen at saturation levels. During daylight periods in the growing season, rooted aquatic plants and algae produce oxygen through photosynthesis and at the same time use oxygen for respiration; DO levels in the photosynthetic zone vary from daylight to nighttime (this is called diurnal variation).

Michigan lakes typically stratify by temperature beginning in the spring when warmer, less dense water on the surface isolates cooler and denser water in the deeper portions of the lake from oxygen-producing rooted plants and algae. In the fall, colder air temperatures cool the surface water and lakes typically “turn over” (invert from top to

bottom); eventually temperatures at the bottom of a lake are warmer than near the surface. Thus, DO can vary both seasonally and by depth.

DO is essential to the survival and growth of aquatic organisms, and water quality standards for minimum DO levels have been established to protect certain groupings of fish species. For coldwater species[4] such as trout and salmon, the minimum DO level is 7.0 milligrams per liter (mg/L) in any 24-hour period. For warmwater[5] species such as largemouth bass and sunfish, the minimum DO level is 5.0 mg/L in any 24-hour period.

Beginning with DO samples taken in 1976 and again in 1985, and through extensive monitoring of DO in 1991 and confirmed again in fisheries surveys in 2001 and 2007, DO levels in Portage Lake at depths of 25 feet and below began to decrease in June of each year. In all four sampling years DO concentrations were 2.0 mg/L or less at 40 feet in the two deepest basins of Portage Lake, reaching near zero at 60 foot depths in the two basins during the June through August period.

The implications of and reasons for this reduced DO concentration at depths below the thermocline (the depth of rapid change in temperature) during the spring through fall period are not clearly understood. Data are not readily available for hard water lakes similar in size and configuration to Portage Lake. However, in nearby Platte Lake, where a discharge from a state-operated trout and salmon hatchery has been the subject of legal battles for the last 25 years, the decrease in dissolved oxygen below the thermocline has been attributed to the addition of phosphorus from the state hatchery. The total number of days and the severity of DO depletion measured in Platte Lake have decreased since phosphorus discharge controls were placed on the hatchery.

There is not sufficient data from Portage Lake to determine whether the severity of DO depletions observed is getting worse or extending over a longer period of time. When concerns related to over-enrichment in Platte Lake were first expressed in the late 1970s and early 1980s, the mean annual total phosphorus was between 9 and 12 ug/L and the Secchi transparencies were 2 meters or less. In comparison, Portage Lake mean total phosphorus levels in 1991 were over 12 ug/L and the average Secchi transparencies were just over 2 meters in depth. While the other problems identified in Platte Lake attributed to over-enrichment have not been documented in Portage Lake, the depletion during summer stratification below the thermocline needs to be further evaluated as a potential indicator that over-enrichment is occurring in Portage Lake. The data upon which the above DO analysis is based are presented below in chronological order.

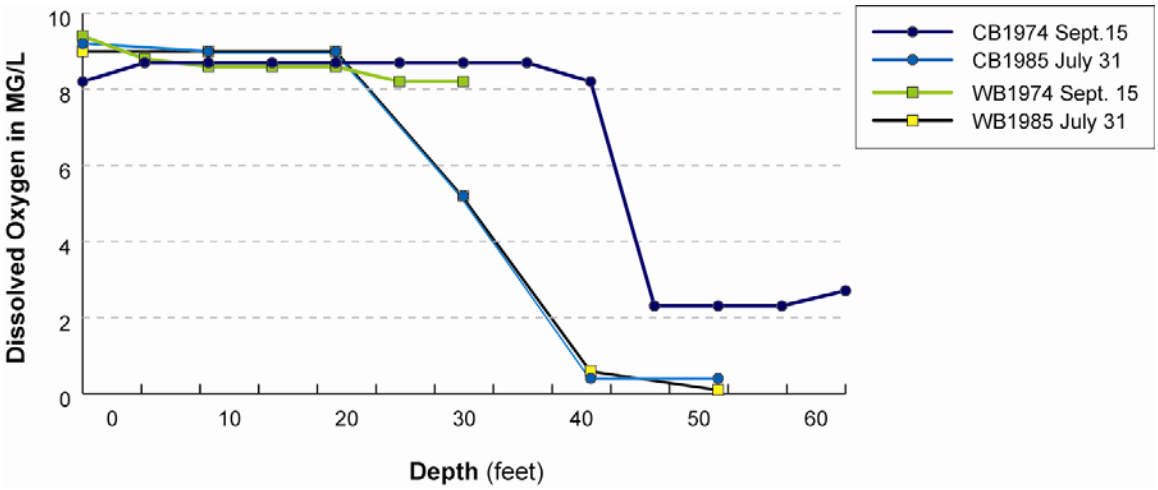
Water Quality Data, MDNR (1974 and 1985)

Exhibit 38 compares the results for DO concentrations at various depths during the periods in 1974 and 1985. During the months of July and September, Portage Lake in both locations for both years showed reduced oxygen levels in and below the thermocline, and for the July period DO was nearly absent in the deepest areas of the lake. The lack of adequate DO limits the habitat available to aquatic organisms,

[4] Fish that prefer clear waters; are not tolerant of extreme temperature changes; and thrive in temperatures that range from 50–65 F.
[5] Fish that have low oxygen requirements and thrive in temperatures 76 F and higher.

particularly fish, and can be a factor under anoxic conditions (zero oxygen) freeing bound phosphorus from bottom sediments.

EXHIBIT 38
Dissolved Oxygen Levels by Depth in Portage Lake Central Basin (CB) and Western Basin (WB), 1974 and 1985



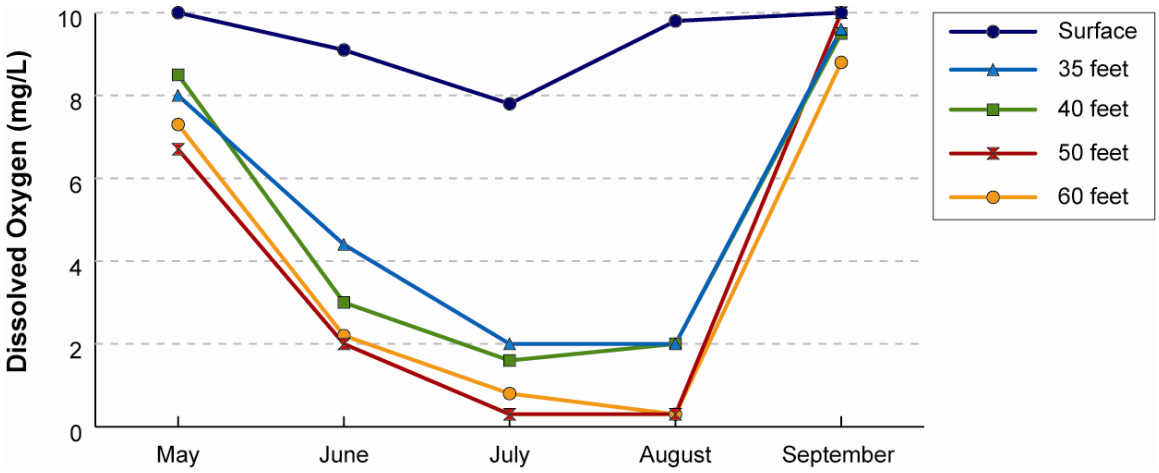
SOURCE: Public Sector Consultants Inc., 2007, using data from MDNR, Michigan/USEPA STORET Water Quality Data 1974 and 1985, Manistee County, Site Numbers 510123 and 510090.

Phase I Study (1993)

According to the Phase I Study results, Portage Lake begins to stratify in May of each year. In 1991 a temperature of 19 degrees Celsius (°C) was measured in May at the surface down to approximately 10 feet of depth. From 10 feet to 55 feet the temperature decreased to approximately 9 °C. DO concentrations during May in the study samplings range from as high as 11.0 mg/L near the surface to as low as 5.0 mg/L at 55 feet. In June the temperature variance from top to bottom increased, and DO concentrations at 40 feet and below decreased to less than 4.0 mg/L. In July the DO concentrations at 35 feet and below were less than 5.0 mg/L, and at 55 feet and below the DO level was less than 1 mg/L. Portage Lake remained stratified by temperature through August until late September when fall turnover began and DO concentration from top to bottom ranged between 8.0 and 10.0 mg/L and temperatures ranged between 11 °C and 14 °C.

Exhibit 39 illustrates the DO levels in Portage Lake at the central basin sampling locations during the period from May through September 1991. Similar DO concentrations were observed at the western basin sampling location.

EXHIBIT 39
Dissolved Oxygen Concentration by Depth at Portage Lake Central Basin Sampling Location, May–September 1991



SOURCE: Public Sector Consultants Inc., 2007, using data from SEG, 1993.

The number of days that the DO levels below the thermocline are less than 5.0 mg/L, and the depth at which the DO levels begin to decrease, may be effective measures for detecting any changes in the productivity of Portage Lake. Unfortunately, there is only 1991 data upon which to evaluate this period of DO depletion in the deeper portions of the lake. It would also be valuable to have comparable data on the daily fluctuation of DO within the photosynthetic zone (the top three meters) to determine whether the DO levels reported in 1991 are representative of daily minimums. Based upon normal sampling times during daylight periods, the surface DO levels reported in 1991 likely represent midday, high DO levels. Minimum DO concentrations could be much lower than those reported in the Phase I Study.

MDNR Status of the Fishery Resource (2000) and Water Quality Data (1997)

Water quality sampling of Portage Lake since 1991 has been limited. The MDNR fishery report included limited Portage Lake water quality data from samples collected on a single day in July of 1999. These samples in 1999 and additional samples collected by the MDNR in July 2007 confirmed earlier water quality sampling that DO concentrations during the summer period below the thermocline were less than 5.0 mg/L. At depths greater than 35 feet, the July 1999 samples indicated that DO concentrations were 3.4 mg/L and less, and July 2007 samples indicated DO concentration were 3.3 mg/L and less.

Bacteriologic Analysis

In a five-year period from 1985 through 1990, representatives of Onekama Township collected lake water samples for fecal coliform analyses. At that time, the State of Michigan used fecal coliform bacteria as the standard indicator bacteria group of potential sources of human waste. During this five-year period, only five of the 144 samples from two sites in Portage Lake exceeded the state standard for total body contact

at that time, 100 fecal coliform bacteria per 100 ml. Four of the high levels were located off the shoreline of the Village of Onekama and one was located near Sandy Point, on the south side of the lake.

In the months from May through September of 1991 the Phase I Study again sampled fecal coliform bacteria at 12 locations around the perimeter of Portage Lake. By 1991, the Village of Onekama had sanitary sewers serving its residents adjacent to the lake while the remainder of homes around the lake operated on septic systems. In 1991, the state standard for total body contact (still 100 fecal coliform bacteria counts per 100 ml) was exceeded only once at one sampling site. This site, located near Eagle Point on the south side of Portage Lake adjacent to residential development, had 200 counts per 100 ml. The Phase I Study attributed the high level to potential septic tile field sources associated with the residential development.

The 1991 one one-time tributary surveys indicated elevated levels of fecal coliform in Schimke Creek and an unnamed small tributary; the bacteria were potentially attributed to cattle raised in the upper portions of both tributaries. Onekama Creek and another small unnamed tributary also had elevated levels that were attributed to potential residential septic tile field drainage in the relatively high-density residential areas upstream of the sampling locations.

Five popular swimming beaches were sampled during July and August 2007 for *Escherichia coli (E. coli)*[6]. All samples met the *current* Michigan water quality standards for total body contact of 130 or fewer counts of *E. coli* per 100 ml of water monthly average and 300 *E. coli* counts or less at any time (Exhibit 40).

EXHIBIT 40
Portage Lake *E. coli* Bacteria, 2007

Site	Sample number	July 26, 2007 *E. coli* colonies/100 ml	August 24, 2007 *E. coli* colonies/100 ml
Portage Point Inn	1	2	12
	2	0	2
	3	1	0
Little Eden Camp	1	17	18
	2	15	29
	3	18	20
Onekama Village Beach	1	7	8
	2	5	7
	3	5	6
Covenant Lake Bible Camp	1	29	1
	2	18	0
	3	23	3
Wik-A-Te-Wak	1	2	3
	2	3	3
	3	14	0

SOURCE: Onekama Township, 2007.

[6] In 1995, the indicator of potential sources of human waste was changed from fecal coliform to a more specific organism, *Escherichia coli (E. coli).*

Drinking Water Quality

The MDEQ reports levels of nitrate, arsenic, and volatile organic compounds in drinking water (MDEQ 1983–2003). Between 1983 and 2003 no drinking water samples from within the Portage Lake watershed were reported with arsenic levels above the maximum contaminant level (MCL) of 0.010 mg/L (10 parts per billion). During the same period two samples out of approximately 100 samples had nitrate levels above the MCL of 10 mg/L (10 parts per million). Maps available from the MDEQ indicate that those samples were from agricultural areas that may experience fertilizer applications. Samples from three sites within the northern and northwestern portions of the watershed were positive for volatile organic compounds between 1983 and 2002.

Tributary Flow, Total Phosphorus, and Suspended Solids

The streams monitored on a monthly basis in the Phase I Study included Glen, Dunham, Onekama, and Schimke Creeks, which had respective average flows of 1.2, 1.6, 3.2, and 17.8 cubic feet per second (cfs.) at the outlet. Eleven additional streams, monitored at three separate times during the Phase I Study, had flows ranging from 1 to 3 cfs. All streams were considered relatively high quality with steady base flow throughout the year.

Stream flow, total phosphorus, and suspended solids were measured in Glen, Dunham, Onekama, and Schimke creeks during base flow and following wet weather events to determine annual variations. Glen and Dunham Creeks show similar patterns throughout the year as well as during storm flow conditions. Both have forested or vegetated watersheds that reduce erosion and surface runoff, especially during storm events. Although both showed normal increases in flow, suspended solids, and total phosphorus during spring and fall, the increases were relatively small. Even during storm events these two streams showed little increase in suspended solids or flow, but total phosphorus did increase. The increase in total phosphorus was believed to be primarily the result of direct input of phosphorus from precipitation.

Onekama and Schimke Creeks exhibited different patterns. The Onekama Creek watershed consists of a residential area within the Village of Onekama and has the next highest discharge after Schimke and Hansen Creeks (3.2 cfs.). The relationship between suspended solids and total phosphorus was strongly associated in Onekama Creek. Every time suspended solids increased, so did total phosphorus, but this was not always associated with an increase in flow. This implies that loading of phosphorus was coming from surface runoff from residential lawns and streets and is carried with sediment load. Other than during storm events, Onekama Creek exhibited relatively low concentrations of phosphorus and suspended solids for a stream that flows through a residential area.

Schimke Creek and its subwatershed are unique in the larger Portage Lake watershed because this subwatershed is by far the largest and the least vegetated/forested with the most agricultural activities. The creek itself has the highest flow (average 17.8 cfs.). However, excluding the spring high runoff period and storm events, this creek still maintained relatively low concentrations of phosphorus and suspended solids. During storm events phosphorus, suspended solids, and flow significantly increased.

A summary of annual average total phosphorus, suspended solids, and flow for Dunham, Glen, Onekama, and Schimke Creeks can be found in Exhibit 41.

EXHIBIT 41
Portage Lake Tributary Water Quality Monitoring Data, 1991–1992

Tributary	Average total phosphorus (ug/L)	Average suspended solids (mg/L)	Average flow (cfs.)
Dunham Creek	17.8	6.7	1.6
Glen Creek	20.0	6.7	1.2
Onekama Creek	25.3	10.8	3.2
Schimke Creek	37.5	37.0	17.8

SOURCE: SEG, 1993.

Biological Data

Fish

Based upon fisheries surveys conducted periodically over the last 30 years, Portage Lake supports a wide range of naturally reproducing, resident coolwater[7] and warmwater fish populations, including largemouth and smallmouth bass, northern pike, yellow perch, black crappie, rock bass, hybrid sunfish, bluegill, and pumpkinseed. With the support of an annual stocking program, Portage Lake also has a popular year-round walleye fishery and a seasonally important brown trout, coho, and Chinook fishery. Many of the tributary streams support naturally reproducing brook trout populations and at least one supports a naturally reproducing brown trout population.

The fish survey data from 1999 indicate that resident fish populations are generally in good condition with growth rates that approximate or exceed statewide averages for the same species. The MDNR fishery management objectives emphasize the need to protect the remaining undisturbed shoreline areas as spawning, nursery, and foraging areas for currently naturally reproducing game and forage fish populations. They also emphasize the need to protect the coldwater fishery habitat of tributary streams, citing past developments that have destroyed spawning habitat for trout and salmon.

Portage Lake Fish Populations and Management

The last intensive survey of the fisheries of Portage Lake was completed in June of 1999 and reported in the MDNR *Status of the Fishery Resourc*e report (2000). The following summary was prepared using information excerpted from this report.

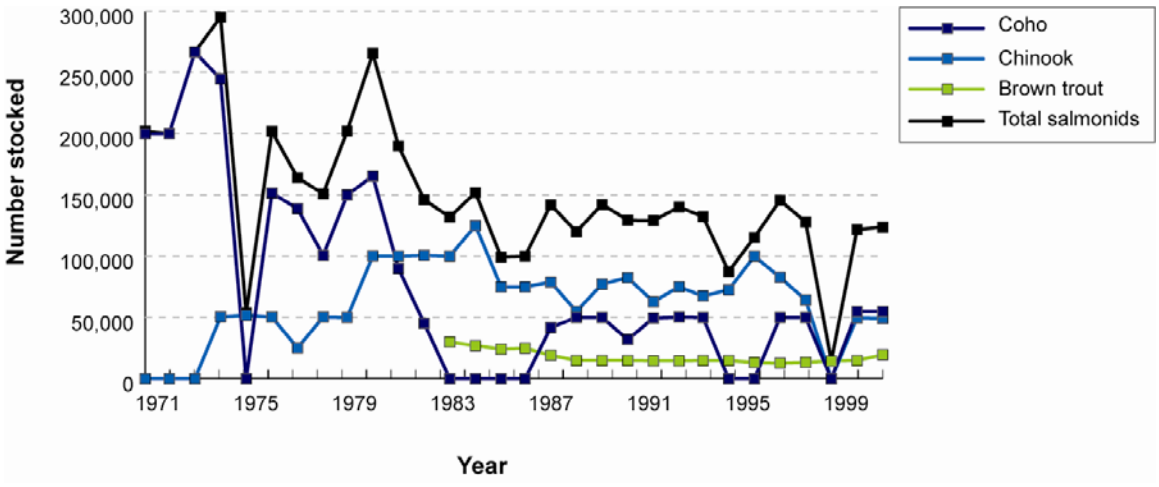
Very little fisheries management occurred on Portage Lake prior to the 1970s. MDNR records indicate that smallmouth bass, bluegill, and rainbow trout were stocked in the lake in the late 1920s and early 1930s, with little evidence of an enhanced fishery. In the 1950s, 70 brush shelters were placed in the lake in a then-popular effort designed to enhance fishery habitat and concentrate fish to improve angling success.

[7] Walleye, northern pike, muskellunge, yellow perch, white suckers, crappie and other fish species that thrive in temperatures that range from 65–70^{o}F.

Because of its open connection to Lake Michigan through the 400-foot-wide, 12-foot-deep Portage Lake Channel, Great Lakes fish populations of yellow perch, cisco, rainbow smelt, round whitefish (menominee), lake whitefish, lake trout, and other Great Lakes species may, under certain wind and temperature conditions, be present in Portage Lake supplementing resident populations. In addition to the resident coolwater and warmwater game fish species, non-game and forage species are also common in Portage Lake. These include bowfin, common carp, yellow and brown bullhead, several species of suckers, alewife, and banded killifish, as well as a variety of other small forage species such as shiners. The fish survey data from 1999 indicated that resident fish populations were generally in good condition with growth rates that approximated or exceeded statewide averages for the same species. Fall walleye recruitment assessments conducted by the Little River Band of Ottawa Indians in 2005 and 2006 indicated average walleye growth rates similar to state averages (LRBOI 2005 and 2006).

Beginning in 1971, Portage Lake has been intensively managed with the annual stocking of trout and salmon, primarily intended to support a Great Lakes fishery in Lake Michigan in the proximity of the Portage Lake Channel. Stocking rates were as high as 300,000 coho (yearlings) and Chinook (fingerlings) in 1974. However, consistent with the overall management goal of reducing stocked predators in Lake Michigan to match available forage, the number of stocked fish was reduced to a total of 100,000 to 200,000 each year between 1980 and 2000; the stocked species during this period included a combination of coho, Chinook, and brown trout (fingerlings and yearlings), as shown in Exhibit 42. Since 1987 fingerling walleye have been stocked annually to support a resident fishery in Portage Lake.

EXHIBIT 42
Portage Lake Trout and Salmon Stocking 1971–2000



SOURCE: Public Sector Consultants Inc., 2007, using data from MDNR, 2000.

The fishery management target established in 2000 called for an annual stocking of Portage Lake with 50,000 coho, 50,000 Chinook, and 15,000 brown trout to maintain a Lake Michigan fishery near the Portage Lake Channel as well as provide a seasonal salmon and trout fishery in Portage Lake itself. In addition, the target included the

stocking of approximately 15,000 walleye fingerlings each year. Lake trout were stocked in Portage Lake once in 1989 (157,000), but have not been planted since.

It should be noted that statewide, Great Lakes trout and salmon stocking rates have been significantly reduced since 2000 because of food web disruptions involving benthic (bottom-dwelling) organisms and an associated decrease in available forage fish in Lake Michigan and Lake Huron. The mix of species and number of trout and salmon stocked in Portage Lake have been adjusted accordingly. Since 2000 approximately 100,000 brown trout have been stocked in Portage Lake through 2007, or an average 16,000 per year. The last Chinook salmon stocking in Portage Lake was in 2005 and from 2001 through 2005 approximately 50,000 Chinook were planted in the lake each year. Coho were stocked from 2001 through 2006 at an annual rate of approximately 50,000 per year. In addition to efforts to reduce the number of predator fish planted to recognize the declining forage base in Lake Michigan, Coho plants in Portage Lake were further reduced due to MDNR budget reductions. Walleye stocking has continued since 2000 with plants of over 50,000 spring fingerlings in 2001, 2002, and 2003. The last stocking of walleye in Portage Lake occurred in 2006, when approximately 58,000 were planted.

In 2007, the MDNR temporarily suspended stocking certain warmwater and coolwater fish species produced from eggs taken from wild fish as a precautionary measure to control the spread of viral hemorrhagic septicemia (VHS), a recently discovered viral disease found in several of the Great Lakes and some inland lakes that has caused massive die-offs of various species The MDNR's decision to resume planting of walleye in Portage Lake will depend upon research now under way to determine the location of species infected with VHS, transmission mechanisms, and potential methods for disinfection at rearing facilities. The implications of VHS for the future of the fisheries of Portage Lake are discussed further in the Invasive Species section of this report.

The overall fisheries management objectives for Portage Lake currently are to maintain a mixed coolwater/warmwater resident fishery supplemented by the stocking of walleye fingerlings. The MDNR has indicated that salmon plants and natural reproduction in other locations are expected to support the Lake Michigan fishery near the Portage Lake Channel and that no future salmon plants are planned for Portage Lake. Limited natural reproduction in tributaries and straying from other planting sites are expected to continue to provide a limited fall salmon fishery in Portage Lake. The MDNR's future fisheries management plans still include annual stocking of brown trout in Portage Lake. The objectives assume that the intact littoral zone and shoreline habitat as well as remaining contiguous wetlands in Portage Lake will be protected, and that natural reproduction and recruitment of other resident game and forage species will be adequate to sustain fishable populations.

Tributary Fisheries and Habitat

The MDNR fishery report also discussed a 1966 fish eletroshocking survey of tributary streams conducted by the Fisheries Division of the Michigan Department of Conservation (now the MDNR) and a 1987 survey by W. Creel of the MDNR Surface Water Quality Division (now housed in the MDEQ). The 1966 study indicated that the Dare, Glen, Hansen, McCormick, McGowan's, and Schimke tributaries to Portage Lake were

coldwater trout streams with brook trout and that brown trout were also present in Schimke Creek. Evidence in the 1987 survey of fish populations indicated that some limited coho reproduction was occurring in McGowan's Creek. Based upon the presence of brook trout, it is expected that limited salmon and steelhead reproduction may occur in most of the larger tributaries to Portage Lake. Another study mentioned in the report, conducted in 1988 by B. Sayles of the MDNR Surface Water Quality Division, indicated that alterations associated with the development of the Links of Portage Golf Course may have eliminated habitat that supported trout and salmon reproduction and recruitment in McGowan's Creek.

Biological integrity and physical habitat conditions of selected sections of McGowan's and Schimke Creeks were assessed by staff of the Surface Water Assessment Section of the MDEQ Water Bureau in 2003 (MDEQ 2007d). The macroinvertebrate community was sampled at two sites including Station 1 (McGowan's Creek and Portage Point Road), which was rated as "excellent," and Station 4 (Schimke Creek and M-22), rated as "acceptable." Habitat quality was assessed at four locations. Habitat quality for Station 1 (McGowan's Creek) scored in the "excellent" range while the three stations on Schimke Creek scored "good." Water chemistry samples were collected at five stations. Concentrations of ions and metals in McGowan's and Schimke Creeks typically varied from less than quantifiable levels to low concentrations. Low concentrations of nutrients were also present, with the exception of elevated concentrations of nitrate/nitrite-nitrogen, suggesting land use influences on water chemistry. According to the macroinvertebrate, habitat, and water chemistry results, water quality standards were being met at all stations sampled in both McGowan's and Schimke Creeks.

Surveys conducted periodically between 1967 and 2007 by the U.S. Fish and Wildlife Service for sea lamprey were consistent with the MDNR fishery resource report (2000) findings of brook and brown trout in Portage Lake tributaries, and neither adult nor larval sea lamprey were ever documented. Various U.S. Fish and Wildlife Service (USFWS) surveys note that good spawning gravel is present in Dare, Dunham, Hansen, McCormick, McGowan's, and Schimke Creeks and that some spawning gravel is present in Erikson Creek (USFWS 2007).

Smelt and many other non-salmonid[8] species from Lake Michigan and Portage Lake use the tributaries as spawning and nursery areas. The MDNR fishery resource report (2000) emphasizes that the protection of the aquatic habitats in Portage Lake tributaries is critical to (1) maintaining stream populations of brook trout, (2) the general health of the Portage Lake fisheries, and (3) the stability of the nearby Lake Michigan ecosystem. The report also expresses concern that efforts to chemically treat aquatic weeds in Portage Lake and to "stabilize shorelines" could further limit littoral zone habitat essential to natural reproduction, growth, and survival of existing fish populations.

Fish and Sediment Contaminant Monitoring

Portage Lake fish were tested by the state for a wide range of organic chemical and heavy metal contaminants in 1990 and again in 2004. Only polychlorinated biphenyls (PCBs) and mercury (Hg) were detected at levels of concern to human consumption of fish from

[8] A family of soft-rayed fishes including the trouts, salmons, whitefishes, and graylings.

the lake. Between 1990 and 2004, PCB levels in fish from Portage Lake declined consistent with similar trends elsewhere in the state following controls on the use and disposal of this chlorinated hydrocarbon.

Based upon the most recent information, recommended consumption warnings related to mercury in fish from Portage Lake are limited to bass over 18 inches. In general, mercury levels in Portage Lake fish are lower than those commonly found in inland lakes within Michigan. While PCB levels in fish are expected to continue to decline, consumption warnings for northern pike over 30 inches, smallmouth bass over 18 inches, and carp over 26 inches are still recommended for persons consuming these species from Portage Lake, particularly for children and women of childbearing age.

The current publication (2007) from the state on fish consumption advisories for Portage Lake does not reflect the most recent testing results and recommendations from the 2004 fish contaminant monitoring. In general, except for carp, the fish consumption advisories for Portage Lake fish based upon 2004 testing are less restrictive than those in the current published advisory. A copy of the Michigan Department of Community Health (MDCH) Fish Consumption Advisory for 2007 is available online at: *http://www.michigan.gov/documents/FishAdvisory03_67354_7.pdf*. For fish species not listed and for Lake Michigan species the MDCH publication provides statewide consumption advisories.

Following the analyses of the 2004 fish contaminant monitoring results, the MDEQ concluded that the sources of mercury and PCB contamination were due to either atmospheric deposition from sources outside of the watershed or the result of Lake Michigan fish entering Portage Lake from other locations. The MDEQ report recommended no further testing of contaminants in Portage Lake fish (MDEQ 2007e).

Plant and Algal Inventories

An increase in the abundance of rooted aquatic plants and algal blooms that interfere with water uses is often the first sign observed by boaters, anglers, and swimmers that a problem with over-enrichment may be occurring. In 1991, both algal and rooted aquatic plant growth were measured.

Cladophora

In response to local concerns about potential water quality degradation in Portage Lake due to the increased use of septic systems around the lake, a preliminary plan was developed in 1976 to provide sanitary sewers in all or a portion of the area surrounding the lake. After reviewing the plan and its updates in 1981, the Northwest Regional Planning Commission expressed concerns echoed by local residents that the plan lacked documentation of pollution problems that would necessitate a perimeter sanitary sewer system and proposed a study subsequently implemented in 1983 with support from the USEPA.

The *1983 Water Quality of Portage Lake, A Shoreline Algal Survey* (NWMRPDC 1983) focused on the use of *Cladophora*, filamentous green algae, as an indicator algal species in combination with models to evaluate phosphorus loadings and sources. Phosphorus was determined to be a limiting factor in the productivity of lakes in the area and

excessive phosphorus loadings from septic systems or other sources could lead to eutrophication (an abundant accumulation of nutrients that support dense growth of algae and other organisms, the decay of which depletes waters of oxygen), and associated water quality problems. Based on work in other areas, *Cladophora* abundance in shoreline areas was used as an indicator of excessive phosphorus loading and potential pollution from shoreline septic systems.

The 1983 report concluded that sources of phosphorus related to septic tank/tile fields represented less than 4 percent of the total phosphorus loading to Portage Lake and that the total loading for the lake at the time of the study was below critical levels. Only one area on the shoreline was found to have excessive *Cladophora* growths attributable to the presence of septic leaching—the shoreline area adjacent to the Portage Point Inn. Phosphorus loading from runoff and atmospheric deposition were estimated to contribute more than 96 percent of the total phosphorus inputs to the lake. The report recommended periodic sampling to detect any changes that might occur in Portage Lake related to pollution from septic tank/tile field failures.

The Phase I study reported visual observations made of *Cladophora* in August of 1991. The length of filament growth within one square foot was used to create a Cladophora Status Index (CSI). Of the 47 observations of *Cladophora* growth, 22 were attributed to possible human uses associated with lawn fertilization and septic systems. Seven of the observed sites with the highest CSI were clustered on the south side of the lake adjacent to high residential development and attributed to possible septic system drainage, the highest of which was in the lake at the Portage Point Inn site. The other 15 CSI sites associated with human activity were attributed to fertilizer use on riparian lawns and lakeshore disposal of lawn waste. All sites with a suspiciously high CSI were located on the south side and west end of Portage Lake where sanitary sewers were not available.

Rooted Aquatic Plant Survey

The Phase I Study of rooted aquatic plants (macrophytes) in Portage Lake identified six major zones where macrophyte growth was most extensive. The areas were mapped and correlated to a large extent to lake contour levels between 10 and 15 feet. Macrophyte growth was highest in areas protected from wind and wave action with suitable organic, bottom substrate. The dominant species in each zone were identified and Eurasian watermilfoil and water celery were cited as dominant in certain zones during the months of August and September. The Phase I Study indicated that while the growth of these two species was widespread, their abundance in 1991 did not appear to be impairing human activities on the lake (see below).

Aquatic Nuisance Organisms

Portage Lake is particularly vulnerable to the introduction of exotic species. The open channel to Lake Michigan allows any exotic species in the Great Lakes to eventually find its way into Portage Lake and establish a population if appropriate habitat exists. Because it is a destination harbor for many Great Lakes anglers, boats from throughout Michigan, and even nearby states, routinely launch in Portage Lake and, as a result, potentially transport to Portage Lake exotic species that have attached to their boats or trailers.

Four exotic species are of particular concern in Portage Lake due to their known presence and their potential impact on existing uses. All four—zebra mussels (*Dreissena polymorpha*), Eurasian milfoil (*Myriophyllum spicatum L.*), purple loosestrife (*Lythrum salicaria L.*) and non-native varieties of the common reed (*Phragmites australis)*—are highly invasive and in other lakes have caused significant changes in fish and wildlife populations and other surface water uses. An exotic virus that causes viral hemorrhagic septicemia (VHS), a viral fish disease, has also had an indirect impact on the fisheries of Portage Lake and deserves special note. A brief overview of these invaders is provided below.

Because of its direct access to the Great Lakes, Portage Lake is also vulnerable to other exotic, invasive species like quagga mussels (*Dreissena rostriformis bugensis*, similar to the zebra mussel*)* and round gobies (*Neogobius melanostomus*), along with several other exotic plant and animal species now found in Lake Michigan. However, the presence and abundance of these species in Portage Lake has not been documented, nor are their potential effects on inland lakes well understood.

Eurasian Watermilfoil

Eurasian watermilfoil (*Myriophyllum spicatum*) was accidentally introduced to North America from Europe. Spread westward into inland lakes primarily by boats and also by water birds, it reached Midwestern states between the 1950s and 1980s. In nutrient-rich lakes it can form thick underwater stands of tangled stems and vast mats of vegetation at the water's surface. In shallow areas the plant can interfere with water recreation such as boating, fishing, and swimming. The plant's floating canopy can also crowd out important native water plants.

Eurasian Watermilfoil
Photo from Wisconsin DNR
http://dnr.wi.gov/invasives/pubs/EWMCard.pdf

A key factor in the plant's success is its ability to reproduce through stem fragmentation and underground runners. A single segment of stem and leaves can take root and form a new colony. Milfoil may become entangled in boat propellers and may wrap around other external parts of the boat. Stems can become lodged among any watercraft apparatus or sports equipment that moves through the water, including boat trailers. Fragments clinging to boats and trailers can spread the plant from lake to lake. The mechanical clearing of weed beds for beaches, docks, and landings creates thousands of new stem fragments. Removing native vegetation creates perfect habitat for invading Eurasian watermilfoil.

This plant has difficulty becoming established in lakes with healthy populations of native plants. In some lakes it appears to coexist with native flora and has little impact on fish and other aquatic animals. In some situations, physical removal of small areas of milfoil has been effective. Once it becomes well established, however, more aggressive chemical or biological controls may be the only effective means to reduce its abundance in order to restore impaired surface uses.

Chemical control through the use of selective herbicides has been used in many Michigan lakes under permits from the MDEQ. Concerns with the application of chemicals and the potential impacts on other aquatic organisms have pushed research into the use of a small aquatic weevil (*Euhrychiopsis lecontei*) that feeds directly on milfoil, causing subsequent bacterial infection that can kill the plant. The effectiveness of this type of biological control is still undergoing investigation (Minnesota Sea Grant 2006).

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria L.*) is a plant native to Europe and was most likely introduced in North America from ballast materials used in ships during the early1800s. Viable seeds in the ballast deposited on the shoreline of eastern North America established the species on the Eastern Seaboard of the United States, where enterprising horticulturalists began distributing the plant for its flowers in perennial gardens. It eventually spread to 34 states by 1985 and is found throughout Michigan.

Purple Loosestrife
Photo from USEPA Great Lakes National Program Office
http://www.epa.gov/glnpo/image/viz_iss4.html

Due to its aggressive growth in wetland ecosystems, purple loosestrife can quickly convert areas to virtual monocultures displacing native plant species and associated wildlife populations that depend upon diverse wetlands habitats. Because of the concerns related to this exotic species and its apparent increasing abundance throughout the state, Michigan has passed laws that prohibit the sale and distribution of this species.

Various means have been attempted to control the abundance of purple loosestrife, including hand pulling, periodic flooding, fire, chemical treatment, and biological controls. Because of the expense and habitat disruption associated with other control mechanisms, biological controls were researched resulting in USDA approval of three insects for introduction to control purple loosestrife. The MDNR began the first releases of leaf beetles and root weevils to control purple loosestrife in 1994 in Saginaw Bay. Since that time numerous locations in the state have received similar introductions and evaluations are under way to determine the effectiveness of biological controls of purple loosestrife (Michigan Sea Grant 1997).

The Common Reed

While the common reed, *phragmites*, is a plant native to Michigan, it is relatively uncommon. A European variant of this species, though, has become established in Michigan and elsewhere in the United States. This variety of reed is very aggressive and, like purple loosestrife, has spread to many wetlands in the Great Lakes and inland waters. The native and non-native variants are difficult to distinguish from one another. A key to identifying the European plant can be found at: *http://www.invasiveplants.net /phragmites/phrag/morph.htm*.

Phragmites
Photo from MDEQ,
http://michigan.gov/documents/deq/deq-ogl-Guide-Phragmites_204659_7.pdf

Phragmites plants range from 6 to 15 feet in height with nearly 80 percent of the plant mass contained in the root mass below ground up to six feet in depth. In the summer its flat gray-green leaves are 2.0 to 2.5 inches wide and 8 to 15 inches long in an alternate pattern on the stem. It has distinctive purple-brown seed heads that appear in late July. These feathery plumes form at the end of the stalks and are up to 20 inches long. While each plant can produce up to 2,000 seeds each year, it normally spreads by rhizome fragments. Left unchecked, the aggressive variant of phragmites can spread rapidly, pushing out native wetlands species and reducing available fish and wildlife habitat in nearshore wetlands.

The deep root system makes control of phragmites difficult. Only chemical control has been successful, followed by cutting, mowing, and/or controlled burning. No biological control is currently available. The application of chemical control agents requires a state permit. Mowing and burning are likely to require state and/or local permits as well (MDEQ 2007c).

Zebra Mussels

Zebra mussels were introduced to the Great Lakes and first observed in the mid-1980s in Lake St. Clair. They are a European mollusk most likely transported to North America in ballast water from transoceanic ships. By 2000, zebra mussels had spread throughout the Great Lakes basin, the Mississippi drainage, and many of the lakes and streams in the eastern United States. This species continues to move south and westward; it is now found in 20 states and two Canadian provinces, as it is easily transported on recreational boats and trailers that have been largely responsible for its wide distribution since the species was first observed in the Great Lakes. In addition to serious water intake fouling, zebra mussels have caused

Zebra Mussels
Photo from Minnesota DNR,
http://www.dnr.state.mn.us/invasives/aquaticanimals/zebramussel/index.html

significant ecosystem changes in the Great Lakes and in inland lakes where they have become abundant.

Zebra mussels feed on phytoplankton (free-floating algae), and in massive numbers deplete this important food source of native invertebrate species, disrupting the flow of nutrient energy required to support forage and predator fish species higher in the food chain. Zebra mussel abundance has been so great in many areas that the clarity of the water has been noticeably increased by their removal of phytoplankton, and rooted aquatic plant species have increased in abundance due to increased light penetration. Some of the increased clarity measured in Portage Lake beginning in 2003 may in fact be due to the invasion and colonization of this species.

While zebra mussels are present in large number in Portage Lake, the impact of this species on resident fish populations is not known. Although some native species, and some exotic fish species introduced into the Great Lakes, have been found to feed on zebra mussels, the abundance of zebra mussels does not appear to be controlled by this predation. There are no effective means to control the abundance of zebra mussels once they become established in a lake system. Strategies to prevent their transport from one lake to another on boats and trailers have had only limited success. Recent information collected in Lake Michigan and elsewhere in the Great Lakes indicates that zebra mussels are being replaced in some areas by another invasive aquatic mollusk, the quagga mussel, which is similar in size and shape to the zebra mussel. Adults of both species are between one quarter and one half inch long and have D-shaped shells. These are the only freshwater mussels that can attach to objects (Wisconsin Sea Grant 2005).

Viral Hemorrhagic Septicemia (VHS)

A recent exotic organism, viral hemorrhagic septicemia virus (VHSv), has already had an indirect impact on the fisheries of Portage Lake and deserves special note. VHSv. causes viral hemorrhagic septicemia (VHS); this disease was confirmed in 2003 in muskellunge taken in Lake St. Clair. Since that time it has been observed in coolwater and warmwater species in Lakes Ontario, Huron, Michigan, and Erie and in connecting Great Lakes waters. VHS has also been documented in a few inland lakes in Michigan, New York, and Wisconsin. While not a human pathogen, VHS has been associated with significant massive fish die-offs for a number of species in the Great Lakes region and elsewhere. Infected fish often exhibit hemorrhaging in the skin in large red patches, particularly on the sides and anterior portion of the head. The genetic fingerprint of the virus in the Great Lakes linked it to a variant previously seen in salmon in the Canadian Maritime provinces. It is believed that this virus was brought into the Great Lakes region through the discharge of ballast water from oceangoing freighters using the Great Lakes.

VHS Clinical Signs
Photo by Mohamed Faisal, Michigan State University, 2007

Because the presence of VHS is relatively new, very little information is available on species potentially affected, species that may serve as carries of the disease, and how infections spread from one area to another. While extensive research is under way to answer questions about this new virus, the MDNR, along with similar fish management agencies in the Great Lakes, has adopted a precautionary approach to taking certain species from the wild for reproduction and hatchery facilities. Conversely, walleye stocking in Portage Lake has been temporarily suspended pending the results of investigations of the presence of VHS to determine how the virus is transmitted and what steps can be taken in hatchery operations to prevent transmission (Whelan 2007).

Uses, Threats, Sources, Causes

A comprehensive watershed plan examines whether or not waterbodies in the watershed meet designated, protected uses specifically identified in water pollution control statutes and promulgated rules, and evaluates compliance with water quality standards adopted to protect those uses. It also identifies desired uses within the watershed.

DESIGNATED, PROTECTED USES

Under the Michigan water pollution control statute (Natural Resources and Environmental Protection Act, Public Act 451 of 1994), discharges to surface waters are unlawful if they may become injurious to

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

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

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

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

In addition to the above protected uses, additional protected uses include the following if identified by the state:

- Coldwater lakes, trout lakes, and trout streams
- Migratory routes for anadromous salmonids (a family of soft-rayed fishes including the trouts, salmons, whitefishes, and graylings, that live in lake environments but spawn in rivers and streams)
- Public water supply intakes

In the case of the Portage Lake, watershed *migratory routes for anadromous salmonids* and designated *trout streams* would apply as additional protected uses. Portage Lake is not a designated cold water or trout lake, and there are no surface water public water supply intakes in the watershed.

Groundwater is also protected under Michigan law and rules. Under state regulations groundwater discharges must essentially meet a non-degradation standard to protect existing or potential uses such as domestic water supplies, irrigation, stock watering, etc. Groundwater flow to trout streams tributary to Portage Lake and to Portage Lake itself is critical to maintaining existing protected uses. New water withdrawal laws in Michigan provide significant measures to regulate groundwater and surface water uses intended to protect groundwater quantity, particularly where such withdrawals may impact trout streams.

EXISTING CONDITIONS COMPARED TO STATE STANDARDS

The Clean Water Act requires Michigan to prepare a biennial report on the quality of its water resources. This report, called the Section 303(d) list, constitutes the principal means of conveying water quality protection/monitoring information to the USEPA and the U.S. Congress. The Section 303(d) list includes Michigan waterbodies that are not attaining one or more designated use and require the establishment of total maximum daily loads (TMDLs) to meet and maintain water quality standards. The Portage Lake watershed is attaining its designated uses currently. A summary of this information can be found in Exhibits 43 and 44. Exhibit 43 details (1) **existing** activities and uses; (2) the categories of designated, protected uses under statute and regulations; (3) the water quality standards that apply to each designated, protected use; and (4) the existing conditions compared to the water quality standard, including the date for the latest information available. Exhibit 44 details (1) **potential future** activities and uses; (2) the categories of designated, protected uses under statute and regulations; and existing conditions.

EXHIBIT 43

Portage Lake Watershed State Designated Uses for Existing Uses, Associated, Applicable Water Quality Standards, and Existing Conditions

Designated, protected uses (Part 31 of Act 451, §324.3109)	Water quality standards (MDEQ 2006)	Existing activities and uses[1]	Existing condition compared to standard[2] (year of most recent data collection)
Total body recreational contact	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	Swimming, SCUBA, snorkeling, water skiing, tubing, kneeboarding, and related full body contact activities	Meets standard based on historical data and tests at major beach areas (2007)
Partial body recreational contact	Counts of 1,000 or less for *E. coli* counts per 100 ml	Canoeing, kayaking, cruising, sailing, and related boating activities	Meets standard based on historical data and tests at major beach areas (2007)
Fish consumption	Fish consumption advisory trigger levels for toxic heavy metals and organic compounds	Fishing	Fish consumption warnings for Portage Lake are limited to PCBs and mercury in certain species due to sources outside of watershed (2007)[3]
Warmwater fish populations and seasonal migratory pathways for anadromous trout and salmon (Portage Lake)	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.		Meets standard based upon historical data and recent summer testing for dissolved oxygen during summer stratification (2007)
Coldwater fish populations (tributary streams)	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		Benthos sampling indicates diverse, stable coldwater bottom organisms (2003)[4]. Presence of trout and salmon in tributary streams would indirectly indicate that standard is being met (2007). No direct data to confirm standard.

Designated, protected uses (Part 31 of Act 451, §324.3109)	Water quality standards (MDEQ 2006)	Existing activities and uses[1]	Existing condition compared to standard[2] (year of most recent data collection)
Protection of wild animals, birds, fish, aquatic life, or plants, and of their growth or propagation	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.)	Hunting, wildlife observation, ecosystem protection, plant and animal diversity	pH (1992), ammonia (1992), phosphorus (2007), physical properties all within acceptable ranges for mesotrophic lakes (1992). No toxic substances reported above levels of concern (1992). No nuisance algae blooms reported, some concerns over excessive weed growth and invasive species (1992–2007).
Navigation	No interference or increased cost to navigation	Access to and from Lake Michigan through Portage Lake Channel	Water quality standards for other protected uses sufficient to protect this designated use

SOURCE: Public Sector Consultants Inc., 2007.
[1] From cited, previous studies, and focus groups, public meetings, and telephone surveys conducted during 2007.
[2] From cited previous studies and information recently provided by Onekama Township and MDNR Fisheries Division.
[3] See Fish Consumption Advisory section below for species and sizes covered by recommended fish consumption advisories for Portage Lake
[4] From cited, previous studies from MDEQ Water Bureau, 2007d.

EXHIBIT 44

Portage Lake Watershed State Designated Uses for Potential Future Use, Likelihood of Future Use, and Existing Condition

Designated, protected uses (Part 31 of Act 451, §324.3109)	Potential future use	Likelihood that designated/surface water use may be made in the future	Ability of existing water quality to support use
Public water supply	New public water supplies from surface waters	Adequate quality and quantity of groundwater in watershed for expected domestic water demand. Surface water sources other than Portage Lake are small. Municipal supply, if from surface water, most likely would be taken from Lake Michigan.	Drinking water quality standards higher than existing water quality and further treatment would be required to meet state drinking water requirements.
Industrial water supply	New industrial/commercial surface water supplies	Future demand unknown, but likely major industrial use would be either from groundwater or Lake Michigan.	Most industrial/commercial uses could be accommodated by existing water quality.
Agriculture	New agricultural surface water uses (possible existing, small quantities used for lawn and garden watering by riparians)	Tributary streams too small to support significant agricultural withdrawal and there are no expected significant agricultural uses riparian to Portage Lake.	Agricultural uses could be supported by existing water quality.

SOURCE: Public Sector Consultants Inc., 2007.

Full and Partial Body Contact

Five popular swimming areas on Portage Lake were sampled on two occasions during 2007 to verify that bacteria levels as measured by the presence of *E. coli* still meet state standards for both full and partial body contact. All results indicated that water quality standards are being met. Historical sampling in Portage Lake has on occasion shown that the bacteria levels have at times exceeded state standards. Many of the problem areas were addressed, however, when the sanitary sewer system was constructed and operated for homes and businesses within the Village of Onekama in the early 1990s. Further testing for *E. coli* would be prudent to assure that the water quality standards for bacteria associated with human and animal waste are being met throughout the year and in locations where potential sources are concentrated near the shoreline of Portage Lake and tributary streams.

Fish Consumption Advisories

According to testing conducted by the state, only polychlorinated biphenyls (PCBs) and mercury (Hg) are being detected at levels of concern for human consumption of fish from the lake (MDEQ 2007e). PCB levels in fish from Portage Lake are declining, consistent with similar trends elsewhere in the state following controls on the use and disposal of this chlorinated hydrocarbon. Mercury levels in Portage Lake fish are lower than those commonly found in inland lakes within Michigan. The source of mercury and PCB contamination is likely atmospheric deposition from sources outside of the watershed or the result of Lake Michigan fish that had accumulated contaminants from other locations entering Portage Lake. (For more detail on fish contaminants in Portage Lake, please see pages 58–59 of this report.)

All Other Numerical and Narrative Water Quality Standards

Historical and recent test results from Portage Lake and tributary streams do not indicate that there are any current exceedances of state water quality numeric or narrative standards intended to protect designated uses. Data collected in 2006 and 2007 by Onekama high school for dissolved oxygen, chlorophyll *a*, water transparency, and phosphorus show no significant change in the productivity level of Portage Lake, and the information collected is consistent with a mesotrophic lake. Additional testing of DO may be warranted to determine whether the state standard is being met throughout a 24-hour period and whether oxygen depletion at the deeper portions of the lake during stratification are existing for a longer period of time. Further monitoring of both exotic plant species and algae may be appropriate to determine whether further actions are needed to protect existing uses of the lake.

DESIRED USES

Desired uses of the watershed are those values identified by the community for protection. These uses expand beyond the uses specifically protected under surface water pollution-control laws and regulations that could be incorporated as part of the watershed plan. In the Portage Lake watershed, the following desired uses were identified by stakeholders through interviews, focus groups, and public meetings:

- Maintain existing undeveloped shoreline habitat

- Preserve diverse upland ecotypes
- Maintain scenic vistas
- Preserve examples of historic agricultural practices
- Identify, protect, and preserve culturally and/or historically significant buildings and sites

These uses are listed in Exhibit 45, along with the location and purpose of the use, existing protections and programs, and potential additional protection and preservation approaches that can be expanded and/or documented with more detail as specific goals, objectives, and actions are identified as priorities.

EXHIBIT 45

Additional Desired Uses Not Protected Under Water Quality Regulations and Location, Purpose, and Additional Protections under Consideration to Preserve and Protect These Uses

Desired use	Location	Purpose	Applicable laws/regulations/ programs	Potential additional protections
Maintain existing undeveloped shoreline habitat	Riparian properties adjacent to Portage Lake and major tributaries	Preserve critical fish habitat, provide filter for land-based storm water–runoff, maintain biological diversity/stability	State wetlands and inland lakes and streams laws and regulations	Education of owners, fee purchase, acquisition of conservation easements, local ordinance adoption related to new development, control of invasive plant species
Preserve diverse upland ecotypes	Need to identify	Maintain ecological diversity; habitat for endangered, rare, and threatened species; study sites for understanding natural ecological functions/processes	State/federal endangered and threatened species laws; state/ local property tax exemption status for certain properties and land conservancy acquisitions/ easements	Education of owners, fee purchase, acquisition of conservation easements, local ordinance adopted related to new development
Maintain scenic vistas	Selected areas or zones	Continue to provide aesthetically pleasing landscape views for residents and visitors to the area	State and local highway rest areas, picnic areas and scenic turnouts, local parks, private land conservancies	Public information on scenic road touring, information/education to landowners, promotion with local and state highway departments
Preserve examples of historic agricultural practices	Selected areas or zones	Maintain examples of cultural heritage of region for the education/enrichment of residents and visitors	MDA Centennial Farm Recognition Program, Farmland Preservation Act, land conservancy programs, accommodation of local zoning requirements	Promotion of locally grown agricultural products through markets days, farm roadside products tour information, featuring of locally produced food at nearby restaurants and markets
Identify, protect and preserve culturally and/or historically significant buildings and sites	Selected areas or zones	Increase awareness and understanding of Native American occupation and use of the area in pre-settlement period; maintain and develop historical examples of significant buildings and locations of interest to area residents and visitors	Need to identify	Partnering with Little River Band of Ottawa Indians and local historical groups to identify, interpret, and map sites of significance

SOURCE: Public Sector Consultants Inc., 2007.

MOST LIKELY THREATS TO PROTECTED USES IN THE FUTURE

In many watershed plans in Michigan and elsewhere in the country there is a focus on restoration of protected use impairments due to water pollution sources, as indicated by non-attainment of water quality standards. In the Portage Lake watershed, water quality standards are being met based upon the information available, and additional monitoring is planned to fill remaining information gaps. The focus of this watershed plan is thus to protect the existing high water quality of the lake and associated protected uses by closely monitoring priority threats to address sources of detected problems *before* they cause significant impairments.

The last column of Exhibit 46 identifies such potential threats based on the review of available information both for the Portage Lake watershed and through the examination of information from other watersheds that have experienced water quality problems and impairment of protected uses. The Portage Lake stakeholders have the opportunity to prevent major impacts on existing uses rather than having to confront the often difficult and costly efforts to restore the quality of the environment after it has been degraded. Not all preventive measures are inexpensive and a case must be established for any costly prevention activities. This initial watershed plan is intended to identify actions that are justified based on current information and building a database so that any future recommendations can be established based on information that clearly demonstrates what further actions are needed to protect the uses valued by the watershed stakeholders.

EXHIBIT 46

Portage Lake Watershed Existing Uses and Associated Designated Protected Uses, Existing Conditions, Sources/Causes of Threat

Designated, protected uses (Part 31 of Act 451, §324.3109)	Existing condition compared to standard[1] (year of most recent data collection)	Most likely source and cause of threat to meeting standard in the future[2]
Total body recreational contact	Meets standard based on historical data and tests at major beach areas (2007)	Pathogens coming from failed septic systems, uncontrolled runoff from farm-raised animals, household pets, and waterfowl
Partial body recreational contact	Meets standard based on historical data and tests at major beach areas (2007)	Same as above
Fish consumption	Fish consumption warnings for Portage Lake are limited to PCBs and mercury in certain species due to sources outside of watershed (2007)[6]	Air deposition of toxic, bioaccumulative heavy metals and persistent organic compounds; potential, but undocumented, historical industrial releases contained in Portage Lake sediments
Warmwater fish populations and seasonal migratory pathways for anadromous trout and salmon (Portage Lake)	Meets standard based upon historical data and recent summer testing for DO during summer stratification (2007)	Over-enrichment due to septic tile field leachate, riparian lawn fertilization, storm water discharges, agricultural practices and resulting excessive plant and algal growth, decomposition, and oxygen consumption
Coldwater fish populations (tributary streams)	Presence of trout and salmon in tributary streams would indirectly indicate standard is being met; no direct data to confirm standard (2007)	Streamside development that would remove natural vegetative cover, large land use changes creating direct, polluted runoff to coldwater trout streams, bank erosion due to stream crossings and adjacent upland uses, riparian agricultural food and animal production
Protection of wild animals, birds, fish, aquatic life, or plants, and their growth or propagation	pH (1992), ammonia (1992), phosphorus (2007), physical properties all within acceptable ranges for mesotrophic lakes (1992). No toxic substances reported above levels of concern (1992). No nuisance algae blooms reported; some concerns over excessive weed growth and invasive species (1992–2007)	There are no known continuous, direct or indirect discharges resulting in violations of water quality standards designed to protect aquatic life and wildlife in Portage Lake and tributaries. However, accidental spills of hazardous substances related to improper storage or use and/or inadequate contingency plans related to transportation, storage, and use do pose a threat through storm drainage systems
Navigation	Water quality standards for other protected uses sufficient to protect this designated use	Unlikely, but potential increase is cost of Portage Lake Channel dredging due to presence of contaminants

SOURCE: Public Sector Consultants Inc., 2007.

[1] From cited previous studies, information recently provided by Onekama Township and MDNR Fisheries Division.

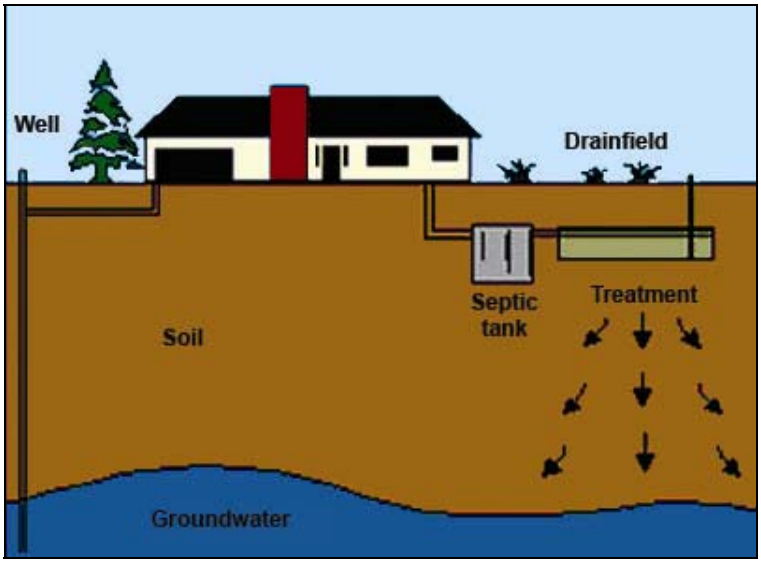
[2] Conclusions of this study by Public Sector Consultants Inc. endorsed by the Portage Lake Watershed Forever Technical Advisory Committee.

Public Health

Pathogens

While there are many potential sources of pathogens (bacteria) in the Portage Lake watershed, including storm water runoff and waterfowl, septic systems (on-site disposal systems or OSDSs) pose the largest threat. OSDSs provide a means of treating household waste in areas that do not have access to public sewers or where sewering is not feasible. They typically consist of two components: a septic tank designed to intercept and hold partially treated solids and a drainfield that disperses wastewater to surrounding soils (see Exhibit 47). OSDS effluent is the substance that passes through the tank to the drainfield and eventually filters through the soils. This effluent contains pathogens and nutrients (nitrogen and phosphorus) that are harmful to ground and surface waters when found in excessive amounts.

EXHIBIT 47
Typical Septic System



SOURCE: MSU, Institute for Water Research, 2007.

When properly designed, sited, constructed, and maintained, a conventional on-site septic system effectively reduces or eliminates most human health or environmental threats posed by pollutants during the course of its design life (typically 30 years). Previous studies cite that approximately 99 percent to 99.99 percent of fecal coliforms that pass through conventional septic systems are removed (USEPA 2002).

OSDSs fail to meet human health and water quality objectives for many reasons, including improper siting (too close to drinking water supply or water table), outdated and under-performing technologies, inadequate maintenance, and systems exceeding

design life[9] (USEPA 2002). Surface water may eventually be affected as groundwater seeps into adjacent streams, lakes, rivers, and wetlands. Surface waterbodies may also be directly affected if a nearby system fails and the effluent ponds on or just below the soil surface.

Septic systems fail at a rate that ranges between 10 and 20 percent each year (USEPA 2002). This means that of the 570 homes with septic systems in the watershed, about 114 may currently be failing, and the threat of failing systems will continue to increase. As the land use projection maps in the Watershed Description section suggest, demand to build homes along Portage Lake and other surface waters in the watershed will continue to increase. Residents will also continue the trend of converting existing waterfront part-time dwellings to permanent residences. Many of these homes were built with septic tanks/tile fields that were adequate for limited summer use but not for year-round residence. Small waterfront lots with a high water table and/or poor soil conditions are not well suited to septic systems in any case. When a cottage once used only a few weeks a year becomes a permanent home, the addition or increased use of automatic dishwashers, garbage disposals, and washing machines can overload the system. Systems will also age, exceeding their design life and increasing the failure rate.

Identifying and eliminating these possible failing septic systems will help control pathogenic bacterial contamination of ground and surface water supplies in the watershed from untreated wastewater discharges. The highest priority for protecting water users from potential human disease threats associated with human or animal waste is monitoring of the areas with relatively high-density development around the lake and adjacent to streams that are not currently served by a sanitary sewer system.

This includes virtually all of Portage Lake and the near lake outlets of significant tributary streams, with the exception of the area served by the Village of Onekama sanitary sewer system. The density, age, number of people served, size of the drainage field, soil type, depth of groundwater, and the waste streams entering septic tank/tile fields are all factors in determining the effectiveness of existing systems to prevent pathogens from entering surface waters.

The capacity of existing OSDSs to treat increased waste loads to control both pathogens and nutrients, particularly phosphorus, is limited. This plan calls for a series of iterative steps, starting with providing better information to property owners on the proper maintenance and use of OSDSs; systematic monitoring of *E. coli*, phosphorus, and nearshore algal growth; and advocacy for time-of-sale OSDS inspections to determine the effectiveness of existing systems and the need to repair/upgrade failed systems. These initial steps will provide the information needed over time to determine if and when a sanitary sewer system is needed for all or portions of the more densely developed areas adjacent to Portage Lake and tributary streams, in order to both ensure the protection of public health and reduce nutrient loadings to surface waters.

[9] Tanks and pipes buried in the ground can be expected to last 20 to 30 years before they begin to deteriorate and require repair or replacement. The soil itself does not "wear out," but its capacity to absorb and assimilate pollutants can become inadequate.

A secondary priority is to begin to monitor land uses that can contribute human or animal waste such as storm water discharges from the Village of Onekama and nonpoint runoff from agricultural animal operations.

Contaminants in Fish

Based upon state testing of contaminants in fish from Portage Lake in 1990 and again in 2004, air deposition from sources outside of the watershed represents the greatest threat to increases in contaminants found in Portage Lake fish (MDEQ 2007e). While PCB contaminant levels in fish have declined statewide following state and federal controls on the use and disposal of this industrial chemical, mercury levels have remained high. Support for regional efforts to control sources of mercury emissions, particularly related to the burning of coal, is a high priority.

Historical industrial operations adjacent to Portage Lake may have resulted in the discharge of toxic materials that could result in the contamination of fish and/or direct exposure to recreational users. While no specific information was uncovered during the development of this plan, residents of the area have suggested that the operation of a tannery, railroad spills of hazardous materials, and/or chemicals associated with wood processing facilities need to be investigated using a more thorough examination of historical information.

Ecosystem Health

The threats to water quality essential to the protection of existing fish and wildlife populations and related angling and hunting opportunities are primarily related to changes in the trophic status, or productivity level of Portage Lake. Alterations in the remaining natural habitats essential to reproduction, survival, and growth of fish and wildlife and related food organisms are also a significant threat in both Portage Lake and its tributaries. Cool, high-quality groundwater is an essential factor in maintaining current protected uses related to coolwater fish species in both Portage Lake and in the coldwater tributaries to the lake. Any significant changes in the quantity or quality of groundwater are a threat to existing uses.

Eutrophication (Increased Phosphorus Loadings)

Phosphorus is the limiting nutrient in Portage Lake. Incremental increases in phosphorus loading over time can significantly alter the productivity level of Portage Lake and result in changes in water chemistry (e.g., decreased dissolved oxygen below acceptable levels) and increased algal and rooted plant growth (e.g., nuisance algal blooms and excessive rooted aquatic plant growth), thus decreasing the quality of fishing, boating, swimming, and other water-related activities. Increases in urbanization and other significant land use changes have been shown to be a significant factor in the eutrophication, or increased productivity, in other inland lakes. The application of best management practices to control nutrient loadings, as well as sediments and other pollutants contained in runoff, is an important long-range strategy to reduce this threat. Based on land use change and population growth estimates, phosphorus will continue to be a significant threat that needs to be monitored and for which corrective action must occur as needed.

An overall watershed runoff analysis was completed using the Long-Term Hydrologic Impact Assessment (L-THIA) model (*http://cobweb.ecn.purdue.edu/~sprawl/LTHIA7*). The model was designed by Purdue University with cooperation from the USEPA. Based on average annual runoff, soil conditions, land use type, and impervious cover, the L-THIA model was used to estimate expected nonpoint source pollution loadings to waterbodies in the Portage Lake watershed. The model was also used to determine the pollutant loading if predicted future land use trends come to fruition.

To determine runoff and pollutant loading for current conditions, the most current land use figures in the watershed from the National Land Cover Database (MRLCC 2001) were used. To estimate potential future loads, a land transformation model developed by the Computational Ecology and Visualization Lab and Michigan State University Land Policy Institute was used for the year 2040. Exhibit 48 shows the estimated phosphorus loading on a watershed-wide scale. This information was derived from the existing land use types and projected increase in development based on modeling. Common sources of nutrient loading include riparian septic systems, fertilizer use, livestock wastes, and storm water runoff.

EXHIBIT 48

Estimate of Phosphorus Loading to Surface Water in the Portage Lake Watershed (pounds per year) 2001 and 2040

Source	Current conditions (based on 2001 existing land use)		Future runoff (based on projected land use in 2040)		Runoff % change
	Acres	Runoff volume (lbs/yr)	Acres	Runoff volume (lbs/yr)	
Commercial	59	38	193	124	226.3%
High-density residential	672	367	2,194	1,199	226.7
Low-density residential	1,043	142	3,403	464	226.8
Forestland	5,494	2	3,408	1	(50.0)
Wetlands	2,938	0	2,314	0	0.0
Grassland/pasture	1,946	1	1,532	1	0.0
Agriculture	3,593	1,774	2,701	1,334	(24.8)
Atmospheric	2,155	576	N/A	576	0.0
Total	15,745	2,900	15,745	3,699	31.2%

SOURCE: Public Sector Consultants Inc., 2007, with data from MRLCC, 2001 (current land use), the MSU CEVL and LPI (future land use), 2007, and SEG, 1993 (atmospheric loading).
NOTE: Atmospheric source area is the water surface area in the watershed.

The current annual phosphorus loading (2001 land use data) is similar to the estimated loading figures calculated in the Phase I study, which estimated an average in-lake phosphorus concentration of 14 ug/L. This estimate is consistent with 2007 sampling results. While phosphorus runoff will increase by more than 31 percent if land use trends continue, it is not expected that this will result in the lake exceeding the range of a mesotrophic lake (10–20 ug/L).

Because septic systems are of great concern in the watershed, an additional loading calculation was made for this particular source. It is difficult to estimate pollutant loading

from septic systems. Many factors need to be considered, including soil type, age, condition, use of system, and proximity of system to ground and surface water. A rough estimate, however, can be calculated using Census information and data from previous studies.

In the Portage Lake Watershed, 60 percent (570) of the occupied housing units are outside the public sewer "envelope" of the Village of Onekama, and an average of 2.3 people live in each household (U.S. Census Bureau 2000). The USEPA estimates average daily wastewater flows of approximately 50 to 70 gallons per person per day (2002). The USEPA has also documented studies that estimate residential septic effluent pollutant levels (2002). The highest value documented among these studies was used to estimate the maximum estimated phosphorus pollutant load in the Portage Lake watershed (see Exhibit 49). If, based on USEPA estimates, 20 percent of the septic systems in the watershed fail, and the functioning systems are 85 percent effective in removing phosphorus, a maximum of 884.17 Kg could be released from OSDSs annually (see Exhibit 49). If even half of that amount reaches Portage Lake, septic systems are a significant source of phosphorus in the watershed. As systems age, homes expand, and amenities such as washing machines and dishwashers are added, this source must be addressed in the future.

EXHIBIT 49

Residential, Conventional Septic System Pollutant Load Estimates, Phosphorus, 2000

Variable	Failed septic systems[1]	Functioning septic systems[1]	Total
Households on septic	114	456	570
Residents on septic[1]	262	1049	1,311
Total effluent generated in watershed[2]	25,359,269 L/yr (6,699,210 gal/yr)	101,456,418 L/yr (26,801,950 gal/yr)	126,796,343 L/yr (479,976,371 gal/yr)
Effluent phosphorus concentration	21.8 mg/L	21.8 mg/L	21.8 mg/L
Total phosphorus in effluent	552,410,368 mg/yr (552.41 Kg/yr)	2,211,749,908 mg/yr (2,211.75 Kg/yr)	2,764,160,276 mg/yr (2,764.16 Kg/yr)
Maximum estimated pollutant load[3]	552,410,368 mg/yr (552.41 Kg/yr)	331,762,486 mg/yr (331.76 Kg/yr)	884,172,854 mg/yr (884.17 Kg/yr)

SOURCE: Public Sector Consultants Inc., 2007, with data from USEPA (pollutant load, average gallons of wastewater generated/person/day), 2002 and U.S. Census Bureau (number of households, average household size), 2000.
[1]Assumes 20 percent failure rate, USEPA, 2002.
[2]Assumes 70 gallons/person/day (265 L), USEPA, 2002.
[3]Assumes failed systems are 0 percent and functioning are 85 percent effective in reducing phosphorus, USEPA, 2002.

The first priority for nutrient control, as it is for protection of human health, is prevention of increased phosphorus loadings from existing septic tank/tile field onsite disposal systems. The iterative approach outlined in the previous section as a priority to address public health threats will also address the threat of nutrient loadings from these OSDSs. A second priority for phosphorus control is reduction in the use and subsequent runoff of fertilizers applied to lawns and gardens adjacent to lakes and streams. Education for riparian landowners on the use of low- or zero-phosphorus fertilizers to maintain lawns can result in reduced nutrient loadings. A third priority for phosphorus control is the

application of best management practices to reduce loadings from point source storm water in the Village of Onekama and other storm water systems that discharge directly to the lake or its tributaries.

Finally, previous studies have identified agricultural runoff as a contributor of animal waste and potentially phosphorus in the lower portion of one tributary to Portage Lake. Because of the predominance of permeable sand and gravel glacial deposits, surface water runoff in the Portage Lake watershed is minimal and the length and size of tributary streams reflect the fact that most water entering Portage Lake and its coldwater tributaries is from groundwater sources rather than from surface water runoff. While significant changes in agricultural practices or other land use changes could pose a threat if storm water runoff were conveyed directly to surface waters, agricultural sources of nutrients in the Portage Lake watershed are significantly fewer than those found where agricultural drains are constructed to move water off poorly drained soils for discharge to surface waterways. In the Portage Lake watershed, agricultural land uses—and for that matter, land use changes that occur significant distances from surface water courses—are not likely to be a significant source of phosphorus loadings to Portage Lake. Nevertheless, potential agricultural sources that are adjacent to waterways need to be monitored.

Habitat Degradation

The shoreline of Portage Lake and the downstream sections of some tributaries have been significantly altered since development first occurred in the late 1800s. The remaining undeveloped shoreline and wetlands are critical to sustaining resident, self sustaining populations of warmwater and coolwater fish populations in the lake, and the trout and salmon in the coldwater tributaries. The number one priority for habitat protection is preservation and enhancement of the remaining wetlands and undeveloped riparian lands that support a diverse habitat for various species and help capture nutrients and sediments from storm water and snow melt coming from adjacent impervious upland areas. The second priority is protection of the undeveloped areas riparian to Portage Lake and tributaries to preserve to the extent possible the nearshore littoral zone in the lake and a vegetated buffer strip along tributaries.

Invasive plant species within Portage Lake (i.e., Eurasian milfoil) and in contiguous wetlands (i.e., purple loosestrife and *Phragmites sp.*) threaten the biological diversity needed to support fish and wildlife populations and surface water recreational uses. Physical, biological, and/or chemical controls may be appropriate if future monitoring indicates that the spread of these species currently present in Portage Lake threatens existing uses.

Sedimentation has not been reported as a major, recurring problem in the lake or in its tributaries. However, lake access areas, bridge crossings, and similar activities that disturb the shoreline have the potential to cause erosion and add sediments and, at least in localized areas, impair benthos habitat. Increases in storm water runoff volumes can also have an impact. Monitoring of lake access areas, stream road crossings, and other shoreline disturbance activities to detect significant erosion problems and encouraging

the application of best management practices by responsible land owners/managers can help to minimize the threat of sedimentation and resulting impairment to aquatic habitats.

Increased storm water runoff can also pose a threat to the health of the Portage Lake watershed ecosystem by causing increased stream bank erosion and degradation of in-stream habitat. An overall watershed runoff analysis was completed using the L-THIA model. Exhibit 50 depicts estimated runoff amounts and pollutant loading for phosphorus for current and future conditions.

EXHIBIT 50
Average Annual Total Runoff Volume (acre-feet), 2001 and 2040

	Current conditions (based on 2001 existing land use)		Future runoff (based on Projected land use in 2040)		
Land use	Acres	Runoff volume (acre-ft.)	Acres	Runoff volume (acre-ft.)	Runoff % change
Commercial	59	31	193	101	118.6%
High-density residential	672	112	2,194	366	226.8
Low-density residential	1,043	18	3,403	59	227.8
Forestland	5,494	5	3,408	3	(40.0)
Water/wetlands	2,938	0	2,314	0	0.0
Grassland/pasture	1,946	6	1,532	5	(16.7)
Agriculture	3,593	176	2,701	132	(25)
Total	**15,745**	**348**	**15,745**	**666**	**91.4%**

SOURCE: Public Sector Consultants Inc., 2007, with data from MRLCC, 2001 (current land use), and MSU CEVL and LPI (future land use), 2007.
NOTE: Acre-ft. = the volume of water necessary to cover one acre to a depth of one foot (1 acre-ft. = 43,560 cu. ft.).

Recreational and Fishing Access

The Portage Lake Channel provides a major attraction to residents and visitors who use Portage Lake as an access point to fish and boat on Lake Michigan. Traditionally the Portage Lake Channel has been maintained by the U.S. Army Corps of Engineers (USACE). However, recent federal budget reductions have threatened the maintenance dredging and breakwater pier upkeep in all Great Lakes harbors with the exception of a limited number of commercially important Great Lakes ports. State and local funding mechanisms are being sought to assure that safe, sustained access through the Portage Lake Channel can be maintained for access to Lake Michigan from Portage Lake. Surface water recreation in Portage Lake is dependent upon adequate and safe boat launching and docking facilities and public swimming and recreational areas. Recent low water conditions have limited the use of some facilities and new or improved shore-based recreational facilities are needed to support existing and potentially expanded use.

Contaminated sediments that require special handling and disposal can increase the cost of navigational dredging. There is no evidence, however, of contaminated sediments in the Portage Lake Channel. If actions called for in this plan are implemented to prevent

hazardous materials from entering surface waters, there should be no increased costs associated with dredging sediments from the channel.

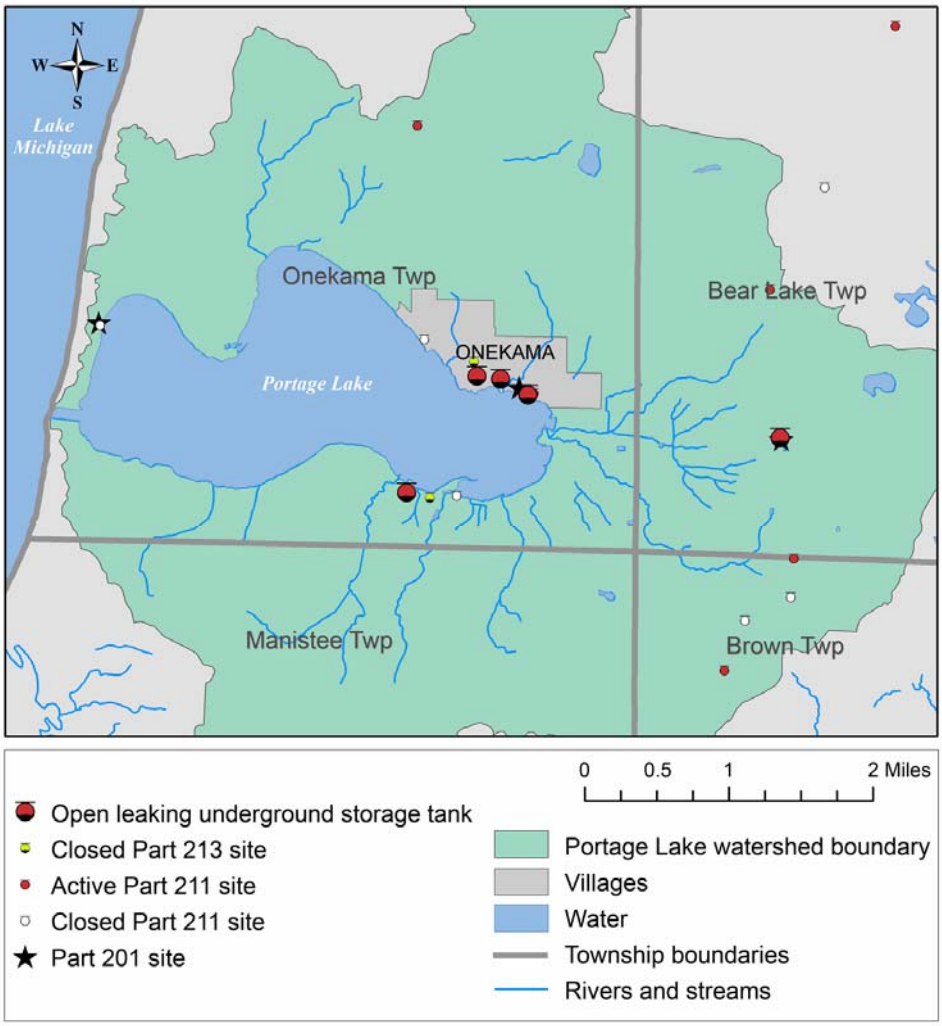
Groundwater

The greatest threats to groundwater in the watershed are related to the unlawful releases of contaminants already identified in this watershed plan, and to the potential release of contaminants from spills and discharges to the surface that either gain direct access to groundwater or enter otherwise protected groundwater aquifers through improperly plugged and/or abandoned hydrocarbon and mineral wells or domestic water wells.

While existing regulations protect groundwater from permitted waste discharges, leaking underground storage tanks and other nonpoint discharges from land uses involving the storage, disposal, transportation, and use of hazardous materials threaten the groundwater resources in the watershed. Groundwater is virtually the only source of potable water in the watershed and it is a major contributor of cool, clean water to Portage Lake and tributary streams. Groundwater pollution is not only a threat to drinking water but to protected uses in surface waters.

Exhibit 51 shows the distribution of hazardous substance releases, leaking underground storage tanks (LUST), and underground storage tanks (UST) in the Portage Lake watershed. Closed LUST and UST sites are potential or past sites of contamination that have been addressed. Active UST sites are locations where there is at least one tank at the facility that is not closed in place or removed, but there is no leaking.

EXHIBIT 51
Groundwater Contamination Sites in Portage Lake Watershed



SOURCE: MDEQ, 2007b.

The sites of concern are the open LUST sites and Part 201 sites. Open LUST sites are those where a release has occurred and corrective actions have not been completed to meet the appropriate land use criteria. Part 201 sites are those where there has been a release of a hazardous substance(s) in excess of the Part 201 of the Michigan Natural Resources and Environmental Protection Act (Public Act 451 of 1994) residential criteria, and/or where corrective actions have not been completed under Part 201 to meet the applicable cleanup criteria for unrestricted residential use. Exhibits 52 and 53 provide details about open LUST and Part 201 sites in the watershed.

EXHIBIT 52
Open LUST Sites in the Portage Lake Watershed

Site	Municipality	Release date	Substance
Spirit of Onekama (Formerly Wesco)	Village of Onekama	Oct. 2, 1991	Unknown
Pete's Repair Service	Village of Onekama	Jun. 19, 1995	Unknown
Onekama Marine Inc	Village of Onekama	Oct. 29, 1998	Diesel
Portage Lake Marina	Village of Onekama	Dec. 1, 1998	Gasoline
Portage Lake Marina	Village of Onekama	Nov. 29, 1993	Gasoline

SOURCE: MDEQ, 2007b.

EXHIBIT 53
Part 201 Sites in the Portage Lake Watershed

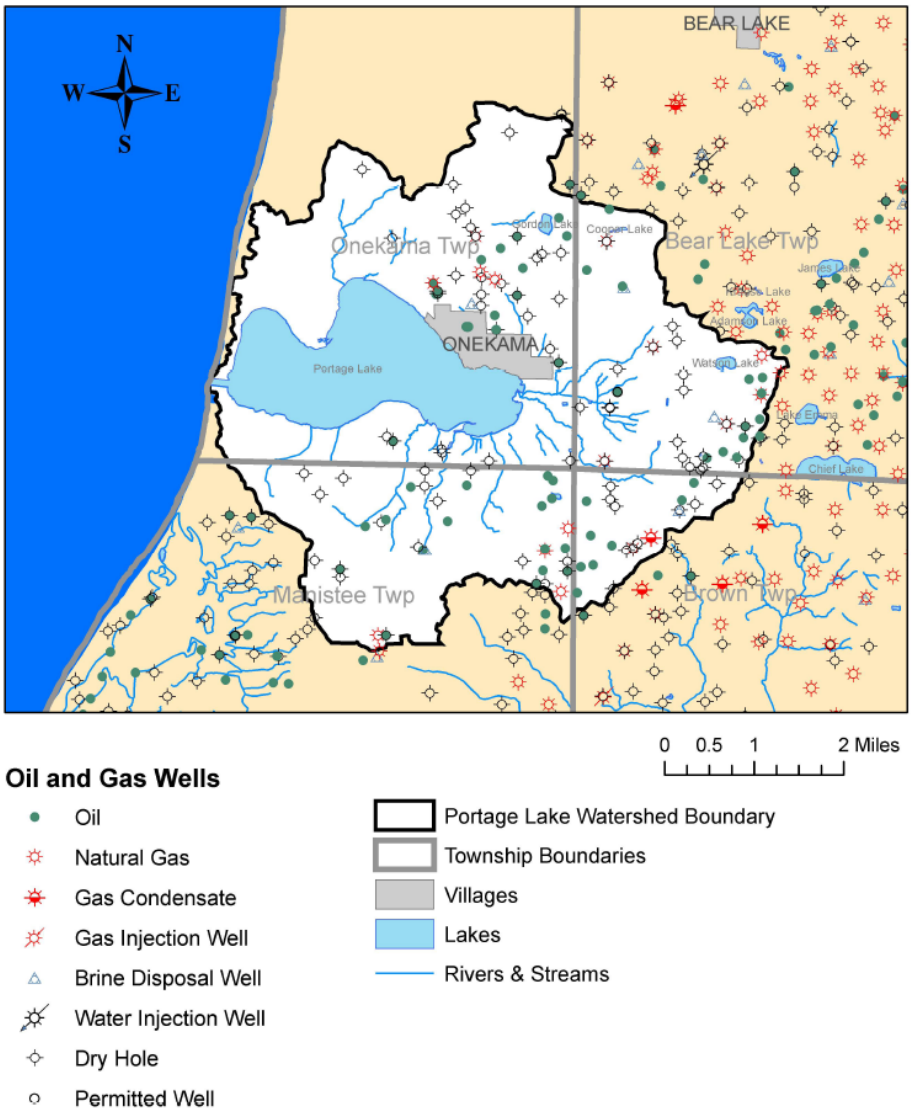
Site	Municipality	Substance	Status
Residential well, Eight Mile Road	Village of Onekama	1,2-Dichloropropane DCP	Interim response conducted—no further activities anticipated
Residential well, Farr Road	Village of Onekama	Chloride	Interim response conducted—no further activities anticipated
Residential spill, Main Street	Village of Onekama	Fuel oil	Inactive—no actions taken to address contamination
Portage Pointe Inn	Village of Onekama	Benzene; Ethylbenzene; Toluene; Xylenes; PNAs	Delisted*

SOURCE: MDEQ, 2007b.
*A delisted site has been removed from the Part 201 list because response actions have reduced the levels of contaminants to concentrations that meet or are below the criteria for unrestricted residential use.

It is important to note that the Part 201 list does not include all of the sites of contamination that are subject to regulation under Part 201 because owners are not required to inform the MDEQ about the sites and can pursue cleanup independently. Sites of environmental contamination that are not known to the MDEQ are not on the list, nor are sites with releases that resulted in low environmental impact.

Contaminants from spills and discharges to the surface can gain direct access to groundwater or enter otherwise protected groundwater aquifers through improperly plugged and/or abandoned hydrocarbon and mineral wells or domestic water wells. This is a considerable threat, given the fact that Manistee County ranks second in the state in the total production of both oil and natural gas that began in Michigan in 1925. Exhibit 54 shows the large number of wells drilled in the Portage Lake watershed.

EXHIBIT 54
Location of Wells Drilled in Portage Lake Watershed



SOURCE: Public Sector Consultants Inc., 2007, with data from MDEQ 2000, Locations – Oil and gas wells.

Pollution prevention education programs targeted to commercial and public facilities that store, handle, and use hazardous materials can be an effective means to protect groundwater. Providing free or subsidized household hazardous waste disposal options for homeowners can reduce unacceptable disposal on the land. Inventorying and the proper closure of abandoned domestic and industrial wells can reduce the potential direct access to groundwater aquifers from contaminated surface runoff. A quick response and cleanup of leaking underground storage tanks and other known groundwater contamination sites can minimize the threat of groundwater pollution. Alerting watershed property owners of low-cost or free water supply testing for various contaminants can also help detect and address potential threats to groundwater.

Priority Areas

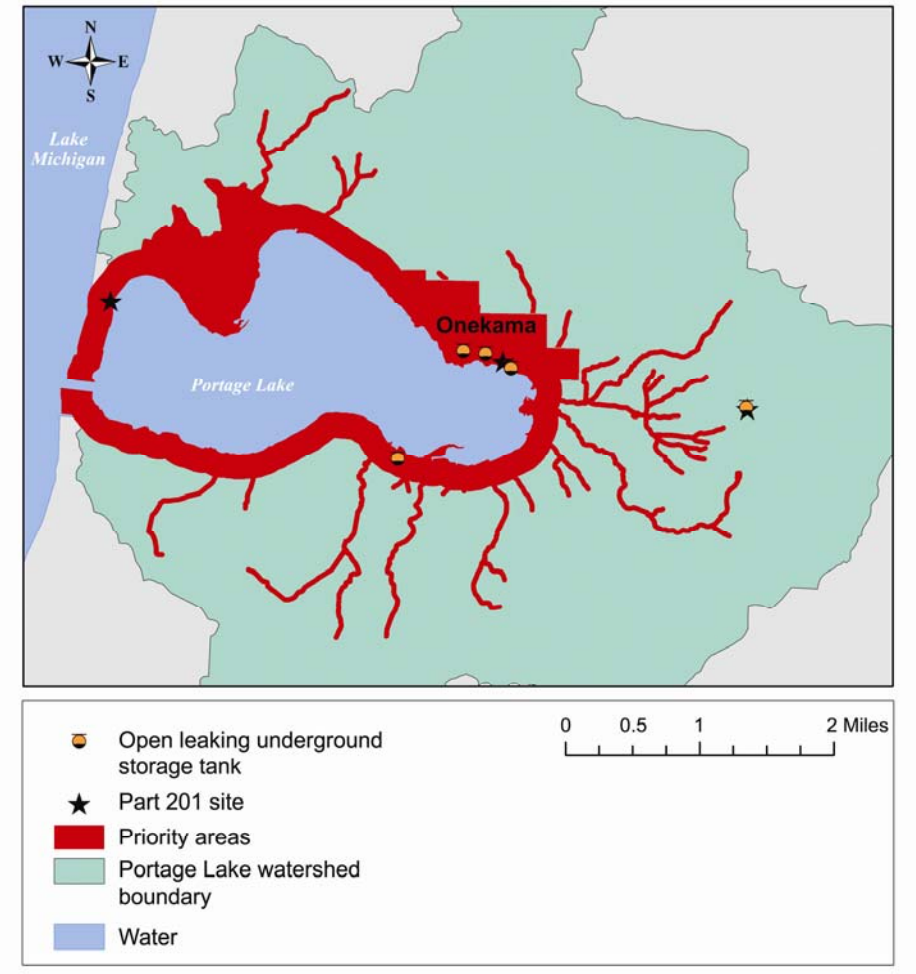
Priority areas in the watershed were identified and mapped to help inform the development of goals and objectives and to guide future monitoring, planning, and management efforts. Priority areas were defined as areas that are either sources of priority pollutants in the watershed or are most susceptible to changes that would result in increased input of priority pollutants, resulting in degradation of habitat and water quality (Exhibit 55 and 56).

EXHIBIT 55
Priority Areas in the Portage Lake Watershed

Critical Area	Description	Priority Pollutant/Threat
Riparian zone and wetland areas riparian to Portage Lake and tributary streams	1,000ft.-wide zone around entire lake; 100ft.-wide existing vegetated zone on either side of tributary streams; road lake access and stream crossings	Nutrients, sediments, temperature Habitat loss
Non-sewered portion of lake	Entire lake shoreline with exception of Village of Onekama, Little Eden Camp, and a few households in-between with existing or planned sanitary sewers	Human pathogens and nutrients
Storm water discharges	Village of Onekama	Nutrients, sediments, and toxic chemicals
Known sites of environmental contamination	Identified sites within the Portage Lake watershed	Toxic Chemicals

SOURCE: Public Sector Consultants Inc., 2007.

EXHIBIT 56
Map of Priority Areas in the Portage Lake Watershed



SOURCE: Public Sector Consultants Inc., 2007, using data from MDEQ, 2007b and MDIT/CGI (LP Watersheds).

Priority areas were also used to inform the development of the monitoring plan to track trends in pollutant levels in the Portage Lake watershed. Types and locations of monitoring were based on priority pollutants within critical areas. For more information about the monitoring plan and locations of proposed sites, refer to the Monitoring and Evaluation section of this plan.

Goals and Objectives

The goals presented in Exhibit 57 were selected based on the numerous public meetings that were conducted in the watershed, a household survey, previous studies, and current water quality monitoring.

EXHIBIT 57
Goals and Objectives for the Portage Lake Watershed

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
Goal 1—Public Health: Ensure that participants in water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish, or wildlife with contaminants in excess of advisories.				
1.A. Monitor Portage Lake and Lake Michigan adjacent to the north Portage Lake channel breakwall and report results to assure residents and visitors that state water quality standards for **total body contact recreational** activities continue to be met at all locations during period of May 31–October 1 of each year.	**1.A.1.** Conduct *E. coli* bacteria sampling once per week at Village Beach May31–October 1, once per week at the Lake Michigan swimming beach adjacent to the north breakwall July–mid-September, and once per month at four other swimming areas in Portage Lake for the next three years at the same locations tested in 2007 (see Monitoring Plan) to confirm that state standards are being met and inform stakeholders of the results (see Public Information and Education Plan).	Onekama Twp, Village, PLA, PLEA, MDEQ, MDNR, LRBOI, EPA, Health Dept., School, PLWF, various locations of sampling	0–2 years (High)	$2,700+ S=50 hours/year V/N
	1.A.2. Support current efforts by Manistee County in cooperation with District 10 Health Department to require time of sale inspections of wells and septic tank/tile filed systems.	PLWF, encourage other partners	0–2 years (High)	S=40 hours/year V
	1.A.3. Evaluate results of the three years of monitoring and, if sample results exceed state standards, determine what new or more frequent sampling or additional actions, if any, are needed. If sample results meet state standards, continue monitoring program.	MDEQ, MDNR, LRBOI, EPA, Health Dept., School, PLWF	2–5 years (High)	S=80 hours/year V
1.B. Assure that all of Portage Lake meets state water quality standards for **partial body contact recreational** activities for the full 12-month period of each year.	**1.B.1.** Conduct *E. coli* bacteria sampling in at least four locations once every three years (see Monitoring Plan) and inform stakeholders of the results (see Public Information and Education Plan).	Onekama Twp, Village, PLA, PLEA, MDEQ, MDNR, LRBOI, EPA, Health Dept., School, PLWF, various locations of sampling	0–2 years (High)	$720+ S=20 hours/year V/N
	1.B.2. Based upon the sampling results and historical data, evaluate the sampling frequency, locations, time of year, etc., and determine what, if any, additional actions are needed.	MDEQ, MDNR, LRBOI, EPA, Health Dept., School, PLWF	2–5 years (High)	S=20 hours/year V

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
1.C. Prevent releases of hazardous substances that pose a risk to human health through the **consumption of contaminated fish or wildlife** taken in the watershed, and provide information to anglers on state fish consumption advisories in the watershed due to sources outside the watershed.	**1.C.1.** Implement a cooperative, pollution-prevention education program targeted to local businesses and governmental agencies located in the watershed that use, store, handle, or dispose of potentially hazardous materials to prevent accidental discharges to the ground or surface waters (see Public Information and Education Plan).	Onekama Twp, Village, PLA, PLEA, MDEQ, MDNR, LRBOI, EPA, Health Dept., School, PLWF, AES, MCD, MSU Ext., USDA-NRCS	2–5 years (Low)	$2,740+ S=80 hours/year V/M/N
	1.C.2. Implement an up-to-date public information mechanism to assure that anglers have the best information on state consumption advisories specifically related to fish taken from Portage Lake (see Public Information and Education Plan).	MDNR, MDEQ, LRBOI, MSU Ext., MCD, PLA, PLEA, PPSRC, PLWF	2–5 years (Low)	S=20 hours/year V/M/N
	1.C.3. Advocate for mercury emission reductions as part of regional Great Lakes effort to reduce levels of this environmental contaminant.	PLWF, encourage other partners	2–5 years (Low)	S=40 hours/year V
1.D. Reduce severity and frequency of **swimmer's itch** (schistosome cercarial dermatitis) by collecting information for distribution to the public that can assist lake users in avoiding exposure, and can guide efforts in minimizing the abundance of intermediate host-animals that contribute to the problem.	**1.D.1.** Establish a mechanism for Portage Lake residents and users to report instances of swimmer's itch and provide information to the public on swimmer's itch, its causes, and steps to minimize exposure (see Public Information and Education Plan).	Onekama Twp, Village, MDEQ, MNDR, LRBOI, PLA, PPSRC, PLEA, PLWF, MCD, MSU Ext., School	0–2 years (Low)	$500+ S=40 hours/year V/N
	1.D.2. Evaluate reports of swimmer's itch on Portage Lake and document any activities that encourage congregations or increased abundance of suspected host waterfowl, and propose appropriate actions.	Onekama Twp, Village, MDEQ, MNDR, LRBOI, PLA, PPSRC, PLEA, PLWF, School	2–5 years (Low)	S=20 hours/year V
1.E. Provide information to watershed residents on actions they can take to have their **drinking water supplies** tested, and advocate best management practices to prevent groundwater contamination.	**1.E.1.** In cooperation with other organizations, become an advocate for groundwater pollution prevention best management practices in the watershed including: the plugging of abandoned domestic and hydrocarbon/mineral wells that provide direct exposure of surface contaminants to groundwater aquifers, quick response to known areas of releases or spills of contaminated materials, encouraging government units to support volunteer household hazardous waste disposal programs (see Public Information and Education Plan).	Health Dept., MCD, USDA-NRCS, MSU Ext., MDEQ, School, PLWF	0–2 years (High)	S=80 hours/year V/M/N
	1.E.2. In cooperation with local health officials and the Michigan Department of Agriculture, develop and distribute information on cost-effective ways to have drinking water supplies tested for bacteria and most likely potential contaminants (see Public Information and Education Plan).	Health Dept., MCD, USDA-NRCS, MSU Ext., MDEQ, PLWF, School	0–2 years (Medium)	S=30 hours/year V/M/N

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
1.F. Protect groundwater from contamination at known leaking underground storage tank (LUST) sites, Part 201 sites, and other known sites of environmental contamination, and research potential and unreported environmental contamination sites.	**1.F.1.** Work with MDEQ and other appropriate public agencies to identify, and keep current, known sites of environmental contamination.	MDEQ, Health Dept., local government, PLWF	0–2 years (High)	S=20 hours/year V
	1.F.2. Determine impacts of known environmental contamination sites on groundwater and advocate for rapid response and appropriate testing by MDEQ and other public agencies to protect public health and the environment.	MDEQ, Health Dept., local government, PLWF	0–2 years (High)	S=15 hours/year V
	1.F.3. Work with MDEQ and other public agencies to determine potential sites of environmental contamination at oil and gas wells that are not currently active but have not been officially abandoned.	MDEQ, Health Dept., local government, PLWF	0–2 years (Medium)	S=15 hours/year V
Goal 2—Aquatic Ecosystem[4]: Protect the quality of water resources in the Portage Lake watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.				
2.A. Monitor Portage Lake to assure that future loadings of nutrients, specifically phosphorus, do not exceed levels that would change the current **mesotrophic status of Portage Lake** capable of supporting coolwater and warmwater fisheries throughout the year, seasonal use by anadromous trout and salmon, and other existing, protected uses.	**2.A.1.** Annually monitor total phosphorus, transparency, and chlorophyll *a* for at least three locations in the spring before turnover and in the fall after turnover in order detect any significant trends in the trophic status index (TSI) of Portage Lake, based on historical monitoring results (see Monitoring Plan).	School, Onekama Twp, Village, PLA, PLEA, MDEQ, MDNR, LRBOI, EPA, Health Dept., PLWF	0–2 years (High)	$456+ S=20 hours/year V
	2.A.2. Support current efforts by Manistee County in cooperation with District Health Department #10 to require septic system inspections at time of sale in or to determine system failure rates and to upgrade failing systems (Note: Also supports objective to prevent recreational user exposure to pathogens.)	PLWF, encourage other partners	0–2 years (High)	S=20 hours/year V
	2.A.3. Develop and distribute information to residents and businesses on proper maintenance and operation of septic tile field sanitary systems (see Public Information and Education Plan). (Note: Also supports objective to prevent recreational user exposure to pathogens.)	MCD, MSU Ext., USDA-NRCS, PLWF, MDEQ, School, PLA, PPSRC, PLEA	0–2 years (High)	S=40 hours/year V/M/N
	2.A.4. Evaluate results of the inspections, surveys, monitoring, and education programs designed to control phosphorus loadings and determine what additional actions, if any, are needed.	MDEQ, MDNR, MCD, MSU Ext., USDA-NRCS, Health Dept., School, PLWF	2–5 years (High)	S=30 hours/year V
	2.A.5. Advocate for meaningful federal requirements and support Michigan's efforts to control invasive species through ballast water discharge controls for ocean-going vessels entering the Great Lakes.	PLWF, encourage other partners	0–2 years (High)	S=20 hours/year V

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
	2.A.6. Inventory existing storm water point-source discharges from the Village of Onekama, other urbanized areas with direct discharges to Portage Lake and tributary streams, and significant nonpoint sources of storm water from urban and agricultural areas and determine whether or not sampling of water quality for phosphorus during wet weather events should be conducted (see Monitoring Plan and Public Information and Education Plan).	Village, Onekama Twp., EPA, MDEQ, Health Dept., MCD, MSU Ext., School, PLWF	0–2 years (Medium)	$1,000+ S=15 hours/year V/D
	2.A.7. Develop and implement a plan to monitor *Cladophora* algae as an index to detect nearshore nutrient sources (see Monitoring Plan and Public Information and Education Plan).	MDEQ, MDNR, LRBOI, School, Onekama Twp., PLWF	0–2 years (Medium)	$1,000+ S=25 hours/year V/D/N
	2.A.8. Implement a monitoring plan that will sample dissolved oxygen (DO) levels in the epilimnion of Portage Lake during summer stratification at two locations (deepest basins) at least three time per year every three years and at least twice per year during a 24-hour period to determine whether or not DO levels meet state water quality standards (see Monitoring Plan).	Onekama Twp, Village, PLA, PLEA, MDEQ, MDNR, LRBOI, EPA, Health Dept., School, PLWF	0–2 years (Medium)	S=25 hours/year V/D
	2.A.9. Determine if additional DO sampling is needed to determine whether or not the severity, depth, and period oxygen depletion below the thermocline has increased significantly based upon historical information on Portage Lake and data for similar lakes (see Monitoring Plan).	MDEQ, MDNR, LRBOI, EPA, Health Dept., School, PLWF	2–5 years (Medium)	S=20 hours/year V
	2.A.10. Develop and distribute information to residents and businesses on limiting phosphorus loadings to surface water through use of low- or zero-phosphorus fertilizers for lawn maintenance (see Public Information and Education Plan).	MCD, MSU Ext., USDA-NRCS, PLWF, MDEQ, School, PLA, PPSRC, PLEA	2–5 years (Low)	S=25 hours/year V/M/N
	2.A.11. Continue efforts to determine type, locations, and potential discharges from any historical industrial uses on or adjacent to Portage Lake to determine if any contaminants from past uses represent a present or future threat to humans or biota of the lake.	Village, Onekama Twp., Historical Museum, MDEQ, PLWF	2–5 years (Low)	S=10 hours/year V

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
2.B. Protect remaining **wetland habitats** contiguous to Portage Lake and tributary streams to assure that they continue to provide a natural filter system and function as spawning, nursery, and refuge areas to support the natural reproduction and survival of resident fish and wildlife populations and other aquatic organisms.	**2.B.1.** Develop and distribute information to area property owners on the importance of protecting existing wetlands to sustaining fish and wildlife populations and in providing a natural filter system to protect the lake and tributaries from sediment, nutrients, and other pollutants contained in surface runoff from adjacent lands (see Public Information and Education Plan).	MSU Ext., MCD, USDA-NRCS, PLA, PPSRC, PLEA, MDEQ, MDNR, LRBOI, local government, School, PLWF	0–2 years (High)	S=40 hours/year V/M/N
	2.B.2. Complete an inventory and mapping of significant contiguous wetland areas associated with Portage Lake and tributary streams and determine whether existing federal, state, and local regulations are adequate to protect these areas from injury should future development occur (see Monitoring Plan and Public Information and Education Plan).	MDEQ, MDNR, LRBOI, USFWS, EPA, MSU Ext. MCD, School, PLWF	0–2 years (High)	$1,000+ S=40 hours/year V/D
	2.B.3. Make recommendations for actions to local units of government, if needed, to assure that critical contiguous wetlands required to support resident fish and wildlife are protected.	MDEQ, MDNR, LRBOI, USFWS, EPA, local government, School, PLWF	2–5 years (Low)	S=15 hours/year V
2.C. Protect the **shallow (littoral) zone habitat** from physical alteration and the spread of invasive plant species that can reduce the diversity of water-related habitats and limit the abundance and sustainability of resident fish populations, impact fishing, and impair other recreational water uses.	**2.C.1.** Develop and implement a plan that will identify and map areas of rooted aquatic plant growth, in or adjacent to Portage Lake, with particular attention to the presence of exotic, invasive species such as purple loosestrife (*Lythrum salicaria*), Eurasian watermilfoil (*Myriophyllum spicatum*), and phragmites (*Phragmites australis*) (see Monitoring Plan and Public Information and Education Plan).	MDEQ, MDNR, LRBOI, USFWS, Onekama Twp., Village, School, MCD, MSU Ext., PLA, PLEA, PLWF	0–2 years (Medium)	$1,000+ S=40 hours/year V/D
	2.C.2. Make recommendations as to what actions, if any, need to be implemented to reduce the impacts and spread of invasive aquatic species.	MDEQ, MDNR, LRBOI, USFWS, EPA, MCD, MSU Ext., School, PLWF	2–5 years (Medium)	S=10 hours/year V
	2.C.3. Develop and distribute educational materials explaining the importance of the nearshore littoral zone and the impacts of beach grooming, shoreline hardening, and permanent mooring structures on the habitat essential to resident fish, wildlife, and fish food organisms (see Public Information and Education Plan).	MCD, MSU Ext, MDEQ, MDNR, School, PLWF, local government, PLA, PLEA, PPSRC	0–2 years (Medium)	S=20 hours/year V/M/N
	2.C.4. Develop and implement a program to identify and make recommendations for the applications of best management practices to address significant soil erosion and sedimentation sources on public and private lands riparian to Portage Lake and tributaries (see Monitoring Plan and Public Information and Education Plan).	USDA-NRCS, MCD, MSU Ext., County, local government, MDEQ, MDNR, LRBOI, School, PLWF	2–5 years (Low)	$1,000+ S=10 hours/year V/D

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
	2.C.5. Identify and map the unimproved shoreline areas of Portage Lake and evaluate the effectiveness of existing federal, state, and local regulations to protect critical undisturbed areas from impairment and make recommendations, if any, for actions needed to protect this limited and essential habitat feature (see Monitoring Plan and Public Information and Education Plan).	Onekama Twp, Village, MDEQ, MDNR, School, PLWF	2–5 years (Low)	$1,000+ S=10 hours/year
Goal 3—Water-Based Recreation: Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake watershed for people of all ages and abilities.				
3.A. Maintain adequate depths in the **Portage Lake Channel** to assure safe, easy access to and from Portage Lake from Lake Michigan and adequate boating access to Portage Lake.	**3.A.1.** Actively support and participate in the efforts of the Portage Lake Harbor Commission to secure adequate, sustained funding for the dredging of Portage Lake Channel to depths required to accommodate recreational boating access to and from Portage Lake and Lake Michigan.	PLWF, other partners as appropriate	0–2 years (High)	S=80 hours/year V
	3.A.2. Support improvement of existing boating access and public marina facilities and acquisition of additional properties for boating and non-boating public access to Portage Lake (also supports 3.C.3. below).	Onekama Twp., Village, MDNR, PLWF	0–2 years (High)	S=15 hours/year V
	3.A.3. Support completion of north and south piers of the Portage Lake Channel breakwall to reduce the frequency of maintenance dredging and at the same time accommodate larger vessels.	USACE, Onekama Twp, Harbor Commission, Village, local businesses, PLWF	0–2 years (Medium)	S=15 hours/year V
	3.A.4. Maintain and enhance quality of current public access sites for launching of watercraft into Portage Lake and monitor use to identify capacity or other concerns at these sites.	MDNR, Onekama Twp., Village, PLWF	2–5 years (Low)	S=15 hours/year V

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
3.B. Actively support sustainable fish community management objectives for Portage Lake watershed that focus on self-reproducing populations of both **warmwater and coolwater fish species** in Portage Lake and resident trout populations in tributaries, supplemental stocking of coolwater species as needed to support fishable populations, and annual plantings of trout and salmon as required to sustain nearby Great Lakes fishing opportunities and seasonal angling in Portage Lake.	**3.B.1.** Periodically inventory and monitor specific and easily measured physical, biological, and chemical conditions within and adjacent to tributary streams to assist state, federal, and tribal resource protection and management agencies with protection of fish habitat, prevention of migration barriers, and protection of the quality of the water entering Portage Lake (see Monitoring Plan and Public Information and Education Plan).	PLWF, MCD, MSU Ext., School, PLA, PLEA, local government	2–5 years (Low)	$1,000+ S=30 hours/year V/D/N
	3.B.2. Establish a forum/communication tool that can be used by the state, federal, and tribal resource protection and management agencies to communicate information to and answer questions from residents and visitors to Portage Lake about issues important to anglers like annual fish plantings in Portage Lake, water quality, fish population surveys, fish diseases or invasive species that are limiting fishery management options, and creel census information (see Public Information and Education Plan).	PLWF, School, MCD, MSU Ext., PLA, PLEA	2–5 years (Low)	$1,000+ S=30 hours/year V
	3.B.3. Determine, in conjunction with other local, state, federal, and tribal resource management agencies, locations on Portage Lake where shore-based fishing opportunities can be enhanced through the use of fishing piers or platforms and/or how accessibility to the existing fishery by those with physical limitation could be enhanced.	MCCF, AES, ESM, MDEQ, MDNR, USFWS, LRBOI, USACE, PLWF, local government	2–5 years (Low)	S=15 hours/year V
3.C. Promote, maintain, and where practicable enhance accommodations for **non-boating public recreational uses** of Portage Lake, including such things as swimming, wading, lakeside walks, and wildlife viewing.	**3.C.3.** Endorse the purchase or acquisition of property within the Portage Lake watershed for habitat protection, public use, access, and recreation.	PLWF, encourage other partners	0–2 years (High)	S=20 hours/year V
	3.C.1. Inventory existing public access opportunities on Portage Lake and determine capacity and appropriateness of various uses and identify opportunities for enhancement of non-boating uses.	PLWF, Onekama Twp., Village, County, MCCF, AES, ESM, MDNR	2–5 years (Low)	S=30 hours/year V
	3.C.2. Prepare recommendations to the public agencies that control the sites for enhancements.	PLWF, PLA, local government	5–10 years (Low)	S=15 hours/year V
	3.C.4. Prepare and distribute information about public access facilities currently available for non-boating users (see Public Information and Education Plan).	PLA, PPSRC, local governments, PLWF	5–10 years (Low)	$1,340+ S=20 hours/year V/N

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
3.D. Provide a forum to help resolve **conflicts between recreational users** of Portage Lake by anticipating problems and proposing alternative solutions that provide for equitable allocation of surface and shoreline natural resources.	**3.D.1.** Collect further information on user conflicts reported during the 2007 Public Sector Consultants phone survey of Portage Lake users and determine whether educational materials and/or better enforcement of existing regulations can resolve conflicts, or whether further actions are needed (see Public Information and Education Plan).	PLWF, Onekama Twp., Village, School, PLA	2–5 years (Low)	$15,000
	3.D.2. Cooperate with the appropriate public authorities and other affected parties to implement recommendations for conflict resolution.	MDNR, Village, USCG, PLWF	2–5 years (Low)	S=10 hours/year V
Goal 4—Natural Resource and Cultural Assets: Invest in protection and enhancement of land-based natural resources and related cultural assets that provide recreational and educational benefits unique to the watershed and contribute to the quality of life and economic well-being of local residents while expanding the vacation experiences of visitors.				
4.A. Preserve, enhance, and promote access and use of the **scenic vistas** in the watershed that characterize the unique natural resources of the region and add to the quality of life of residents and attract visitors.	**4.A.1.** Map the location of scenic vistas in the watershed that local residents and visitors identify as significant places that characterize the aesthetic qualities of the region that make them want to live and/or vacation in the area (see Monitoring Plan).	PLWF, Townships, Village, School	2–5 years (Low)	S=80 hours/year V
	4.A.2. Develop a plan to provide special designation for these locations; develop and distribute public information that describes each location or series of locations associated with a scenic drive; and recommend education, information, and voluntary actions to private land owners and actions by public agencies to encourage protection and provide enhancements that will accommodate sustained public enjoyment of these local assets.	Townships, Village, County, MDOT	5–10 years (Low)	$1,340+ S=80 hours/year V/N
4.B. Preserve and enhance public understanding and appreciation of specific **historical sites**, structures, centennial farms, and historical artifacts that provide an opportunity for residents and visitors to better understand how the natural resources of the region attracted and supported Native American, early European	**4.B.1.** Map sites of historical significance in the watershed identified as key locations that give the watershed residents a sense of place, and that can provide important information on the past uses of natural resources in the region and lessons learned that encourage future stewardship of the natural assets of the region.	Historical Museum, School, PLWF, local government	2–5 years (Low)	S=50 hours/year V
	4.B.2. Develop and distribute public information that describes each historical site.	Historical Museum, PLWF, local government, service clubs	2–5 years (Low)	$1,340+ S=50 hours/year V/N

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
settlers, and later immigrants, and how important many of the same natural resources are to the future economic well-being of the region.	**4.B.3.** Develop a plan that will encourage private and public efforts to preserve, protect, and provide interpretation of sites of historical significance in cooperation with other public entities, private organizations, and other interested stakeholders.	Historical Museum, PLWF, service clubs	5–10 years (Low)	$500+ S=30 hours/year V
4.C. Promote recognition of the **agricultural heritage** in the watershed, present agriculture, the use of local agricultural products, and sustainable agricultural practices that rely on the unique combinations of micro-climates, soils, and topography of the region that have been important in the past and are a significant component needed to support a future diverse and sustainable local economy.	**4.C.1.** Encourage and facilitate development of a program to celebrate local agricultural products and encourage their sale and use in partnership with local farmers and other interested stakeholder organizations and individuals that will include potential for: establishing seasonal, central, open-air farm markets; published guides for farm tours including locations of on-site/roadside farm markets; special promotions of local products in local retail stores, groceries, and restaurants; and, promotion of locally grown agricultural products in tourist information distributed to potential visitors to the watershed.	USDA-NRCS, MCD, MSU Ext., AES, PLWF, local farmers and businesses	0–2 years (Low)	S=15 hours/year V
	4.C.2. Begin implementation of recommended promotion of locally grown agricultural products in cooperation with partners.	AES, USDA-NRCS, MCD, MSU Ext., PLWF	2–5 years (Low)	$1,340+ S=10 hours/year V/N
Goal 5— Local Management and Implementation Institutions: Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.				
5.A. Create an **organizational structure** that will encourage sustained local leadership needed to engage the public, manage projects, and raise funds needed to implement and periodically update this plan from various sources through the voluntary participation of governmental and private interests in the watershed.	**5.A.1.** Establish a volunteer organization under the umbrella of the existing Alliance for Economic Success with bylaws that establish, as a minimum, the purpose of the organization; membership qualifications; method of electing, qualifications, and number of officers; terms of officers; standing committees and appointment of committee chairs; number of annual meetings; method of decision making; and process for approving budgets, grant requests, and expenditures.	PLWF, AES	0–2 years (High)	S=120 hours/year V
	5.A.2. Commence operation of standing committees to assist in the implementation of the plan and in combination with the officers of the organization determine a reasonable proposed budget for the following 12 months including the needed staff support and the direct expenses related to the 2008 fiscal year actions.	PLWF, AES	0–2 years (High)	S=120 hours/year V
	5.A.3. Evaluate results of voluntary organization operation and make changes, if necessary.	PLWF, AES	2–5 years (High)	S=40 hours/year V

Objectives	Tasks	Potential partners[1]	Timeline (and priority)[2]	Estimated cost/year[3]
5.B. Provide sufficient **resources to support plan** implementation, including staff support to assist volunteer officers and committee chairs; encourage participation and in-kind contributions from public agencies, local private entities, tribal interests, and interested residents; and, seek grants from public agencies and private foundations.	**5.B.1.** Secure funding to provide for paid staff or a secure commitment from an experienced volunteer to assist in: development of the bylaws of the organization; initiating work on the actions identified in this plan that are to be commenced as early as January 1, 2008; and securing funds, in-kind contributions, and volunteer participants needed to sustain public interest in the plan and meet public expectations for early results from actions identified in the plan.	PLWF	0–2 years (High)	S=120 hours/year V
	5.B.2. Provide support for and participate in building the Portage Lake Forever Endowment Fund to assure long-term financial support needed to involve stakeholders in the implementation and periodic updates of this plan.	MCCF, PLWF	0–2 years (High)	S=120 hours/year V
5.C. Ensure that growth and development in the communities within the watershed is directed to areas of the watershed with existing adequate infrastructure in a compact and mixed use manner, allowing for the conservation of existing open space and farmland outside of those areas.	**5.C.1.** Form a joint planning authority among the five communities in the watershed and develop a joint master plan and complementary zoning ordinances The emphasis of the plan and ordinances should be to direct development to areas of the watershed with existing adequate infrastructure; ensure that compact, mixed use development occurs in those areas; and conserve existing open space and farmland outside of those areas (see next section for specific tools/ordinances that could be considered).	AES, EPA, local government, LRBOI, MCCF, MCD, MDEQ, MDNR, MDOT, MSU Ext., PLA, PLEA, PLWF, School, USDA-NRCS, USFWS	0–2 years (High)	$50,000 S=120 hours/year S/V/M/N
	5.C.2. Implement watershed protection ordinances (see next section for specific tools/ordinances that could be considered).	AES, EPA, Health Dept., LRBOI, local government, MCCF, MCD, MDEQ, MDNR, MDOT, MSU Ext., PLA, PLEA, PLWF, School, USDA-NRCS, USFWS	2–5 years (Medium)	S=120 hours/year S/V/M/N

SOURCE: Public Sector Consultants Inc., 2007.

[1]Partner Abbreviations:
AES = Alliance for Economic Success (formerly Manistee Economic Development Office)
County = Manistee County
EPA = U.S. Environmental Protection Agency
ESM = Easter Seals of Michigan
Harbor Commission = Portage Lake Harbor Commission
Health Dept. = District Health Department #10
Historical Museum = Manistee County Historical Museum
LRBOI = Little River Band of Ottawa Indians
MCCF = Manistee County Community Foundation
MCD = Manistee Conservation District
MDEQ = Michigan Department of Environmental Quality
MDNR = Michigan Department of Natural Resources
MDOT = Michigan Department of Transportation
(Continued on following page)

School = Onekama Consolidated Schools
MSU Ext. = Manistee County Michigan State University Extension Office
Onekama Twp = Onekama Township
PLA = Portage Lake Association
PLEA = Portage Lake Environmental Association
PLWF = Portage Lake Watershed Forever
PPSRC = Portage Point Summer Resort Corporation
Townships = Onekama, Bear Lake, Manistee, and Brown Townships
USACE = U.S. Army Corps of Engineers
USDA-NRCS = U.S. Department of Agriculture – Natural Resources Conservation Service
USFWS = U.S. Fish and Wildlife Service
Village = Village of Onekama

[2] Timeline is from plan approval. All tasks to be accomplished in the 2–10 year time horizon are ranked as low priority for now, but should be reprioritized two years after the plan is approved.

[3] The estimated cost figures do not include anticipated volunteer time, donated equipment, existing educational material that will be adapted, PLWF newsletter that will deliver educational information, or staff support for coordination of all tasks within the watershed plan. Project coordination is estimated at $45,000–$65,000 per year (1/FTE) depending on experience and responsibilities. PLWF newsletter is estimated to cost $2,265/newsletter for 1,000 copies to produce and mail. Elements that require volunteer time (V), staff time (S), donated equipment (D), PLWF newsletter (N), and/or existing educational material (M) are noted.

Staff costs are based on the estimated number of hours multiplied by an average staff salary of $45,000 to $65,000, resulting in an average cost of $20–$30 per hour.

[4] An ecosystem is a sustainable, functioning complex or community of organisms interacting with each other and their physical and chemical environment as a unit.

Local Programs, Projects, and Planning

LOCAL GOVERNMENT PLANNING AND ZONING

Protecting water quality requires looking at what happens on the land within a watershed. How communities manage their land use has a direct impact on their water quality. Since watershed boundaries cross jurisdictional boundaries, it is important to consider each jurisdictional unit within a watershed while evaluating the effectiveness of local government planning and regulations in protecting water quality.

Five local government units are represented within the Portage Lake watershed: Onekama Township, Bear Lake Township, Manistee Township, Brown Township and the Village of Onekama. Exhibit 9 shows the acreage of each jurisdiction that falls in the Portage Lake watershed and the percentage of watershed area within each jurisdiction. Onekama Township comprises approximately one-half of the watershed area; Bear Lake Township and Manistee Township comprise approximately one-fifth each; Brown Township comprises less than one-tenth, and the Village of Onekama constitutes approximately 2 percent of the watershed area. It is important to note that the Village includes Portage Lake frontage.

A comprehensive or master plan is a blueprint or set of long-term goals and policies that a community uses to guide development decisions. A master plan can also be used to assist with special land use and site plan reviews; capital improvement programs; special programs such as economic development, parks, trails, gateway improvements, etc; and leveraging financial support for community efforts. Zoning is a tool for making master plans a reality. Zoning is regulatory and provides specific enforceable standards. Benefits of zoning include local control/autonomy over land use decisions, communicating clear expectations to potential developers based on community needs, and an opportunity for local residents to have input on designing the type of community in which they want to live. A review of master plans and zoning ordinances was conducted for each jurisdiction within the watershed. The status or lack of such documents is summarized in Exhibit 58.

EXHIBIT 58
Status of Planning and Zoning Documents for Jurisdictional Units within the Portage Lake Watershed

Jurisdiction	Comprehensive or master plan (last date of revision or adoption)	Zoning ordinance (last date of revision or adoption)
Village of Onekama	None on record (currently under development)	1990 (revision in progress)
Onekama Township	Adopted 2002 (revision in progress)	Adopted 1991; last revised 2005
Bear Lake Township	Adopted 2002 (Bear Lake Community Comprehensive [Joint] Plan adoption pending)	Adopted 1995; last revised 2007
Manistee Township	Adopted 2001	Adopted 1986; last revised 2006 (revision in progress)
Brown Township	Adopted 1991 (revision in progress)	Adopted 2001; last revised 2005

SOURCE: Public Sector Consultants Inc., 2007.

How and where a community grows has an enormous impact on water quality. Fortunately, a community can plan for growth in a way that protects water quality through planning and zoning. Exhibit 59 provides a brief summary of planning and zoning tools that protect water quality.

EXHIBIT 59
Planning and Zoning Tools to Protect Water Quality

Tool	Description
Joint planning	Storm-water management in a watershed basin typically involves cooperation and integration among several municipalities, jurisdictions, and planning agencies. Michigan's Joint Planning Act (Public Act 226 of 2003) authorizes local governments to pull together regional planning entities—Joint Planning Commissions. These commissions facilitate cooperation and coordination by overseeing issues for the region, or a portion of a region, in which they may have an interest, such as a business district, watershed, or greenway.
Storm management ordinance	An ordinance intending to minimize the potential adverse impacts on natural resources and water quality from storm- water runoff. It can require low-impact development,* soil erosion and sediment control for development projects, and best management practice incentives.
Mixed-use zoning	Allows residential, office, and retail buildings to be built close to one another, something traditional zoning forbids. More intense, compact development works best when different uses are within walking distance, so mixed developments can reduce the amount of land needed per unit. It also supports a range of transportation options and facilitates shared parking, thereby reducing the amount of surface needed for roads and parking lots.

Tool	Description
Septic system point-of-sale ordinance	An ordinance geared to protect water quality by requiring inspections and, if necessary, upgrades to septic systems at the time of property transfer.
Compact lot sizes	Allows land to be used more efficiently by building on smaller lots. Smaller lots also mean smaller lawns—large lawns treated with fertilizers and chemicals are a significant contributor to storm-water pollution.
Maximum setbacks	Establishes a maximum distance between buildings and the street. This change encourages more efficient use of space and pedestrian friendliness.
Open space planned unit developments (PUDs) and non-contiguous PUDs	Allows local governments to approve a PUD that preserves open space, whether it is connected or not to the rest of the PUD.
Purchase of development rights (PDR)	Allows municipalities, individuals, and organizations to purchase just the rights to develop (or not develop) a piece of land, instead of buying the land outright. PDR is currently available at both the state and local government levels; conservancies and land preservation groups can provide more information about these programs.
Urban service districts	Municipalities use urban service districts to define the edge of a community by limiting the extension of urban infrastructure. This encourages growth in areas with existing and adequate infrastructure while discouraging growth in undeveloped and environmentally beneficial areas.
Watershed alliances	Public Act 517 of 2004 allows two or more municipalities, by resolution of their governing bodies, to establish a voluntary watershed alliance to study problems and to plan and implement activities designed to address surface water quality or water flow issues.
Form-based codes	A method of regulating development to achieve a specific form — including the relationship of buildings to each other, to streets, and to open spaces—rather than allowing a certain use. “Design is more important than use” embodies the underlying philosophy behind the form-based code.

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

Zoning ordinances were specifically reviewed to help determine regulatory coverage for aquatic resources within the Portage Lake watershed, in order to help determine what, if any, environmental provisions are in place (see Exhibit 60).

EXHIBIT 60
Water Quality Protection Regulations in Zoning Ordinances within the Portage Lake Watershed

Water quality protection regulation	Village of Onekama	Onekama Township	Bear Lake Township	Manistee Township	Brown Township
Minimum parcel size	• 15,000 ft.^{2} within Portage Lake Shoreline Overlay Zone (PLSOZ) • 12,000 ft.^{2} elsewhere	• 1 acre agricultural, residential, and resort residential 1 • 90,000 ft.^{2} special and unique residential • 15,000 ft.^{2} resort residential 2, 3, and 4 • 15,000 ft.^{2} commercial	• 1 acre agricultural • 20,000 ft.^{2} resort residential and residential • 40,000 ft.^{2} commercial and multi-use	• 40 acres agricultural • 5 acres multi-use • 20,000 ft.^{2} country residential	• 10 acres for agricultural, forestry, and rural residential
Minimum parcel width	• 100ft. within PLSOZ • 75 ft. elsewhere	• 200 ft. agricultural residential • 300 ft. special and unique residential • 100 ft. resort residential 1, 2, 3, 4, and commercial	• 200 ft. road front for agriculture • 100 ft. road front resort residential and residential • 150 ft. road front commercial and multi-use	• 200 ft. agricultural • 300 ft. multiple use • 100 ft. country residential	• 330 ft.: Ratio of depth to width shall not exceed 4:1
Minimum buildable area	Not addressed	Not addressed	Not addressed	Not addressed	• 15,000 ft.^{2} of minimum 10-acre parcel including slopes >25 percent, beach contiguous to lake, river or stream, wetlands, or part of floodplain where flood waters expected to have destructive current
Maximum percentage developed or open space	Not addressed	Not addressed	Not addressed	Not addressed	Not addressed

Water quality protection regulation	Village of Onekama	Onekama Township	Bear Lake Township	Manistee Township	Brown Township
Setbacks from water	• 40 ft. (horizontal) or 2 ft. (vertical), whichever is greater, from surface water if connected to sewer • If not connected, distances are doubled	• 40 ft. from lakes and ponds	• 50 ft. from wetlands or flowing bodies of water	• 50 ft. from edge of water	• 200 ft. from edge of bodies of water in any district
Surface water buffer	• If manicured lawn within 11 ft. of waterbody, then trees with diameter of 3 in. shall not be removed unless dead or chronically diseased within 10 ft. of waterbody except for pruning • Other trees or woody plant material shall not be removed except to prune or clear filtered view • Landowner must maintain/establish this vegetation belt	Not addressed	• Within 50 ft. from edge of wetlands and flowing water only 10 percent trees, shrubs, and other natural growth may be removed in a five-year period	Not addressed	• Within 50 ft. from the edge of bodies of water only 10 percent of shrubs and trees may be removed in a five-year period
Wetlands	• Permit not issued for any land use or structure that is located on, drains, or fills a wetland • Variance if permit issued by State	Not addressed	• No building shall be built, located, or constructed within a wetland as determined by MDNR	Not addressed	Not addressed
Groundwater protection/hazardous waste	Not addressed	• Required provisions for businesses or facilities that generate or use hazardous substances	• Required provisions for businesses or facilities that generate or use hazardous substances	Not addressed	• Required provisions for businesses or facilities that generate or use hazardous substances

Water quality protection regulation	Village of Onekama	Onekama Township	Bear Lake Township	Manistee Township	Brown Township
Waste accumulation/outside storage	• No accumulation of junk, no sewage, wastewater, or water containing foreign substances may be deposited into water bodies unless approved (not including manure, fertilizers, or other soil conditioners for farming, forestry, home garden, and lawn uses)	• No accumulation of junk, no sewage, wastewater, or water containing foreign substances may be deposited into water bodies unless approved (not including manure, fertilizers, or other soil conditioners for farming, forestry, home garden, and lawn uses)	• No accumulation of junk, no sewage, wastewater, or water containing foreign substances may be deposited into water bodies unless approved (not including manure, fertilizers, or other soil conditioners for farming, forestry, home garden, and lawn uses)	• No accumulation of junk, no sewage, wastewater, or water containing foreign substances may be deposited into water bodies unless approved (not including manure, fertilizers, or other soil conditioners for farming, forestry, home garden, and lawn uses)	Not addressed
Storm water	Not addressed	Not addressed	Not addressed	Not addressed	Not addressed
Planned Unit Development	Included	Included	Included	Included	Included
Other	• Portage Lake Shoreline Overlay District was created to protect shoreline of Portage Lake and other bodies of surface water in the Village while providing for development of waterfront uses that are in compliance with Portage Lake Management Plan (1987)	• One boat dock for private use on lakefront parcels • Wind Energy Conversion System	• Keyhole Waterfront Access provision to protect integrity of lakes while preserving quality of recreational use	• Special provisions for other watersheds not including Portage Lake	• Special provisions for other watersheds not including Portage Lake

SOURCE: Public Sector Consultants Inc., 2007.

Although all jurisdictions have some water quality protection measures in their zoning ordinances it is important to keep in mind that the effectiveness of zoning ordinances depends on many factors, including restrictions in the language, enforcement, and public support. Zoning can be a sensitive issue for some units of government and there are multiple challenges to implementing and enforcing a strong ordinance, including community understanding and support and fiscal and legal challenges.

Joint Planning

Recently the Village of Bear Lake, Bear Lake Township, and Pleasanton Township informally agreed to a process to combine planning and zoning responsibilities and established the Bear Lake Community Joint Planning Commission under the Joint Municipal Planning Act, Public Act 226 of 2003 (MCL 125.131 et seq.), and established a joint comprehensive plan. The commission is only the sixth such commission in Michigan.

Recommendations

While all jurisdictions within the watershed have some water quality protection measures in place, additions could be made to provide greater protection. To further the goals and objectives of the Portage Lake Watershed Forever Plan, the five communities in the watershed should form a Joint Planning Authority and develop a joint master plan and complementary zoning ordinances. The emphasis of the plan and ordinances should be to direct development to areas of the watershed with existing adequate infrastructure; ensure that compact, mixed use development occurs in those areas; and conserve existing open space and farmland outside of those areas. Specific tools/ordinances that could be considered include the following:

- Storm water management ordinance
- Compact development tools including mixed use zoning, compact lot sizes, maximum setbacks, and an urban service district
- Open space PUDs and non-contiguous PUDs that encourage low densities near headwater areas and high densities in the Village of Onekama
- Purchase of Development Rights program or other farmland preservation tools
- Buffer ordinances and setbacks along surface waters
- Local wetland protection ordinance
- Goundwater protection regulations
- Form-based code zoning

Effective land use planning is one tool for watershed protection. It is most effective when used in conjunction with other measures including educational outreach programs, land protection for critical habitat areas, and implementation of best management practices.

OTHER AGENCIES AND LOCAL ORGANIZATIONS

Numerous agencies and local organizations play important roles in enhancing the quality of life and economic well-being of the Portage Lake watershed. It will be important to leverage their expertise and efforts to help further the goals and objectives of the Portage

Lake Watershed Forever Plan through the implementation of the plan. In addition to the local government units discussed in the section above, the following federal, state, and local agencies should continue to be engaged.

- District Health Department #10
- Manistee County
- Manistee County Road Commission
- Michigan Department of Environmental Quality
- Michigan Department of Natural Resources
- Michigan Department of Transportation
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture—Natural Resource Conservation Service
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service

In addition, numerous organizations should also be engaged as partners in the implementation phase of the plan. Some of these organizations and their missions are listed in Exhibit 61. Additional entities include Onekama Consolidated Schools, Portage Point Summer Resort Corporation, and various service clubs including the Lions, Clio, and Garden Clubs.

EXHIBIT 61
Mission Statement of Local Organizations

Organization	Mission statement
Manistee County Community Foundation	Changing the way we give, enhancing the way we live.
Alliance for Economic Success (formerly known as the Manistee Economic Development Office)	The Alliance for Economic Success has three missions: *Retention, Expansion, & Attraction.* To be the recognized leader in customer service and meaningfully improving the economic well-being and quality of life for Manistee County through programs involving the retention, expansion, and attraction of businesses and jobs. *Economic Development Cornerstones.* To ensure and assist in creating an environment that makes Manistee County a first-choice community for new and existing businesses. *Resource Development*. To support the development of financial and human resources in order to meaningfully impact or influence the economic well-being and quality of life for Manistee County.
Manistee Conservation District	The Manistee Conservation District will strive to promote good stewardship, protect the natural resources, and provide the education necessary to achieve these goals in partnership with our community.
MSU Extension, Manistee County	Helping people improve their lives through an educational process that applies knowledge to critical needs, issues, and opportunities.
Portage Lake Association	A nonpolitical organization formed to advance, support, and promote the welfare of the Onekama and Portage Lake area.
Portage Lake Environmental Association	To promote sound environmental programs for the conservation, protection, and preservation of Portage Lake and its environs from environmental degradation and impairment, and to stimulate the public interest in environmental matters.

SOURCE: Public Sector Consultants Inc., 2007.

Information and Education Plan

This Information and Education (IE) strategy addresses the communication needs associated with implementing the Portage Lake Watershed Forever Plan. Increasing awareness and understanding about how actions on the land within a watershed can impact water quality is a critical step toward water quality protection and improvement.

During the planning process, a variety of means were used to inform the public and other stakeholders about the planning process and outcomes, and also to seek input to be used in the development of the plan: numerous focus groups were held with stakeholders, a resident survey was conducted, presentations were made to various civic organizations and property owner associations, e-mail updates were issued, and many informal conversations were held. These activities helped to educate community members about the planning process and the benefits of having a watershed management plan, and engaged them in the development of this plan.

To help inform future public education efforts, a series of questions were included in the survey of households in the Portage Lake Watershed conducted by Public Sector Consultants in 2007. These questions asked residents where they obtain their information about the watershed and which sources of information they trust. Local newspapers were the most cited source. The sources of information considered the most trustworthy by residents are neighborhood or lake associations, the District 10 Health Department, and MSU Extension. When respondents were asked to list other organizations, people, or groups that they would trust or look to for information about the Portage Lake watershed, the Portage Lake Watershed Forever Committee was the group most frequently mentioned. (For more detailed information about these efforts and findings refer to the Stakeholder Involvement section of this plan.) These public engagement efforts helped to shape the goals and objectives of the watershed plan and helped to identify specific needs and strategies for information and education.

The purpose of the IE strategy is to establish and promote educational programs that support effective implementation of watershed planning goals, objectives, and tasks. Exhibit 62 outlines key tasks in this strategy. It is important to note that a great deal of educational material exists on many of the issues this plan seeks to address. Therefore, to keep costs down, existing materials will be modified for the Portage Lake watershed rather than generating new sources of information.

EXHIBIT 62
Public Information and Education Plan

IE task	Target audiences	Frequency	Medium or method	Potential partners[1]	Timeline (years out)	Estimated cost/year[2]
Inform stakeholder of results of *E. coli* beach monitoring	Beach owners, general public, riparian owners, local governments, tourists	Immediately upon results, annual summary	Website, e-news list, newspaper, newsletter, kiosk/bulletin board	PLWF, MSU Ext., MCD, PLA, PLEA, PPSRC, School	0–2	S/V/N
Inform stakeholders of results of other *E. coli* monitoring efforts and other monitoring efforts	Riparian owners, local governments, general public, tourists	Immediately if public health risk, otherwise quarterly summaries	Website, e-news list, newspaper, kiosks/bulletin board	PLWF, MSU Ext., MCD, PLA, PLEA, PPSRC, School	0–2	S/V/N
Implement a cooperative pollution prevention program to protect groundwater from hazardous chemicals	Businesses, local governments	Initiate, annual reminder as needed	Letter, brochure, workshop, newspaper	PLWF, MSU Ext., MCD, MDEQ, EPA	2–5	S/V/M/N
Implement a mechanism to ensure anglers have the best information on state consumption advisories for fish taken from Portage Lake	Anglers, general public, tourists, local governments	Develop, update as needed	Website, e-news, kiosk/bulletin board, newsletter, newspaper	MDNR, MDEQ, LRBOI, MSU Ext., MCD, PLA, PLEA, PPSRC, PLWF	2–5	S/V/M/N
Establish a reporting mechanism for incidences of swimmer's itch in Portage Lake	General public, riparian landowners, tourists, local governments	Develop, then ongoing	Website, e-mail, newsletter, comment card	Onekama Twp., Village, PLWF, School, PLA, PLEA, PPSRC	0–2	$500+S/V/N
Provide information about swimmer's itch, its causes, and steps to minimize exposure	General public, riparian landowners, tourists, local governments	Develop, repeat annually	Brochure, newspaper, website, e-news	MSU Ext., MCD, PLA, PLEA, PPSRC, PLWF	0–2	S/V/N
Develop and distribute information about cost-effective ways to have drinking water tested for bacteria and contaminants	General public, businesses, local governments	Develop, repeat annually	Strategy, brochure, newspaper, newsletter, website, e-news	Health Dept., MSU Ext., MCD, USDA-NRCS, MDEQ, School	0–2	S/V/M/N
Advocate for groundwater pollution prevention best management practices, including plugging of abandoned domestic	Well drillers, Health Dept., general public, businesses, local	Develop, implement strategy, annual	Strategy, brochure, newspaper,	MSU Ext., MCD, USDA-NRCS, Health Dept.,	0–2	S/V/M/N

IE task	Target audiences	Frequency	Medium or method	Potential partners[1]	Timeline (years out)	Estimated cost/year[2]
and hydrocarbon wells, quick response to known areas of release or spills of contaminated materials, and encouraging local governments to support volunteer household hazardous waste disposal programs	governments	update	newsletter, e-news, website	MDEQ, PLWF		
Develop and distribute information on proper maintenance and operation of septic systems	General public, riparian landowners, local governments, businesses	Develop, annual distribution	Brochure, newsletter, newspaper, video, website, e-news, workshop	MSU Ext., MCD, USDA-NRCS, MDEQ, Health Dept., School, PLWF	0–2	S/V/M/N
Develop and distribute information on limiting phosphorus loadings to surface water through use of low- or zero-phosphorus fertilizers	Riparian landowners, businesses, general public	Develop, annual distribution	Brochure, newspaper, newsletter, website, e-news	MSU Ext., MCD, USDA-NRCS, MDEQ, Health Dept., School, PLWF	2–5	S/V/M/N
Develop and distribute information on the important functions of wetlands	Riparian landowners, local governments	Develop, annual distribution	Brochure, newspaper, newsletter, website, e-news	MSU Ext., MCD, USDA-NRCS, USFWS, MDEQ, EPA, MDNR, School, PLA, PLEA, PPSRC, PLWF	0–2	S/V/M/N
Develop and distribute information on the importance of the nearshore littoral zone and the impacts of beach grooming, shoreline hardening, and permanent mooring structures on the habitat essential to resident fish, wildlife, and fish food organisms	Riparian landowners, local governments	Develop, annual distribution	Brochure, newspaper, newsletter, website, e-news	MSU Ext., MCD, USDA-NRCS, USFWS, MDEQ, EPA, MDNR, School, PLA, PLEA, PPSRC, PLWF	0–2	S/V/M/N

IE task	Target audiences	Frequency	Medium or method	Potential partners[1]	Timeline (years out)	Estimated cost/year[2]
Train local volunteers in a Portage Lake Watershed Stewardship program to periodically inventory and monitor certain stream and lake conditions (e.g., point-source and nonpoint source discharges, *Cladophora* algae, invasive species, erosion, shoreline development, wetlands, physical/biological/chemical conditions, etc.)	Riparian landowners, general public, School, PLWF, local governments	Develop, implement, repeat as necessary	Training packet, newsletter, workshop	MDEQ, MDNR, LRBOI, PLWF, MSU Ext., MCD	2–5	$6,000+S/V/D/N
Establish a forum/communication tool that can be used by various resource protection and management agencies to communicate information to and answer questions from residents and visitors to Portage Lake	MDEQ, MDNR, LRBOI, general public, School, riparian landowners	Develop and maintain	Website, newsletter, bi-annual meeting	MSU Ext., MCD, PLA, PLEA, School, PLWF	2–5	$500+S/V/N
Prepare and distribute information about public access facilities currently available for non-boating users	General public, tourists	Develop, update, and distribute annually	Brochure, website, e-news, newspaper, newsletter, kiosk/bulletin board	PLA, PPSRC, local governments, PLWF	5–10	$1,340+S/V/N
Collect further information on user conflicts reported during 2007 Public Sector Consultants phone survey of Portage Lake residents and determine whether further actions are needed	General public, riparian landowners, tourists	Once, update as necessary	Survey, meetings, interviews	PLWF, local governments, School, PLA, PPSRC, PLEA	2–5	$15,000
Develop and distribute information about the location of scenic vistas, historical sites, and locally grown produce in the watershed	General public, tourists	Develop, update, and distribute as necessary	Brochure, newspaper, newsletter, e-news, website, kiosk/bulletin board	PLWF, local governments, School, Historical Museum, service clubs	2–5	$1,340+S/V/N
Recommend education, information, and voluntary actions by private landowners and public agencies about how to protect and enhance public enjoyment of scenic vistas	Private landowners and public agencies that own property that provides scenic vistas	Once, repeat as needed	Strategy, letter, meetings	PLWF, MDOT, GTRLC	5–10	$500+S/V

IE task	Target audiences	Frequency	Medium or method	Potential partners[1]	Timeline (years out)	Estimated cost/year[2]
Encourage private and public efforts to preserve, protect, and provide interpretation of sites of historical significance	Private landowners and public agencies that own/operate historic sites	Once, repeat as needed	Strategy, letter, meetings	Historical Museum, PLWF, local governments, service clubs	5–10	$500+S/V
Promote local agricultural products and encourage their sale and use.	General public, tourists	Develop, update, and distribute as necessary	Guides, newspaper, newsletter, e-news, website, kiosk/bulletin board	USDA-NRCS, MCD, MSU Ext., AES, PLWF, local farmers and businesses	0–2	$1,340+S/V/N

SOURCE: Public Sector Consultants Inc., 2007.

[1]Partner Abbreviations:
EPA = U.S. Environmental Protection Agency
GTRLC = Grand Traverse Regional Land Conservancy
Health Dept. = District Health Department #10
Historical Museum = Manistee County Historical Museum
LRBOI = Little River Band of Ottawa Indians
MCD = Manistee Conservation District
MDEQ = Michigan Department of Environmental Quality
MDNR = Michigan Department of Natural Resources
MDOT = Michigan Department of Transportation
MSU Ext. = Manistee County Michigan State University Extension Office
Onekama Twp. = Onekama Township
PLA = Portage Lake Association
PLEA = Portage Lake Environmental Association
PLWF = Portage Lake Watershed Forever
PPSRC = Portage Point Summer Resort Corporation
School = Onekama Consolidated Schools
USDA-NRCS = U.S. Department of Agriculture – Natural Resources Conservation Service
USFWS = U.S. Fish and Wildlife Service
Village = Village of Onekama

[2]The estimated cost figures do not include anticipated volunteer time, existing educational material that will be adapted, donated equipment, PLWF newsletter that will deliver educational information, or staff support for coordination of all tasks within the watershed plan. Project coordination is estimated at $45,000–$65,000 per year (1/FTE) depending on experience and responsibilities. PLWF newsletter is estimated to cost $2,265/newsletter for 1,000 copies to produce and mail. Elements that require volunteer time (V), staff time (S), PLWF newsletter (N), donated equipment (D), and/or existing educational material (M) are noted.

Monitoring and Evaluation

The true test of the efficacy of this watershed management plan will be the implementation of the plan goals and objectives. Implementation of watershed plan goals and objectives for site-specific activities will require continuous monitoring. Evaluation of monitoring activities will also be necessary to determine the progress and effectiveness of the proposed activities.

MONITORING PLAN

Exhibit 63 summarizes the key elements of the proposed monitoring plan that correspond to specific actions items listed under Goals and Objectives (Exhibit 57). For elements that involve sampling, a map of monitoring locations can be found in Exhibit 64. Monitoring of conditions within the Portage Lake watershed is a key component of this watershed plan since the focus is on sustaining current conditions that support designated and other beneficial uses. The proposed monitoring plan will also help fill information gaps on both habitat conditions and conformance with water quality standards. The intent of the monitoring plan is to detect changes in environmental conditions early enough to develop corrective actions before significant impairments occur. The monitoring plan focuses the three priorities of the watershed plan—public health, aquatic ecosystem health, and groundwater protection.

EXHIBIT 63
Portage Lake Watershed Monitoring Plan

Type of sampling	Frequency	Start date/ End date	Locations	Total number samples/year	Estimated cost/year*	Responsibility/ potential partners
Public Health						
***E. coli* (bacteria)** Portage Lake swimming areas	• Once per week through time of operation (assume May 31–Oct 1) for Village Beach (public beach—per District 10 Uniform Sanitary Code pending adoption) • Once per month at other sites May 31–Oct 1	Summer 2008/2011	Up to five swimming areas in Portage Lake including: • Portage Point Inn • Little Eden Camp • Village of Onekama Beach • Covenant Bible Camp • Wik-A-Te-Wak	Village: 18 weeks x 3 replicates = 54 samples; Other sites: 4 months x 4 sites x 3 replicates = 48 samples.	Village: 54 samples x $20 = $1,080; Other sites: 48 samples x $20 per sample = $960. Total = $2,040	• Onekama Township • Village of Onekama • Covenant Bible Camp • Little Eden Camp • Portage Point Inn • Portage Lake Environmental Association • Portage Lake Association • District 10 Health Department • Onekama Consolidated Schools • Portage Lake Watershed Forever • Michigan Department of Environmental Quality (MDEQ)
E. coli Lake Michigan beach/Onekama Township	Once per week through time of operation (July–mid-September in past)	2008/2011	Lake Michigan beach north of Portage Lake Channel Onekama Township Park	11 weeks x 3 replicates = 33 samples	33 samples x $20 = $660	• District Health Department #10 • Onekama Township • MDEQ

Type of sampling	Frequency	Start date/ End date	Locations	Total number samples/year	Estimated cost/year*	Responsibility/ potential partners
E. coli Other sites	Three times per year for at least four sites of suspected sources	2008/TBD	High-density residential areas along Portage Lake, near mouths of selected tributaries, and at areas of heavy use (boat launches and marinas)	4 sites x 3 events x 3 replicates = 36 samples each year	36 samples x $20 = $720	• Onekama Township • Portage Lake Environmental Association • Portage Lake Association • District 10 Health Department • Portage Lake Watershed Forever • Onekama Consolidated Schools • MDEQ
Aquatic Ecosystem Health						
Long-Term Trend Water Quality Data Dissolved oxygen (DO), phosphorus, Chlorophyll *a*, clarity (Secchi), temperature, and pH	Twice per year each year (spring and fall turnover)	2008/TBD	At two deepest basins in Portage Lake and at least one other area (established sites)	DO: 2 events x 3 sites = 6 samples; Total Phosphorus: 2 events x 3 sites = 6 samples; Chlorophyll *a*: 2 events x 3 sites = 6 samples; Clarity: 6 Secchi disk readings; Temperature profile pH = 6 reading using pH meter	DO: 6 samples by titration process = $0; Total Phosphorus: 6 samples x $21 = $126; Chlorophyll *a*: 6 samples x $55 = $330; Clarity: $0; Temperature: $0; pH: $0. Total = $456	• Onekama Consolidated Schools • Portage Lake Watershed Forever • Onekama Township • Village of Onekama • MDEQ

Type of sampling	Frequency	Start date/ End date	Locations	Total number samples/year	Estimated cost/year*	Responsibility/ potential partners
Dissolved Oxygen Profile	At least three times per year every three years during summer stratification to detect duration of DO depletion	2008	At two deepest basins in Portage Lake	Hydrolab/YSI: Assume donated use and labor	S/V/D	• Portage Lake Watershed Forever • Little River Band of Ottawa Indians • Michigan Department of Natural Resources (MDNR) • MDEQ • Onekama Consolidated Schools
Dissolved Oxygen Profile	At least twice per year every three years at two locations during summer stratification over a 24-hour period	2008	At two deepest basins in Portage Lake	Hydrolab/YSI: Assume donated use and labor	S/V/D	• Portage Lake Watershed Forever • Little River Band of Ottawa Indians • MDNR • MDEQ • Onekama Consolidated Schools
Tributary Survey Inventory benthos, bank erosion sites, road/stream crossing, fish migration barriers, habitat, wetlands, bank cover, water temperature, etc.	Once every five years	2010–13	Walking in up to seven tributary streams at sites TBD including: • Schimke • Onekama • Glen • Dunham	TBD	$1,000+S/V/D/N	• Portage Lake Watershed Forever • Little River Band of Ottawa Indians • MDNR • MDEQ • U.S. Fish and Wildlife Service • Onekama Consolidated Schools • Townships and Village

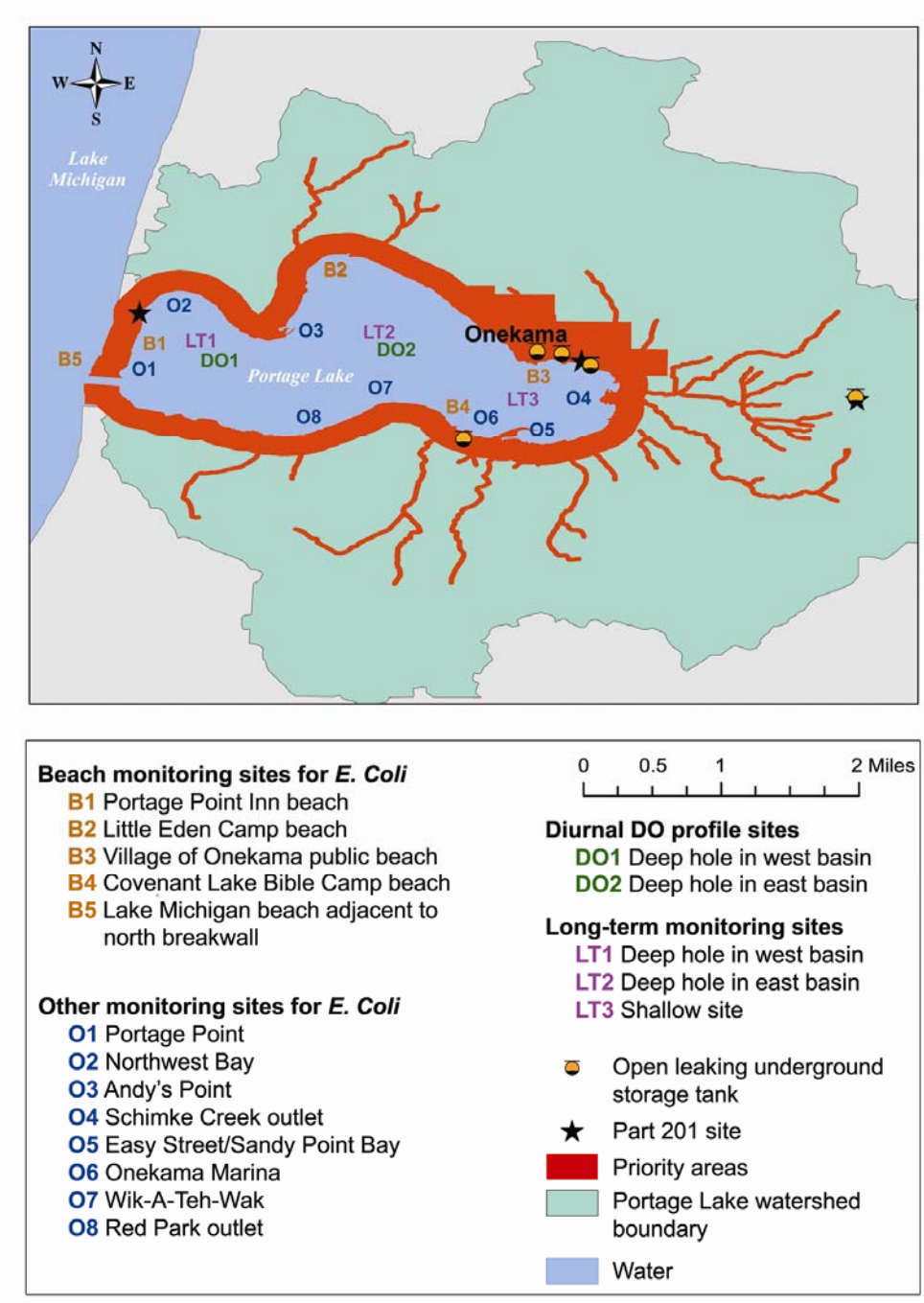
Type of sampling	Frequency	Start date/ End date	Locations	Total number samples/year	Estimated cost/year*	Responsibility/ potential partners
Shoreline Survey Wetlands, erosion, shoreline development, *Cladophora* and invasive plant species	Every five years late May–early July	2008–10	Boat/kayak/canoe survey of Portage Lake	None	$1,000+S/V/D/N	• Portage Lake Watershed Forever • Little River Band of Ottawa Indians • MDEQ • MDNR • Onekama Consolidated Schools • Onekama Township
Fisheries Surveys Creel, walleye, general lake survey, tributary	Every five years	TBD	Creel: public access sites and boat survey; Walleye: electroshocking; Lake: netting and electroshocking; Tributary: electroshocking	TBD	$1,000+S/V/D/N	• MDNR • Little River Band of Ottawa Indians • U.S. Fish and Wildlife Service
Aquatic Plant Survey	Once every 5–10 years during late July/early August	2008–10	Use grid system to map lake	TBD	$1,000+S/V/N	• MDNR • MDEQ • Portage Lake Watershed Forever • Onekama Consolidated Schools
Storm Water Inventory and Monitoring	Inventory once, monitor every year during base flow and storm flow conditions	TBD	TBD after inventory	TBD	$1,000+S/V/N	• Village of Onekama • Onekama Consolidated Schools • MDEQ • Portage Lake Watershed Forever

Type of sampling	Frequency	Start date/ End date	Locations	Total number samples/year	Estimated cost/year*	Responsibility/ potential partners
Groundwater Protection						
Artesian Wells and Abandoned Wells	Inventory once, plug abandoned wells	Year TBD	TBD after inventory	TBD	$1,000+S/V/N	• District 10 Health Department • MDEQ • Village of Onekama • Townships • Portage Lake Watershed Forever • Onekama Consolidated Schools
Map Locations of Scenic Vistas and Historical Significance	2008	2010–13/TBD	Watershed	NA	S/V	• Portage Lake Watershed Forever • Little River Band of Ottawa Indians • Manistee County Historical Society

SOURCE: Public Sector Consultants Inc., 2007.

*The estimated cost figures do not include anticipated volunteer time, existing educational material that will be adapted, donated equipment, PLWF newsletter that will deliver educational information, or staff support for coordination of all tasks within the watershed plan. Project coordination is estimated at $45,000–$65,000 per year (1/FTE) depending on experience and responsibilities. PLWF newsletter is estimated to cost $2,265/newsletter for 1,000 copies to produce and mail. Elements that require volunteer time (V), staff time (S), PLWF newsletter (N), donated equipment (D), and/or existing educational material (M) are noted.

EXHIBIT 64
Map of Monitoring Locations in the Portage Lake Watershed



SOURCE: Public Sector Consultants Inc., 2007, using data from MDEQ, 2007b, MDIT/CGI (Manistee Final Wetland Inventory), and MDIT/CGI (LP Watersheds).

As a not-for-profit group, the Portage Lake Watershed Forever organization will seek public-agency and private-entity partners, train volunteer watershed stakeholders and, when necessary, raise funds in order to implement the proposed monitoring plan. In some

cases technical laboratory services will be contracted to perform needed chemical or bacteriological analyses. In most cases the cost, types and frequency of sampling, locations, and partners have been identified along with the projected start and end dates. For some sampling activities, such as stream monitoring, specific locations, the cost and time needed to train volunteers, and other elements will need to be determined.

The monitoring plan reflects the priorities of the watershed stakeholders based upon available information and the potential threats to protected and desired uses. The end point and measures of success are based primarily upon meeting and maintaining state water quality standards. In the absence of specific water quality standards, other measures have been established. The monitoring plan focuses the three priorities of the watershed plan—public health, aquatic ecosystem health, and groundwater protection. If the water quality standards and critical aquatic habitats for these three priorities are met, all existing designated uses can be protected. The monitoring plan also provides for collecting information on non-water-related desired natural resource uses that the Portage Lake Watershed Forever organization is also including in its watershed plan.

Public Health

Monitoring of *E. coli* bacteria to determine compliance with both total-body and partial-body contact water quality standards will require more frequent sampling and added sites in the future. Testing in public swimming areas will be conducted in compliance with the District 10 Health Department's pending Uniform Sanitary Code and will include the popular swimming areas in Portage Lake as well as the swimming area in Lake Michigan immediately north of the Portage Lake Channel. Once every three years other areas of Portage Lake will be sampled for *E. coli* to determine year-round compliance with total- and partial-body contact standards where human uses near the shoreline pose a threat of bacterial contamination.

Aquatic Ecosystem Health

The primary concerns and/or threats to ecosystem health in the Portage Lake Watershed are over-enrichment or eutrophication, loss of critical physical habitat, and changes in the quantity and quality of groundwater. Fortunately, historical monitoring of productivity of Portage Lake has created a baseline that can be used to determine changes in the productivity or trophic status of the lake. As part of the science education curriculum at Onekama High School, students have participated in annual monitoring of critical parameters needed to establish whether the trophic status of Portage Lake has changed. Students have monitored and reported on total phosphorus, transparency, and chlorophyll *a* that together can be used to establish a trophic status index (TSI), which has been used widely throughout Michigan, Wisconsin, and other states to monitor productivity. With the support of Portage Lake Watershed Forever, this routine annual monitoring can continue, supplemented by other monitoring efforts.

Dissolved oxygen concentrations in Portage Lake will be measured to establish conformance with state water quality standards as well as to supplement information related to the potential threat of over-enrichment. While current information indicates that state standards are being met, more information is needed on DO levels during a 24-hour period to assure that minimum levels are being met both in the summer stratification

period and throughout the year. The monitoring plan includes testing during periods where there has not been sampling in Portage Lake recently, and complements the annual DO analyses conducted as part of the spring and fall sampling by Onekama Lake High School students. In addition, DO measurements will be made to determine whether the period of DO depletion in deeper portions of the lake is increasing in terms of intensity or length of time during the period of spring through fall temperature stratification.

A *Cladophora* algae survey will also be conducted under the monitoring plan to establish whether there are significant nearshore sources of phosphorus (e.g., septic tank/tile field, sheet runoff coming from lawns, storm water runoff from impervious surfaces) that are contributing to enrichment of the lake. This information will be used in combination with *E. coli* monitoring to evaluate the effectiveness of current septic tank/tile fields serving a significant portion of the residences surrounding Portage Lake. The planned *Cladophora* survey can be compared to the previous algae surveys that provide a baseline for measuring changes over time.

A baseline survey of rooted aquatic plants (macrophytes) is needed to determine the status of various exotic, invasive plant species identified in this plan. The monitoring plan calls for mapping of macrophyte growth with particular attention to identifying areas that have purple loosestrife, *Phragmites* within adjacent wetland areas, and Eurasian watermilfoil in the lake proper. These three species are very aggressive and monitoring can assist in determining whether their abundance represents a threat to designated protected uses (e.g., swimming, boating, habitat for fish and wildlife) that needs to be addressed. Because of existing very low water levels of Portage Lake, the previous inventory completed in 1991 does not provide an adequate baseline for levels of invasive species.

The remaining undisturbed shoreline habitat in Portage Lake and the habitat quality in tributary streams have been identified as critical to the survival, reproduction, and growth of resident fish and wildlife populations. The monitoring plan outlines efforts to identify and map critical shoreline wetlands and other undisturbed shoreline littoral zones in the lake and conditions on tributary streams through use of trained volunteers. At the same time, trained volunteers will be recording visual observations of potential problems (erosion areas, fish movement impediments in streams, bank vegetation, storm-water discharge pipes, etc.) and collecting samples (benthos and simple water chemistry and temperature). Although the details of the sampling, mapping, and recording of information by the volunteers are yet to be determined, successful use of volunteers in other watersheds (e.g., Clinton River, Rouge River, and Huron River) will be used as models for developing this program.

In partnership with the MDNR, the USFWS, the MDEQ, and the Little River Band of Ottawa Indians, sampling of fish populations in Portage Lake and its tributaries, periodic biological monitoring of tributary streams for sea lamprey control, and hoped-for benthos monitoring by the MDEQ, will complement other information on ecosystem health and habitat changes.

Groundwater Protection

While the MDEQ is addressing known sources of groundwater contamination in the watershed caused by surface discharges of hazardous materials or leaking underground storage tanks of hydrocarbon products, an inventory of uncapped industrial hydrocarbon/mineral wells and abandoned domestic water wells is needed. In partnership with appropriate local and state authorities, the monitoring plan includes efforts to identify, map, and appropriately plug unused wells because they provide direct access of potentially contaminated surface water to groundwater aquifers. Groundwater aquifers provide drinking water to watershed residents and are also a major source of cool, unpolluted recharge water to Portage Lake and tributary streams. One portion of the monitoring effort will be to identify and close flowing artesian wells that no longer serve their intended purpose and may be contributing to depletion of essential groundwater aquifers.

EVALUATION

In cooperation with its partners, the Portage Lake Watershed Forever organization will routinely evaluate the monitoring results. Where baseline information is currently available, new monitoring information will be compared to baseline information and if significant adverse changes are noted, specific actions will be recommended to expand monitoring efforts to further define the source of the problem or, if the source is known, direct action will be taken to correct the problem. Where specific numeric or narrative water quality standards apply, exceedances will be reported and actions needed to implement best management practices and/or to institute regulatory actions will be recommended. The monitoring plan identifies specific times to evaluate results and to determine the need to modify, expand, or eliminate monitoring activities, or take corrective actions. Unless otherwise specifically noted, the monitoring results and the watershed plan will be reevaluated every five years beginning in 2010. If the review of monitoring results identifies significant problems prior to the established evaluation date, further direct actions will be taken to address the documented problem and, if appropriate, immediate actions and public notification will occur to minimize potential imminent threats to public health or the environment.

A measure of success will be confirmation that all water quality standards continue to be met and designated uses are protected. Where state standards are not available, the measure of success will be no evidence of significant deterioration of current environmental conditions. If information is uncovered through monitoring that state water quality standards are not being met or that other changes have occurred that will likely impair protected or desired uses, further actions will be recommended to address the most likely sources of the impairments.

Successful establishment of the institutional structure to assure implementation of the recommendations of this plan is critical. While volunteers can contribute substantially to the monitoring effort, the Portage Lake Watershed Forever organization needs to formalize its structure and operations as recommended to assure that it has staff that can organize and manage the elements in the monitoring plan and evaluate the results.

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