STRESSORS ON THE ENVIRONMENT

For the purposes of this technical report, stressors on the environment are those human induced changes to the environment that have produced a corresponding detrimental effect on the ecosystem. Two key stressors, land use and commercial navigation and recreational boating, have been identified in this technical report as being detrimental or as having the potential to detrimentally affect the Lake St. Clair Canadian watershed ecosystem. A summary of each stressor and the identification of management issues are contained here.

Land Use

Land use is the single largest stressor to the Lake St. Clair ecosystem. The appropriate management of this stressor will result in the greatest improvement to the Lake St. Clair ecosystem.

The creation of impervious landscapes associated with urban, industrial and agricultural environments has altered the natural hydrologic cycle, fragmented forests and wetlands into isolated components, degraded aquatic communities and reduced the habitat of floral and faunal populations. These pressures have created the challenge of protecting and sustaining the natural environment while providing opportunities for people to thrive and prosper.

Settlement History

Prior to European settlement, the southern Ontario landscape was primarily forest with some tallgrass prairie and large areas of wetlands that included wooded swamps.

From about AD 900 to the initial European contact, the presence of Aboriginal peoples had a limited impact on the ecosystem of the Lake St. Clair watershed (Federation of Ontario Naturalists 1999). Their agricultural society involved regular 10 to 30 year cycles of clearing new locations. Farming based on corn (and later squash, beans, sunflowers and tobacco) supported large villages. Water travel made the St. Clair River, Lake St. Clair and their tributaries an important part of the pre-European settlement.

There was a drastic decrease in the Aboriginal population through disease, displacement and warfare after European contact in the 1600s. The Thames River valley was greatly de-populated after the 1650s when the Iroquois dispersed the Neutral peoples. Other First Nation groups began to re-settle along the Thames River prior to 1700. The history and cultural heritage of the four First Nations located on the Thames River are described in the *Thames River Watershed Background Study* (Upper Thames River Conservation Authority 1998). Along the St. Clair River, the Aamjiwnaung First Nation is located at Sarnia, and the St. Clair delta is home to the Walpole Island First Nation.

By the time organized land surveys were being done in the late 1700s and early 1800s, regenerated forest had erased the impacts of native agriculture. Most of southern Ontario had relatively mature forest cover and old growth forests were common.

Early European settlers recognized the potential for harvesting lumber and the ecosystem began to change as the mature forest was harvested. Access to water transport to float logs and ship timber made the larger watercourses a primary focus for the lumber industry and subsequent agricultural development. Early farmers viewed forests more as impediments to development rather than a resource. If a tree was not fit for square timber it was burned for ashes that were sold for the manufacturing of potash. Mechanization and the development of new farm equipment in the latter part of the 1800s and early 1900s hastened the process of deforestation and conversion of natural landscapes to farmland.

Over a period of 100 to 150 years, forest, swamp and prairie lands were converted into a rural agricultural landscape. The drainage of wetlands to develop agricultural land and to improve the network of roads resulted in a significant change to the ecosystem. In Ontario, the *Drainage Act* supported construction of municipal drains in the 1880s and beyond. Intricate farm and township drainage systems were developed and now link virtually every farm in the watershed. Most of the wetlands were drained for agricultural purposes. Tallgrass prairie was easily converted to farmland and very little prairie remains. By the early 1900s, most of the original woodlands had been converted to non-forest land use, primarily agriculture.

Urban settlement was part of the rural-agricultural development throughout the 1800s. Successful farming resulted in the need for grist (flour and feed) mills, distilling and brewing and early textile manufacture (wool and flax) to convert farm products into commercial goods. Within the watershed, a number of villages, towns and cities emerged. Urban development often started at strategic river crossings and at mill sites where the availability of waterpower contributed to industrial development. Small plants that began by manufacturing farm equipment were often the start of larger industrial developments that led to the employment and residential growth of a community. London, the largest Canadian city in the Lake St. Clair watershed, grew in association with several mill sites located along both the north and south branches of the Thames River.

Water transportation supported urban development and most early urban centres began as strategic trans-shipment points. The cities of Sarnia and Windsor, located at the heads the St. Clair and the Detroit Rivers respectively, were important terminals for goods and people. Lake St. Clair did not have a good harbour but Chatham, near the mouth of the Thames River, provided access for both lake and river vessels. It became an important port within the water-based transportation system. The pattern of urban development in southwestern Ontario owes much to the availability of water for transport. Rail transport and, more recently, road transport replaced the water transport system that served early settlers. The rail lines and major roads were built to connect the urban communities that had become established based on water transport and power.

A notable exception to the early agricultural-based industry was the development of the petroleum industry in Lambton County (Ford 1964). Beginning at Oil Springs and Petrolia in the 1860s, the oil industry in Ontario grew and prospered to supply a demand for fuel with the advent of the automobile and later the airplane. Water was an important component of the major refinery operations developing in Sarnia where water transport was available and there were good water supplies for industrial operations. Over the course of time, the petrochemical complex located along the St. Clair River became collectively known as Chemical Valley.

The combination of changing land use, population growth, and industrial development resulted in increasing water pollution problems into the 1960s when more stringent controls began to be applied to both municipal and industrial sources. The lack of adequate treatment for both domestic and industrial sewage resulted in bacterial

contamination and other pollutants entering the local watercourses. In 1888, the case of the Queen v. City of London ruled that the "emptying of sewage into the river (Thames) had rendered the waters of it less fit for domestic use." In 1919, the International Joint Commission documented the levels of pollution along the St. Clair River - Detroit River corridor but action was not taken by the governments of the day.

Over the last 40 years, government regulations, together with voluntary efforts, have addressed the worst pollution problems, including reductions to the amount of chemical and bacterial contaminants discharged into the local watercourses.

Present Settlement

The Canadian Lake St. Clair watershed is predominately agricultural and supports approximately 750,000 residents (Statistics Canada 2001a). The U.S. Lake St. Clair watershed is highly urbanized and is home to nearly six million residents of the greater Detroit area (U.S. Army Corps of Engineers in preparation).

Development to support agricultural, residential, industrial, commercial, recreational and other human activities has had a dramatic effect on the landscape of southwestern Ontario. Figure 4 shows the change in the Lake St. Clair coastal wetlands between 1873 and 1968 as the land was drained for settlement and agriculture. Agricultural drainage to reclaim land for cropland began late in the 19th century. Dykes, canals and pumps were used to systematically drain the areas, and by the mid-1960s more than 40% of the wetlands directly associated with the lake had been destroyed. The wetlands from the mouth of the Thames River north to the Chenal Ecarte continued to dwindle and these wetlands were reduced from 3,574 ha in 1965 to 2,510 ha in 1984, as shown in Figure 5 (McCollough 1985). Draining for agriculture accounted for 89% of the wetland loss while marina or cottage development consumed the remainder. By 1982, Kent and surrounding counties had lost 80-100% of their original wetland areas. The resulting agricultural land is among the most productive and intensively farmed in Canada. Shoreline dykes, constructed by the Agricultural and Rural Development Agency, protect existing farmland and facilitate the conversion of remaining wetlands. The rate of conversion to agriculture has slowed in recent years. Decisions to convert wetlands

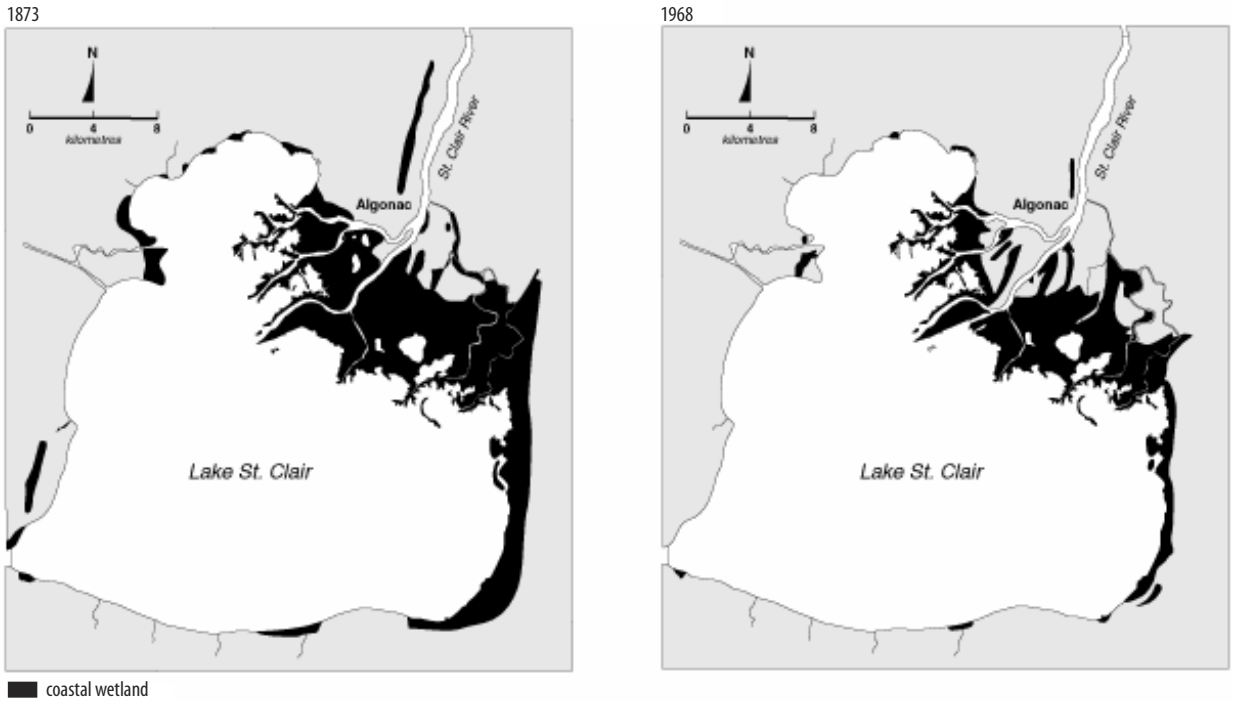

Figure 4: Extent of Lake St. Clair coastal wetlands in 1873 and 1968. (Source: Herndandorf et al. 1986)

are often influenced by climate and economics. Today, agriculture is the dominant land use and about 75% of the land in the watershed is rural farmland. Approximately 13% of the land is urban including the rail and road transport systems. Only about 12% of the watershed remains as forest or wetland.

In recent years (1996-2001), the overall growth rate in the Lake St. Clair watershed area was approximately half the provincial average of 6.1%. Only Essex County (7%) had a growth rate that exceeded the provincial average. Lambton County (-1.6%) and the Municipality of Chatham-Kent (-1.8%) experienced a reduction in populations. Middlesex, Perth, Oxford and Elgin Counties had growth rates that ranged from 2.2% to 3.5% (Statistics Canada 2001a).

Planning for Future Growth

The population of Ontario is 11.4 million, over one-third the population of Canada (Statistics Canada 2001a), with a large part of the population in the Greater Toronto Area. Of the eight counties that are (partially) in the watershed, six are projected to have growth of fewer than 1,000 people per year while two counties are expected to grow at rates of fewer than 5,000 people per year.

Based on information obtained from the Ontario Ministry of Agriculture and Food, Figure 6 provides an overview of land uses for the municipalities in the Lake St. Clair watershed. The projected growth in population for area municipalities indicates that there will be limited urban land development demands over the next decade. Most of the land in the watershed is expected to remain as agricultural or rural.

To aid municipalities in directing where local growth and development should occur, Municipal Official Plans are key planning documents required for each municipality under the *Ontario Municipal Planning Act*. Municipal Official Plans incorporate provincial policies and recognize federal, provincial and local land use, and environmental, social and economic issues related to anticipated municipal development. They provide information regarding present land use and plans for future

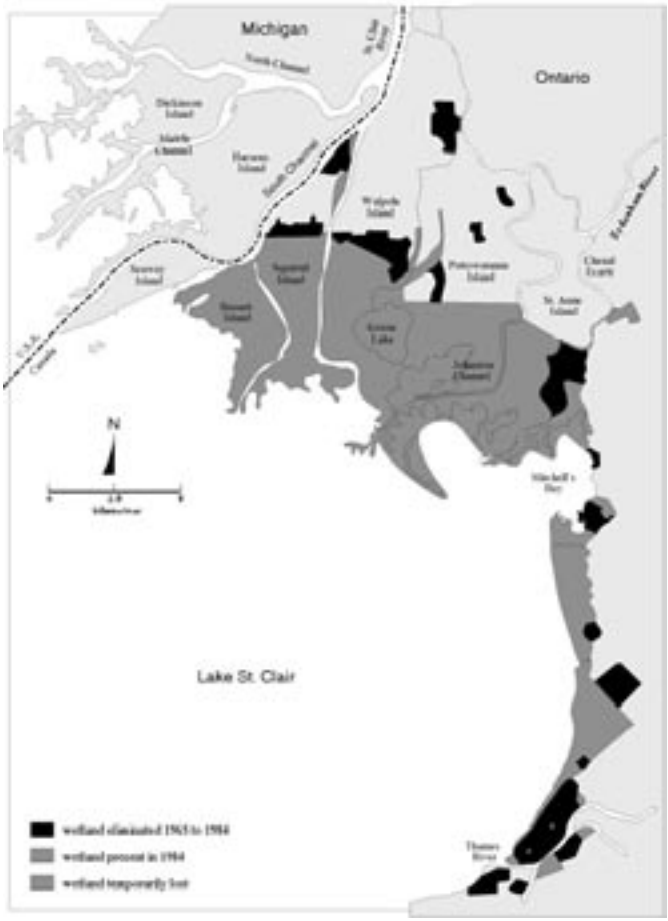

Figure 5: Wetland loss on the Ontario portion of Lake St. Clair from 1965 to 1984. Source: McCullough 1985)

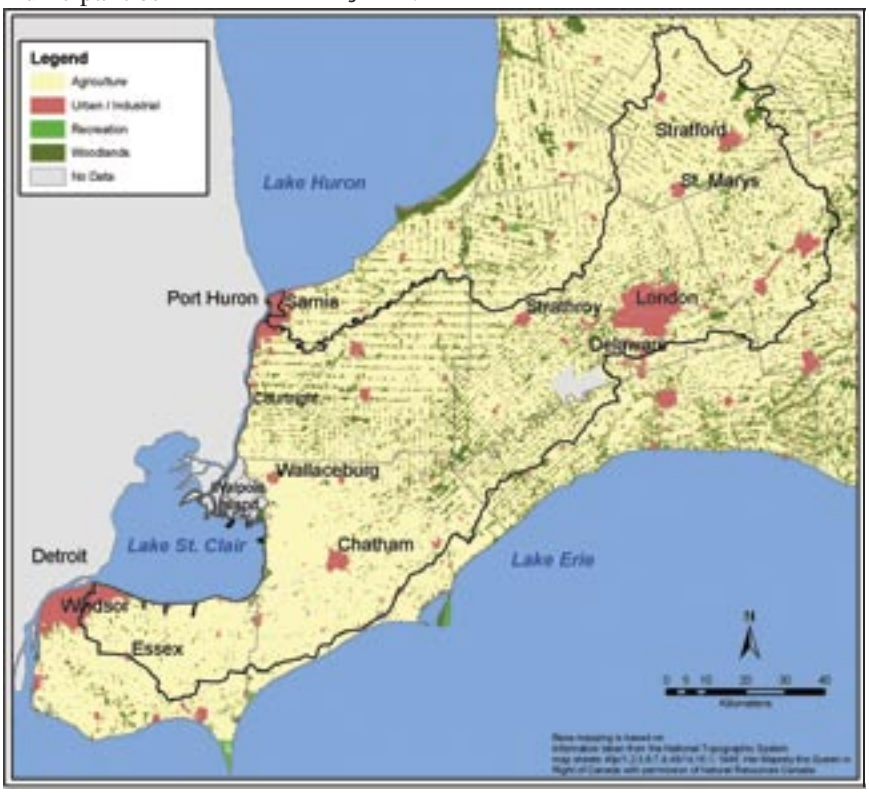

Figure 6: Land use in the Lake St. Clair Canadian watershed. (Source: St. Clair Region Conservation Authority)

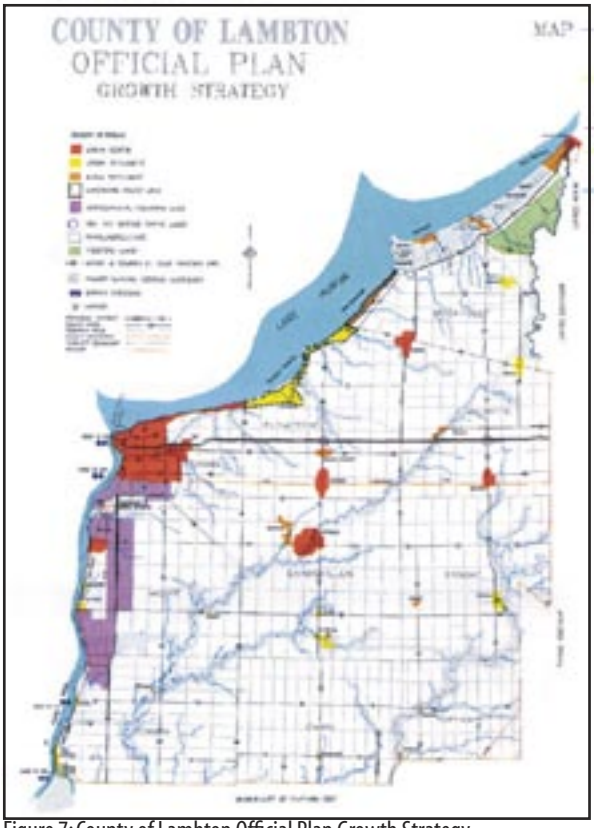

Figure 7: County of Lambton Official Plan Growth Strategy. (Source: County of Lambton)

Figure 8: County of Lambton Official Plan Natural Heritage Strategy. (Source: County of Lambton)

development in the Lake St. Clair watershed. For example, the Provincial Policy Statement states that "Development and site alteration will not be permitted in: significant wetlands south and east of the Canadian Shield and significant portions of the habitat of endangered and threatened species." In the lake, the largest remaining wetland areas are in the St. Clair River delta and along the eastern shore of Lake St. Clair.

Section 3 of the *Municipal Planning Act* requires that, in exercising any authority that affects planning matters, planning authorities "shall have regard to" policy statements issued under the Act. The Provincial Policy Statement is intended to promote a policy-led system that recognizes the complex inter-relationships among environmental, economic and social factors in land use planning. The provincial policies focus on key provincial interests related to land use planning with the expectation that they will be complemented by locally generated policies regarding matters of local interest.

For example, the County of Lambton Official Plan has a growth strategy that encourages growth in urban centres and urban settlement areas where there will be development of full municipal services. The 1996 population was 128,975 (Statistics Canada 2001a) and the Official Plan projects that the County population could reach 142,000 by the year 2016 (Figure 7). The Official Plan recognizes the significance of the petrochemical industry in the County and land is designated to accommodate existing and future large-scale industrial uses. This petrochemical industrial land is located along a major highway that runs parallel to the St. Clair River and newer development is set back from the river. Rural and agricultural land uses will continue as the major land uses in Lambton County. The Lambton County Official Plan also includes a Natural Heritage System with a goal of protecting and restoring natural heritage corridors that will promote and protect the biodiversity of species found within the local ecosystem. Figure 8 provides an outline of the Natural Heritage System. The intent of the Official Plan is to direct development away from the Natural Heritage System. Similar planning efforts have been completed in Essex County and are underway in Chatham-Kent and Middlesex Counties.

Land Use Impacts on the Watershed

Development for agricultural, municipal, industrial, and recreational uses has had the most significant impact on the local ecosystem. Development has resulted in much of the natural habitat in the watershed being removed or fragmented. Impacts and threats to natural areas from development include removal or degradation of natural areas that once buffered significant habitats (e.g., wetlands), fragmentation and loss of connections between habitat areas on landscape, loss of habitat for endangered species, and decreases in biodiversity.

Agricultural and Rural Land Use

As previously discussed, agricultural and rural land use dominates the landscape (75%) of southwestern Ontario and is expected to continue to be the major land use. The agricultural landscape has changed from small parcel farms to fewer, larger, more intensive farms and there continues to be a demand to convert remaining natural areas into productive farmland.

The removal of natural or permanent vegetative cover (buffers) along tributaries, shorelines, drains and ditches threatens biodiversity. This occurs by increasing sedimentation into tributaries and wetlands, and impairing water quality by increasing nutrients and chemicals entering the system. The extensive use of tile drainage techniques for agriculture results in field run-off flowing directly into the tributaries, thus altering the hydraulic cycle and removing the benefit of the water being filtered by buffers. In addition, faulty private septic systems in many rural areas have resulted in inadequate treatment of private sewage.

Alterations to the lands and hydrologic cycle have resulted in increased runoff, erosion, and the associated discharges of contaminants, such as bacteria, nutrients, and chemicals. Impacts to the watercourses affect the quality and quantity of habitat, the quality and quantity of water, and the quality of recreational water uses. Recent dry weather years have further exacerbated the water quantity problem by increasing the demand for water to irrigate crops and this can be a concern during low water flow conditions in local watercourses.

There is a need for continued efforts to increase buffers and improve management practices along watercourses, including agricultural drains, to mitigate environmental impacts. Regulations under the *Nutrient Management Act* and the development of Nutrient Management Plans will provide significantly more filtering of agricultural run-off than is currently occurring. In addition, Agriculture and Agri-Food Canada's national Greencover Program will encourage permanent cover, buffers, and shelterbelts. Ontario's Environmental Farm Plan Program is an on-farm voluntary risk assessment and strategy to address environmental issues that has been widely adopted in southern Ontario.

Some of the drained pasturelands and poorer cropland in the areas have been reflooded and returned to wetland habitat. Hunt clubs such as Balmoral, Bradley's, St. Lukes and Snake Island, and Dover Marsh (now St. Clair National Wildlife Area) are all restored wetlands. In addition, some farmland near the lake is seasonally leased for waterfowl hunting after the corn is harvested. Recently, many of the hunt clubs have drained and farmed some of their wetlands in an effort to offset the rising costs of maintaining these lands for hunting, thus demonstrating the vulnerability of these wetlands to the economic climate.

Municipal, Recreational and Industrial Land Use

Residential and industrial land uses in the Lake St. Clair watershed comprise approximately 13% of the total land use.

Past residential growth has led to the destruction of natural habitat, increased amounts of impervious surfaces, increased volumes of stormwater runoff, and increased discharges of sediments and other contaminants (e.g., oil, salt and fertilizers). Often untreated or poorly treated human sewage from wastewater control plants or combined sanitary and storm sewer overflows was discharged into local watercourses resulting in bacterial contamination, increased oxygen demand, and elevated nutrient levels. Routine sampling and several studies completed in the 1980s by the conservation authorities found that watersheds with faulty septic systems can lead to beach closings. However, the impacts of faulty septic systems on the waters of Lake St. Clair are difficult to quantify.

Over the past 50 years, increased government regulation has resulted in improved protection of natural habitats through Municipal Official Plans, enhanced municipal sewage treatment plants, control of combined sewer discharges, the use of stormwater retention/treatment facilities and improved private sewage treatment systems. Installing new sanitary sewers and repairing individual systems have addressed some problem areas.

Recreational land uses can have both adverse and beneficial impacts. Marina and residential development in the Lake St. Clair marshes have resulted in the hardening of the shoreline and the removal of bottom sediments. Dredging and the corresponding movement of these sediments to another location (called translocation) can remove the original marsh habitat and can significantly alter the hydrology (properties, distribution and circulation of water) of the lake. The altered hydrology can permanently change the movement of sediment within the lake and can irreversibly change the location, extent, and habitat diversity of wetlands.

There are several marinas and boat launches located along the Canadian shores of Lake St. Clair and the St. Clair River. The municipal docks at Wallaceburg and Chatham have facilities to accommodate over 150 transient boats. In addition to the marinas and public docks, private facilities and docks located along the shoreline give cottage and homeowners sites to moor their boats. The impacts of recreational boating are discussed in the section on Commercial Navigation and Recreational Boating.

Public interest in using the land for recreational purposes helps support efforts to protect and restore the local environment. Recreational uses are changing as the demographics of the watershed population changes. Walkways, bike paths and associated parking lots often intrude into the riparian zone replacing vegetation and increasing stormwater runoff.

Discharges from industrial sources have had severe impacts on local watercourses in the past. Increased government regulation and voluntary actions have reduced the contaminant concentrations and loads discharged from industrial sources across the Lake St. Clair watershed. Larger industries with significant wastewater discharges have been the focus of provincial regulatory controls under the *Clean Water Act* and federal controls such as the Petroleum Refinery Liquid Effluent Regulations.

New industries and expansions of existing industries are subject to stringent government regulations and controls to prevent adverse environmental impacts. Contaminated sediments from past discharges and the brownfield sites of former industries are issues of concern. The St. Clair River Remedial Action Plan identified areas of sediment contamination that impact Lake St. Clair and that require remediation. Fish utilizing the St. Clair River-Detroit River corridor are exposed to contaminated sediments in the St. Clair and Detroit Rivers that contribute to fish consumption advisories for the lake. Additional information about this is available at a number of websites (e.g., www.ec.gc.ca).

Climate Change and Land Use

In the spring of 2003, the Union of Concerned Scientists and the Ecological Society of America released a comprehensive report that detailed what was known and predicted about climate change in the Great Lakes. This document, *Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems*, stated that human activities that release gases, such as carbon dioxide, into the atmosphere are blanketing the planet and trapping heat. As a direct result, the climate is changing and indicators of the changes include increases in average annual temperature, shorter

winters, increased frequency of severe rainstorms and decreases in the amount of time lakes are covered with ice. The future impacts of climate change may be broad, affecting the ecosystem, land use and human health.

Numerous changes are expected to occur as climate change impacts current land use. There is expected to be increased pressure for water extraction and increased erosion and alteration in runoff patterns that may prevent flushing of nutrients, pesticides and other toxins. Despite some positive changes for agriculture, such as a longer growing season and warmer temperatures, declining soil moisture, thin soils and severe rainstorms might outweigh any benefits to local farms. In addition, pests and pathogens might become more difficult to control and new species are likely to expand their current ranges northward and expose livestock and crops to additional stressors. In urban areas, municipalities may be forced to upgrade water related infrastructure (e.g., sewers) to prevent property damage associated with frequent extreme rainfalls and flooding, and ensure public safety. Marinas and industries may have increased costs resulting from lower water levels, including costs for dredging, adjusting docks, extensions to water intake pipes, and alterations to other infrastructure.

Management Issues

- Detrimental impacts to water quality and quantity resulting from land use (e.g., reduced natural cover, increased imperviousness) have increased sediment, nutrient, bacterial and chemical inputs.
- Challenges exist for municipal governments to provide a balance among a healthy environment, a healthy lifestyle, and a healthy economy.
- Impacts of climate change on land use, human health and the ecosystem require ongoing research and monitoring, and adaptive and preventative management strategies.

Commercial Navigation and Recreational Boating

Commercial navigation and recreational boating have been stressors to the Lake St. Clair ecosystem (Johnson 2001; Jude and Crawford 1995; and Edsall et al. 1988) and have the potential to be a future problem in the watershed (U.S. Army Corps of Engineers 2002). Appropriate management actions are needed to ensure these stressors do not detrimentally alter the Lake St. Clair ecosystem.

Commercial and recreational vessels move throughout Lake St. Clair and have access to the other Great Lakes and beyond via the St. Lawrence Seaway. Lake St. Clair is an integral part of the St. Lawrence Seaway system because it links the upper Great Lakes with the lower Great Lakes and the Atlantic Ocean. Therefore, the importance of Lake St. Clair to commercial navigation cannot be over stated.

The navigational channel has impacted the natural environment of Lake St. Clair. Shorelines have been hardened in nearshore areas removing or reducing habitat, dredging has permanently altered habitat and flow regimes, and shipping traffic has introduced the risk of spills and ballast water being released from commercial ships.

There is a wide range of motorized and non-motorized recreational watercraft in use on Lake St. Clair and they are important to the local economy. However, the large numbers of recreational boats plying Lake St. Clair has not been without environmental impact. Boats accessing environmentally sensitive areas disturb wildlife and damage habitat, boat wakes erode shorelines, two-stroke engines release pollutants into the water, and

dredging to accommodate marina access permanently alters the habitat and biodiversity of the system. These impacts can be significantly reduced when boaters use more environmentally friendly boating practices while on the water.

Commercial Navigation

The main commercial navigation season is generally from mid-March to mid-January. The St. Lawrence Seaway is usually open from the end of March to the end of December. Commercial navigation between upper Great Lakes ports continues throughout the winter months with the assistance of Canadian Coast Guard (CCG) icebreakers. Vessels over 20 m in length are required to report to the CCG Marine Traffic Center in Sarnia. In recent years, commercial traffic through Lake St. Clair has been estimated to range between 61 and 71 million tonnes (60 to 70 million tons). The CCG records indicate that there were a total of 6,262 up-bound and down-bound transit calls from ships passing through Lake St. Clair in 2000. These data apply to the total number of vessels moving through Lake St. Clair including ocean-plying vessels and lake liners that remain within the Great Lakes.

Historical shoreline hardening to protect against ship or boat wakes and flooding has resulted in restrictions to the necessary landward movement of wetland communities during high water periods. This reduces the size and diversity of wetland communities and changes the way water interacts with the shoreline, resulting in changes to coastal currents patterns, sediment transportation, and deposition within the lake.

Navigational dredging of the St. Clair River-Detroit River shipping corridor began in 1873. In the 1950s, the opening of the St. Lawrence Seaway required that the minimum channel depth be maintained throughout the seaway. The maximum natural depth of the St. Clair River is 30.5 m (100 ft) with a mean depth of 11 m (36.1 ft). Lake St. Clair has an average depth of 3.7 m (12.1 ft), a maximum natural depth of 6.4 m (21 ft), and maximum dredged shipping channel depth of 8.3 m (27.2 ft). The construction of the St. Clair Cutoff Channel created a large volume of dredged material that was deposited beside the new channel at the edge of Lake St. Clair, creating Seaway Island.

Dredging is usually associated with the removal of bottom sediments to maintain and improve shipping channels. Navigational dredging has altered the St. Clair River delta area and Lake St. Clair by replacing shoal habitat with channel habitat and by altering flow regimes. Until 1976, dredged material removed from the shipping channel was disposed of in the lake. The U.S. Army Corps of Engineers established confined disposal facilities and constructed two diked facilities on Dickinson Island adjacent to the North Channel in the St. Clair River delta. Neither site infringed upon adjacent wetlands. The Ontario Guidelines for the Protection and Management of Aquatic Sediment Quality sets safe levels for metals, nutrients and organic compounds, thereby protecting the aquatic environment. Published in 1993, these guidelines replaced the 1976 Open Water Disposal Guidelines. The Aquatic Sediment Quality guidelines are available at the Ontario Ministry of Environment website www.ene.gov.on.ca. Any dredging activities require a permit issued by the Fisheries and Oceans Canada under the *Fisheries Act*.

Shipping traffic associated with the presence of the large petrochemical industry upstream of the lake represents an ongoing risk to the ecology of the lake. There are four *Canada Shipping Act* designated oil handing facilities along the St. Clair River where petroleum products are loaded or unloaded from ships. The Response Organizations and Oil Handling Facilities Regulations govern these facilities. These regulations require that the facility have an oil pollution emergency plan, programs in place for oil spills, and an arrangement with a response organization that is certified by the CCG. The only organization that is certified by CCG for the Great Lakes is the Eastern Canada Response Corporation located in Corunna.

The Great Lakes Sewage Pollution Prevention Regulations control the treatment and discharge of human sewage on commercial vessels.

The St. Lawrence Seaway locks and channels currently can accommodate only 13% of the world's merchant fleet (and only 5% of the container fleet). The U.S. Army Corps of Engineers has completed the first phase of a Great Lakes Navigation Study (U.S. Army Corps of Engineers 2002) to address the feasibility of improving commercial navigation on the entire Great Lakes–St. Lawrence Seaway system to accommodate larger ships. Under Option 4 in the study, the locks and channels would be re-constructed to accommodate vessels drafting up to 10.7 m (35 ft) throughout the system from the Atlantic Ocean to Chicago, Illinois. The study reports that the St. Clair River, Lake St. Clair and the Detroit River would have to be deepened by 9.5 feet and concludes that the dredging and construction required to accomplish this would result in large habitat losses, increased turbulence, increased wave disturbance and added stress on remaining habitat. In addition to dredging and construction altering habitat, flow patterns might be altered through the system and that, in turn, could change the current distribution of wildlife and plants within the lake, nearshore areas and adjacent wetlands. An expansion to the current seaway system would provide significantly larger vessels with access to the Great Lakes. While not necessarily increasing the risk of environmental disasters (i.e., spills), the magnitude of disasters could change.

The majority of unintentional species introductions to the Great Lakes have been attributed to commercial ships. One of the most common methods of invasion is from the ballast (water and sediment) of commercial ships plying the Great Lakes from overseas ports. Other methods of invasion include hull fouling, intentional and accidental transfer or release of animals into the watershed, as well as the spread of invasive species from connecting waters.

A number of invasive species have arrived and spread throughout Lake St. Clair, the St. Clair River and the Detroit River. Invasive species have been found the Lake St. Clair watershed periodically for decades. Some recent invading species have had very little impact on the community ecology of the lake (e.g., tubenose goby), while others have profoundly disrupted the ecology (e.g., zebra mussels or purple loosestrife) by causing food web changes and extirpating native species from their preferred habitats (Nalepa et al. 1996).

Substantial changes occurred following the invasion of the zebra mussel. Zebra mussels arrived in ballast water and first became established in Lake St. Clair in 1988. The mussels caused wide-spread changes to the ecology of Lake St. Clair and became a costly nuisance species because of their ability to attach to metal items including the water intake pipes of power plants, factories, and municipal drinking water supply plants. Current control measures are limited and costly (e.g., chlorine flushing).

Another invading species that caused problems in the Lake St. Clair watershed is the round goby which was first observed in the St. Clair River in 1990. Believed to have been present in the Michigan waters of Lake St. Clair since the early 1990s, the round goby was found in the Ontario waters of the lake in 1993 (MacLennan et al. in preparation). Now one of the lake's most abundant fish species, round gobies are found throughout the lake inhabiting both nearshore and offshore areas. In contrast, the tubenose goby, first observed in the St. Clair River in 1990, is less abundant, has established only around the perimeter of Lake St. Clair, and is uncommon in offshore areas. Both fish species are believed to have arrived via ballast water.

At least one third of the aquatic invasive species that have entered the Great Lakes did so in the ballast water discharged by ocean-going ships. Currently, there is no known

treatment technology that is both effective and practical to deal with aquatic organisms in ballast water or in ballast sediment. Researchers are continuing to investigate ballast treatment options. One of the best ways to prevent invasions is to identify routes that enable species to enter the Great Lakes and establish regulations that help to reduce invasive species dispersal.

Transport Canada is responsible for the management of ballast water on board ship. Guidelines regarding ballast water in the Great Lakes and St. Lawrence Seaway were developed in 1989 and guidelines were extended to all Canadian waters in 2000. Under these guidelines, all ships entering Canadian waters and bound for a Canadian port must have a valid ballast water management plan specific to their ship and must provide a Ballast Water Report to the appropriate Marine Communications and Traffic Centre prior to entering Canadian waters. Samples may be taken from their ballast water by government staff to verify compliance with the guidelines. Currently, this is a voluntary program for the purpose of reducing the risk of introducing harmful invasive aquatic organisms and pathogens. However, it is an offence under the *Canada Shipping Act* to refuse to provide information or to knowingly provide false information to a Marine Communications and Traffic Officer when such information is requested for the purposes of environmental protection. Flushing and refilling a ship's ballast tanks with mid-ocean saltwater while still at sea is currently the most accepted method of control, but it is not always effective.

In February 2004, the U.S. and Canadian delegations of the International Maritime Organization signed a Ballast Water Convention that will require all ships to implement ballast management plans and procedures and carry a record book. This is an important first step toward reducing the arrival and spread of invasive species.

The potential exists for invasive species to spread throughout the Great Lakes watershed when ballast is exchanged at ports along the transport corridor. In some cases, this may help to distribute a species that has no strong dispersal ability or may enable some species to reach locations more quickly than natural distribution patterns would normally permit. Even if ocean going ships do not travel the entire length of the Great Lakes–St. Lawrence Seaway, the arrival and spread of invasive species is a continuous threat to the Lake St. Clair watershed via lake liners that transport goods among local harbours.

In addition to species that arrive in the Lake St. Clair watershed in ballast water and ballast sediment, invasive species continue to be problematic as they spread throughout the Great Lakes watershed. Action is needed now, as there are several species that are present in or near the Great Lakes watershed and may be on the verge of entering the Lake St. Clair watershed. These species include the fish hook flea, the European ruffe, and the four species of Asian carp, all of which have the potential to disrupt the current aquatic community. The fish hook flea feeds on zooplankton and has the potential to compete with juvenile fish for this food resource. The fish hook flea has already caused problems for recreational anglers and boaters as well as for the commercial fishing industry in other areas of the Great Lakes. The European ruffe is an adaptable species that reproduces quickly. It may compete with native fish species for food and/or habitat but is unlikely to become a significant food item for native predators. Asian carp eat considerable amounts of plankton and/or vegetation and grow rapidly, and therefore may out-compete native species for resources. Asian carp are reported to become agitated by propeller noise causing these fish to leap out of the water, a potentially dangerous situation for recreational boaters that may be hit by these large fish.

The Asian carp have not yet established in the Great Lakes watershed and to try to prevent this from occurring, a dispersal barrier has being constructed on the Chicago Sanitary and Ship Canal. The Ontario Ministry of Natural Resources has recently prohibited the

sale of live Asian carp (four species), snakehead (28 species) and goby (two species). These fish will also be banned from sale for use in aquariums and backyard ponds.

The National Alien Invasive Species Strategy is currently being developed by federal and provincial agencies and is scheduled to be completed in fall 2004. These are positive steps in the deterrence of invasive species dispersal in the Great Lakes watershed.

Invasive plants such as purple loosestrife, *Phragmites*, and eastern frogbit can dominate wetland areas and replace native vegetation leading to decreases in biodiversity. Invasive wild mute swans defend large territories, up to 6 ha, and they can attack and displace native waterfowl from breeding and feeding habitats. Mute swans uproot vegetation and consume large amounts of submergent aquatic vegetation. Expanding populations of mute swans have the potential to reduce the carrying capacity of wetlands for native species of migratory birds and waterfowl (Petrie and Francis 2003).

Recreational Boating

In Canada, all recreational vessels under 15 gross tons and powered by an engine 10 horsepower (5.5 kilowatts) or more must be licensed or registered. Licensing is done through the Canada Customs and Revenue Agency on behalf of the Canadian Coast Guard (CCG). Vessels over 15 gross tons must be registered. The Office of Ship Registration, Marine Safety, within the Department of Transport Canada handles registration. The licensing program is not computerized and information detailing local boating is not available.

There are 13 marinas located along the Canadian shores of the St. Clair River and Lake St. Clair with more than 2,300 boat slips and 10 boat launches. Most of the boat slips at the marinas are rented on a seasonal basis. The Sarnia Bay Marina has approximately 190 visitor slips and the municipal docks at Wallaceburg and Chatham have facilities to accommodate over 150 visiting boats. In addition to the marinas and public docks, private facilities and docks located along the shoreline give cottage and homeowners sites to moor their boats, jet skis, canoes, etc. By comparison, along the U.S. shoreline there are 211 marinas found in three U.S. counties and more than 200,000 boats registered in the four U.S. counties adjacent to or near Lake St. Clair (U.S. Army Corps of Engineers in preparation).

Significant alteration to the original shoreline of Lake St. Clair has occurred during the last century to the detriment of fish and wildlife populations. Altered shorelines change the sediment erosion and depositional areas of the lake, and alter wave action and current direction impacting the habitat that fish and wildlife depend upon. Marinas, boat launch facilities, and dredged channels constructed to accommodate recreational boating have contributed to near-shore alterations that are detrimental to fish and wildlife and their habitats. Fisheries and Oceans Canada (DFO) is responsible for the management and protection of fish habitat under Section 35 of the *Fisheries Act*. Approval must be obtained before making any alterations to the shoreline or undergoing any construction associated with building or modifying a dock, boathouse or boat ramp. To improve client services, DFO has agreements with local conservation authorities to review such projects.

Canadian Wildlife Service observations, along with those of local marsh managers, indicate that as fall fishing and boating pressure increased the amount of disturbance experienced by staging waterfowl has also increased. The increase in disturbance is viewed as a potentially serious problem for Ontario's premier waterfowl staging area. The small islands and wetlands within the lake and delta are particularly subject to disturbance by watercraft. The popularity of jet-propelled personal watercraft that can operate in extremely shallow water presents several potential problems as increased wave action can uproot aquatic vegetation, bottom sediments can be re-suspended leading to

decreases in water quality, and increased traffic and noise can reduce waterfowl nesting success and disrupt waterfowl in traditional feeding and resting areas.

Recreational boaters have the potential to inadvertently spread invasive species within and beyond the Lake St. Clair watershed. Hull fouling is a potential dispersal mechanism for organisms that can withstand short periods of dessication (e.g., zebra mussels). Other mechanisms include water from live wells that may contain invasive species, and fouled fishing gear, boat trailers, water skis, or inner tubes. Attention is needed to appropriately clean all items when transferring between two waterbodies.

The two-stroke marine engines manufactured in the United States pre-1998 or currently manufactured in Canada, can vent between 30% and 50% of their fuel through the combustion chamber unburned and into the water, along with much of the oil that is mixed with the fuel. In two-stroke engines, the intake and exhaust cycles are combined into a single piston stroke, and a mixture of air and fuel blows the exhaust products out of the engine. Environment Canada's Environmental Technology Centre tested outboard exhaust for total hydrocarbons, nitrogen oxides, carbon monoxide, carbon dioxide, oil and grease, and BTEX (benzene, toluene, ethylbenzene, xylenes). Results showed that two-stroke engines can produce 12 times as much BTEX as four-stroke engines, and five times as much oil and grease. The two-stroke engine can also emit 15 times more unburned hydrocarbons than the four-stroke engine, and nearly 125 times more than a small van (Environment Canada 2000). Studies completed by the Sarnia-Lambton Environmental Association have shown elevated levels of toluene that are linked to high recreational boating use periods in the St. Clair River (Munro et al. 2002). In February 2001, the Canadian government announced a 10 year Clean Air Strategy that will include introducing emission standards for new spark-ignition (gas) marine engines used in personal watercraft, and jet boat applications that are predicted to result in significant reductions in hydrocarbon emissions (Environment Canada 2002).

Sewage discharges from recreational watercraft are controlled under Regulation 343 of the Ontario *Environmental Protection Act*. The law requires that no person shall discharge or deposit, cause or permit to be discharged or deposited into any water, sewage from a pleasure boat. Sewage means organic and inorganic waste, and includes fuel, lubricants, litter, paper, plastics, glass, metal, containers, bottles, crockery, rags, junk or similar refuse or garbage, and human excrement. The owner and the operator of every pleasure boat that has a toilet shall ensure that, while the boat is on water, the boat is equipped with storage equipment, and such toilet and storage equipment are installed so as to be non-portable. Regulation 351 of the Ontario *Environmental Protection Act* requires that the operator of a marina shall have a pump-out facility that is easily accessible to, and can be conveniently used by, occupants of pleasure boats that have toilets. The Ontario Ministry of Environment encourages voluntary compliance through education and outreach activities such as the Clean Marine Partnership Program. There are currently no regulations in Ontario for the disposal of grey water including bilge pump out, sink and shower waters.

Marinas are audited by an independent third party as part of the Clean Marine Partnership Program and given an Eco-rating ranging from low (1) to high (5). As of 2004, four marinas on Lake St. Clair and the St. Clair River have their Eco-ratings: Sarnia Bay Marine, Radlin's Marina and Café, Rochester Place Resort, and Deerbrook Marina. Certified marinas are listed at the Ontario Marine Operators Association's website www.omoa.com.

Management Issues

- Shoreline hardening to accommodate commercial navigation and marina development, as well as to protect exposed shorelines against wave-erosion, has resulted in significant reductions in coastal habitat and altered current and sediment deposition patterns.
- The increased seasonal boating pressures and the popularity of jet-propelled personal watercraft that can operate in very shallow waters have the potential to increase wave action, uproot aquatic vegetation, and re-suspend bottom sediments, leading to habitat degradation at the shoreline and in nearshore areas.
- Knowledge of the effects of BTEX (benzene, toluene, ethylbenzene, xylenes) emissions from two-stroke marine engines on the environment is limited.
- Efforts to restrict or prevent the arrival and spread of invasive species into the Great Lakes via hull fouling or the de-ballasting of water and sediment have been limited.
- The shipping traffic associated with the presence of the large petrochemical industry upstream of the lake represents an ongoing risk to ecology of the lake.
- The potential expansion of the seaway system may alter existing habitat by increasing habitat losses, turbulence and wave disturbance, altering flow patterns, and disrupting the distribution of wildlife and plants within the lake, nearshore or adjacent areas.