Solid Waste Disposal
Indicator #7060

Overall Assessment

Status:	**Trend Not Assessed**
Trend:	**Undetermined**
Primary Factors Determining Status and Trend	**This year the indicator report focuses only on disposal data in the U.S. instead of generation or recycling data. Disposal data was the most consistently collected by the counties/states in the U.S. Generation and recycling data were available for Ontario, Canada. Over time, a change in disposal tonnages can be used as an indicator for solid waste in the Great Lakes, however more consistent and comparable data would improve this indicator.**

Lake-by-Lake Assessment
Due to insufficient data, a lake-by-lake assessment is not available for this indicator.

Purpose
•To assess the amount of solid waste disposed in the Great Lakes basin; and
•To infer inefficiencies in human economic activity (i.e. wasted resources) and the potential adverse impacts to human and ecosystem health.

Ecosystem Objective
Solid waste provides a measure of the inefficiency of human land based activities and the degree to which resources are wasted. In order to promote sustainable development, the amount of solid waste disposed of in the basin needs to be assessed and ultimately reduced. Because a portion of the waste disposed of in the basin is generated outside of basin counties, efforts to reduce waste generation or increase recycling need to occur regionally. Reducing volumes of solid waste via source reduction or recycling is indicative of a more efficient industrial ecology and a more conserving society. This indicator supports Annex 12 of the Great Lakes Water Quality Agreement (United States and Canada 1987).

State of the Ecosystem
Canada and the United States are working towards improvements in waste management by developing strategies to prevent waste generation and reuse and recycle more of the generated waste. The data available to support this indicator are limited in some areas of the basin and not consistent from area to area. For example, while most of the U.S. states in the basin track amount of waste disposed in a landfill or incinerator located in a county, they may define the wastes differently. Some track all non-hazardous waste disposed and some only track municipal solid waste. Because the wastes disposed of in each county in the basin were not necessarily generated by the county residents, per capita estimates are not meaningful. Not all of the U.S. counties provide generation and recycling rates information. Canada provides estimates of waste generation rate for each of its Provinces for residential, industrial/commercial, and construction and demolition sources. The summary statistics report also provided disposal data, however the disposal data included wastes that were disposed of outside the Province, some of which is captured in the U.S. county disposal data within the basin. For this reason, generation and

diversion estimates were used only for Ontario, Canada; disposal data were used for the U.S. counties. Types of waste included in the disposal data are identified below.

Statistics for the generation of waste in Ontario were gathered from the Annual Statistics 2005 report. More than 11 million tonnes of wastes were generated in Ontario in 2000 and slightly more than 12 million tonnes were generated in 2002. These figures include residential wastes, commercial/industrial wastes, and construction and demolition wastes. Diversion information was also provided in the report and can be seen in Figure 1. In 2000, 20.8% of the residential waste generated was diverted to recycling and in 2002 that figure increased to 21.6%. The industrial/commercial recycling rate was 22.7% in 2000 and 20.2% in 2002. Finally, the C&D recycling rate was 11.6% in 2000 and 12.5% in 2002. Ontario has a goal to divert 60% of its waste by 2008.

Minnesota Great Lakes basin counties provided data on the amounts of waste disposed of in the county as well as an estimate of the amount of waste buried by residents (on their own property). Data are provided in Figure 2. In 2003, 124,931 tons of waste were disposed of or buried in the 7 basin counties in MN. In 2004, there was a 5% increase to 132,128 tons disposed or buried. Each county showed an increase in waste disposed. These figures only include municipal solid waste (not construction and demolition debris or other industrial wastes).

The Indiana Department of Environmental Management's data regarding amounts disposed of at permitted facilities were used to determine the total amount disposed in each Indiana Great Lakes Basin county. The data are provided in Figure 3. The disposal in 2004 was approximately 9% greater than in 2003. The 15 basin counties disposed of 2,468,913 tons of waste in 2004 and 2,224,581 tons in 2005. About 15% was generated outside of the counties in 2004. The data include municipal solid waste, construction and demolition wastes, and some industrial byproduct waste.

The Illinois Environmental Protection Agency, Bureau of Land, reported the amounts disposed of in permitted landfills in the 2 Great Lakes basin counties. Data were compiled for 2004 and 2003 and are shown in Figure 4. There was less than a 2% change in total materials. In 2004 1,814,529 tons were disposed and in 2003 slightly less waste (1,784,452 tons) was disposed. The data include municipal solid waste, construction and demolition waste, and some industrial waste.

The Michigan Department of Environmental Quality reports on total waste disposed in Michigan landfills in cubic yards. General conversion factors (to translate cubic yards to tons) could not be used because the waste totals include a variety of waste sources (municipal solid waste, construction and demolition debris, and some industrial byproducts). Data for the 83 Great Lakes basin counties were compiled and are presented in Figure 5. There was less than a 1% difference between the total cubic yards disposed in 2004 and 2005 in these counties. The total for 2005 was slightly smaller. For both years, approximately 64 million cubic yards were disposed of in the 83 counties in the Great Lakes Basin.

The New York Department of Environmental Conservation provided municipal solid waste disposal data for facilities located in the 32 Great Lakes basin counties for the years 2004 and

2002. The data are presented in Figure 6. There was an approximate 5% increase in waste disposed. The total waste disposed was 7,853,087 tons in 2004 and 7,333,685 tons in 2002. This data includes municipal solid waste only. More than 65% of the states waste is managed in the basin counties.

The Pennsylvania Department of Environmental Protection provided disposal data for the three Great Lakes basin counties. Municipal solid waste and construction and demolition debris are combined in these annual totals which are presented in Figure 7. For 2004, 282,004 tons were disposed in the three basin counties. There was a 25% decrease in waste disposed in the counties in 2005 to 209,229 tons.

The Wisconsin Department of Natural Resources collects data on the amount disposed of in each facility located in the Great Lakes basin counties. Data were compiled for the 26 basin counties and are presented in Figure 8. In 2005, 7,663,187 tons of wastes were disposed, within 1% of the total disposed in 2004. Totals include a wide variety of wastes such as municipal solid waste, sludges, and foundry sand.

The Ohio Environmental Protection Agency collects data for waste disposed of in landfills and incinerators. The data for the 36 Great Lakes basin counties was compiled for 2003 and 2004 and are presented in Figure 9. There was an approximate 5% increase in waste disposed. More than 60% of these waste disposed in the counties came from outside the counties. The data includes municipal solid waste, some industrial wastes, and tires. Construction and demolition debris is not included. In 2004, the 36 basin counties disposed of 8,791,802 tons and in 2003 8,334,865 tons were disposed.

Pressures

The generation and management of solid waste raise important environmental, economic and social issues for North Americans. Waste disposal costs billions of dollars and the entire waste management process uses energy and contributes to land, water, and air pollution. The U.S. EPA has developed tools and information linking waste management practices to climate change impacts. Waste prevention and recycling reduce greenhouse gases associated with these activities by reducing methane emissions, saving energy, and increasing forest carbon sequestration. Waste prevention and recycling save energy when compared to disposal of materials.

The state of the economy has a strong impact on consumption and waste generation. Municipal solid waste generation in the U.S. continued to increase through the 1990s and has remained steady since 2000 (USEPA 2003). Generation of other wastes, such as construction and demolition debris and industrial wastes is also strongly linked to the economy. The U.S. EPA is developing a methodology to better estimate the generation, disposal, and recycling of construction and demolition debris in the U.S.

Because waste disposed of in the Great Lakes Basin may be generated outside of the Basin or moved around within the Basin, efforts to reduce waste generation and increase recycling need to focus on a broad area, not just the Basin. Continued collaboration of state, local, and federal efforts is important for long term success.

Management Implications

The U.S. EPA supports a bi-annual study that characterizes the municipal solid waste stream and estimates the national recycling rate. The latest study (2003) estimates a 30.6% national recycling rate. The U.S. EPA has established a goal of reaching a 35% recycling rate by 2008. The 2003 study indicated that paper, yard and food waste, and packaging represent large portions of the waste stream. The U.S. EPA's is concentrating its efforts on these materials; working with stakeholders to determine activities that may support increased recovery of those materials. The federal government is also working to promote strategies that support recycling programs in general, including Pay-As-You-Throw (generators pay per unit of waste rather than a flat fee); innovative contracting mechanisms such as resource management (includes incentives for increased recycling), and supporting demonstration projects and research on various end markets and collection strategies for waste materials. The States are also working to increase recycling rates and provide support for local jurisdictions. Each state with counties in the Great Lakes basin provides financial and technical support for local recycling programs. Many provide significant market development support as well.

Canada and the U.S. both support integrated solutions to the waste issue and look for innovative approaches that involve the public and private sectors. Extended Producer Responsibility (EPR), also known as Product Stewardship is one approach that involves manufacturers of products. EPR efforts have focused on many products including electronics, carpets, paints, thermostats, etc.

Ontario's Waste Diversion Act was passed in 2002 and created Waste Diversion Ontario, a permanent, non-government corporation. The Act gave WDO the mandate to develop, implement and operate waste diversion programs-to reduce, reuse or recycle waste.

The City of Toronto has set ambitious waste diversion goals and reported a 40% diversion rate in 2005. The development of a green bin system (allowing residents to separate out the organic fraction of the waste stream from traditional recyclables) is credited for the high diversion rate achieved.

Improved and consistent data collection would help to better inform decisionmakers regarding effectiveness of programs as well as determining where to target efforts.

Comments from the author(s)

During the process of collecting data for this indicator, it was found that U.S. states and Ontario compile and report on solid waste information in different formats. Future work to organize a standardized method of collecting, reporting and accessing data for both the Canadian and U.S. portions of the Great Lakes basin will aid in the future reporting of this indicator and in the interpretation of the data and trends. More consistent data may also support strategic planning.

Acknowledgments
Authors: Susan Mooney, Julie Gevrenov, and Christopher Newman U.S. Environmental Protection Agency, Waste, Pesticides, and Toxics Division, Region 5, Chicago, IL.

Data Sources

The United States data regarding national recycling rate and municipal solid waste characteristics was collected from Municipal solid waste in the United States: 2003 facts and figures; available on the U.S. EPA's web site at http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm.

Solid waste data for Ontario was collected from Human Activity and the Environment. Annual Statistics 2005, Featured Article: Solid Waste in Canada, Catalogue number 16-201XIE, Statistics Canada.

Illinois waste disposal data for the 2 basin counties was compiled from the Illinois Environmental Protection Agency, Bureau of Land's 2004 Landfill Capacity report found on their web site at: http://www.epa.state.il.us/land/landfill-capacity/2004/index.html. The 2 Great Lakes Basin counties are located in Illinois EPA's Region 2.

Indiana waste disposal data for the basin counties were compiled from the Indiana Department of Environmental Management's permitted solid waste facility reports found at http://www.in.gov/idem/programs/land/sw/index.html.

Michigan waste disposal data for the basin counties were compiled from the Michigan Department of Environmental Quality's Annual Report on Solid Waste Landfills. Data from the 2005 and 2004 studies were compiled. The author accessed the data via the Border Center's WasteWatcher web site (http://www.bordercenter.org/wastewatcher/mi-waste.cfm) to more easily search for the appropriate county – level data.

Minnesota municipal solid waste disposal data for the basin counties was compiled from the 2004 and 2003 SCORE data available on the Minnesota Pollution Control Agency's web site at: http://www.moea.state.mn.us/lc/score04.cfm The SCORE report is a report to the Legislature, the main components of this report are to identify and target source reduction, recycling, waste management and waste generation collected from all 87 counties in Minnesota.

New York municipal solid waste disposal data for the basin counties were compiled from New York State Department of Environmental Conservation's capacity data for landfills and waste to energy facilities available on their website at: http://www.dec.state.ny.us/website/dshm/sldwaste/newsw2.htm.

Ohio waste disposal data for the basin counties were compiled from Ohio Environmental Protection Agency's 2003 and 2004 facility data reports which are available on their web site at http://www.epa.state.oh.us/dsiwm/pages/general.html.

Pennsylvania waste disposal data for the basin counties were compiled from the Pennsylvania Department of Environmental Protection, Bureau of Land Recycling and Waste Management's disposal data located on their web site at: http://www.depweb.state.pa.us/landrecwaste/cwp/view.asp?a=1238&Q=464453&landrecwasteNav=|.

Wisconsin municipal solid waste disposal data for the basin counties were compiled from the Wisconsin Department of Natural Resources, Bureau of Waste Management's Landfill Tonnage Report found on their website at:. http://www.dnr.state.wi.us.

United States and Canada. 1987. Great Lakes Water Quality Agreement of 1978, as amended by Protocol signed November 18, 1987. Ottawa and Washington.

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Source: Indiana Department of Environmental Management, Permitted Solid Waste Facility Report.

Figure 4. Illinois Basin County Disposal.
Source: Illinois Environmental Protection Agency, 2004 Landfill Capacity Report.

Figure 5. Michigan Basin County Disposal.
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Figure 8 Wisconsin Basin County Disposal
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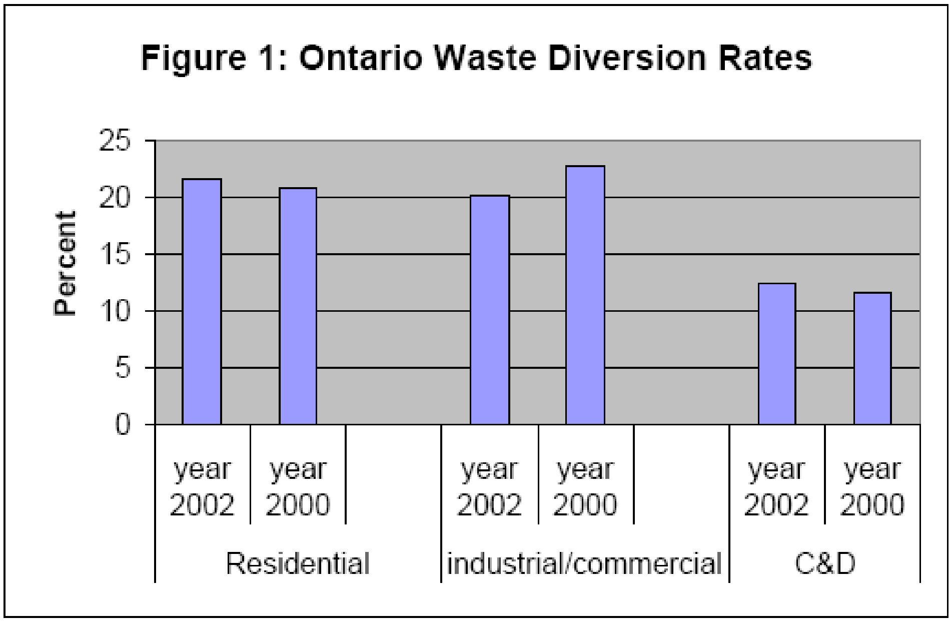
Figure 9. Ohio Basin County Disposal.
Source: Ohio Environmental Protection Agency, 2003 and 2004 Facility Data Reports.

Last updated
SOLEC 2006



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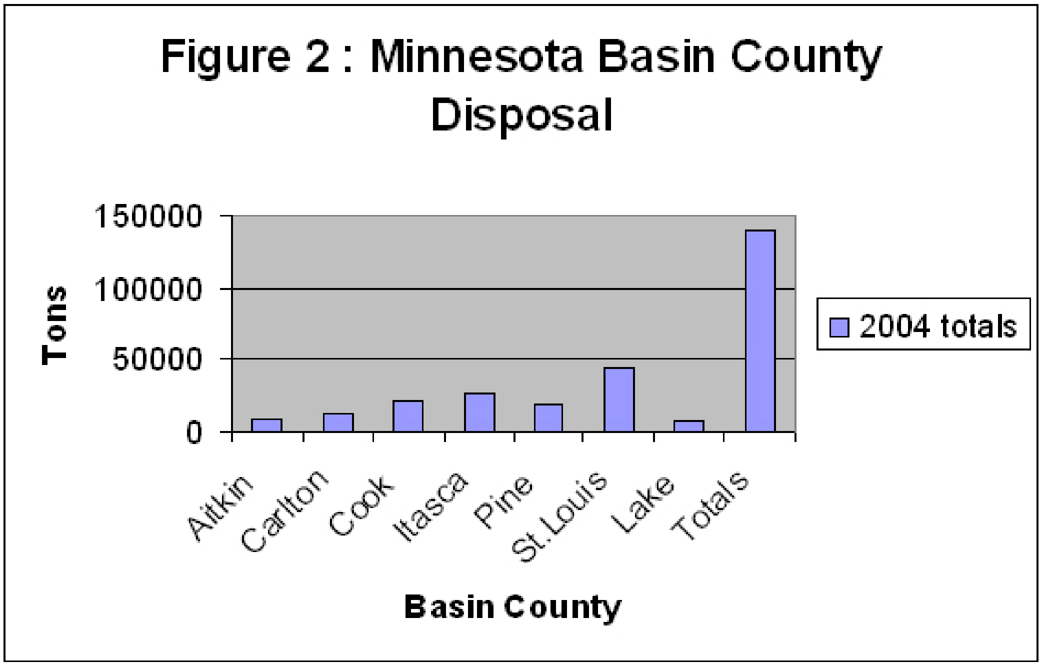

Figure 2. Minnesota Basin County Disposal.
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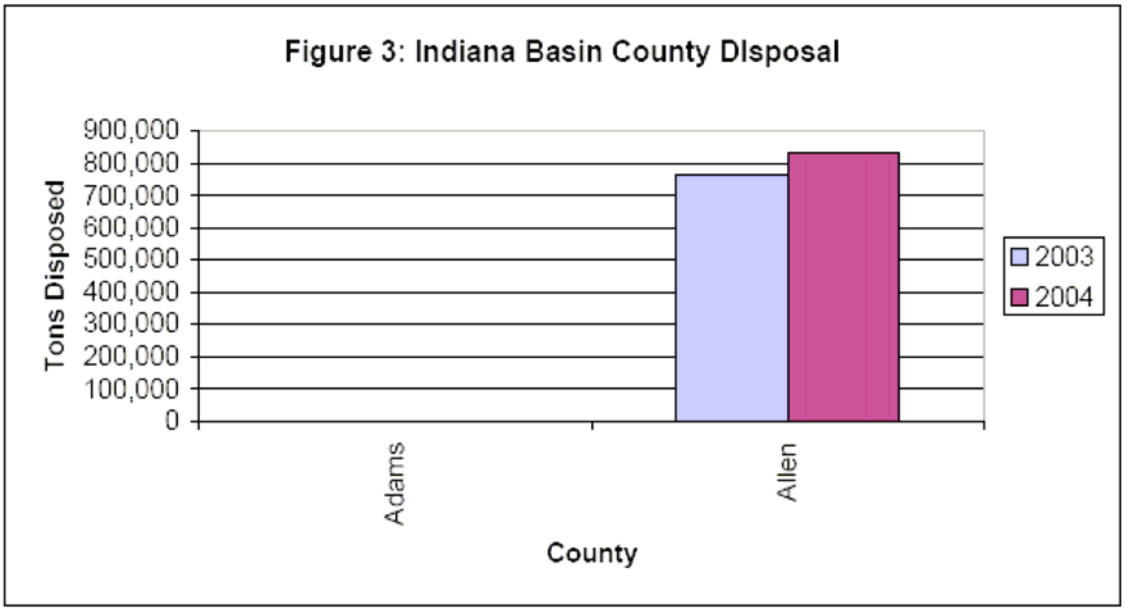

Figure 3. Indiana Basin County Disposal.
Source: Indiana Department of Environmental Management, Permitted Solid Waste Facility Report.

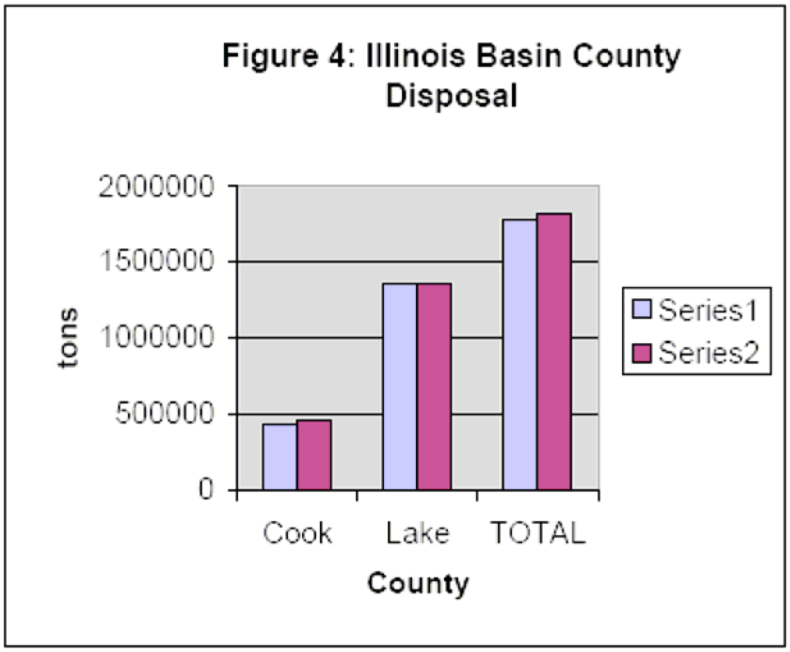

Figure 4. Illinois Basin County Disposal.
Source: Illinois Environmental Protection Agency, 2004 Landfill Capacity Report.

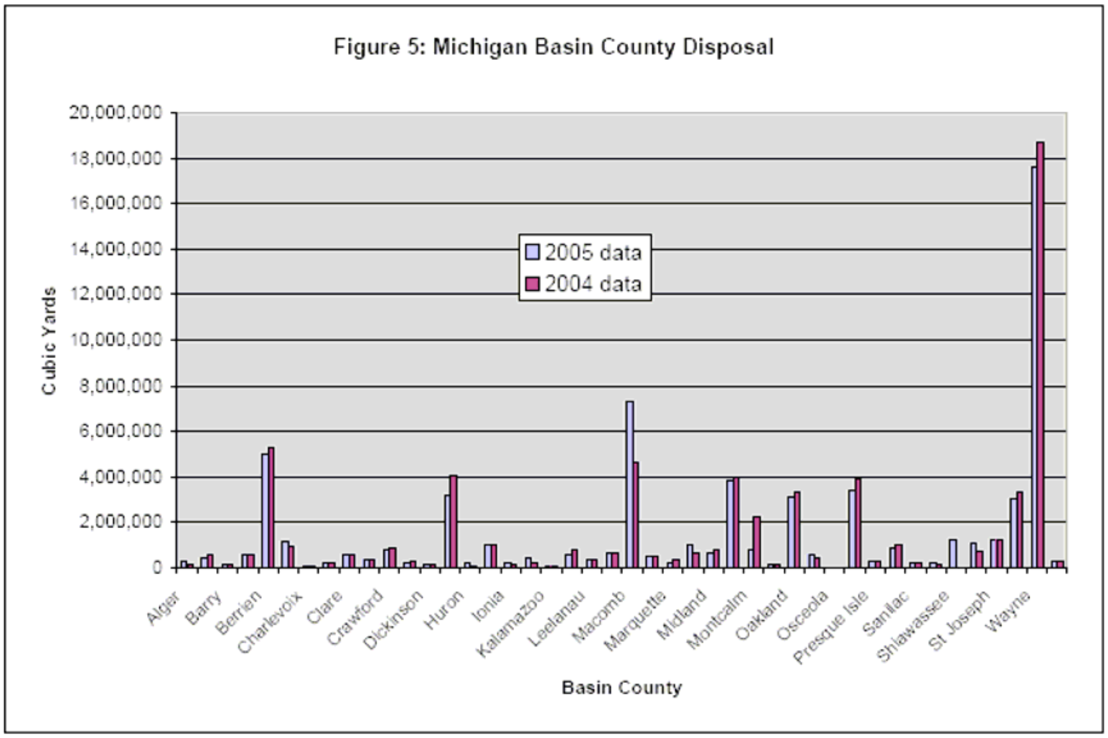

Figure 5. Michigan Basin County Disposal.
Source: Michigan Department of Environmental Quality, 2005 and 2004 Annual Report on Solid Waste Landfills.

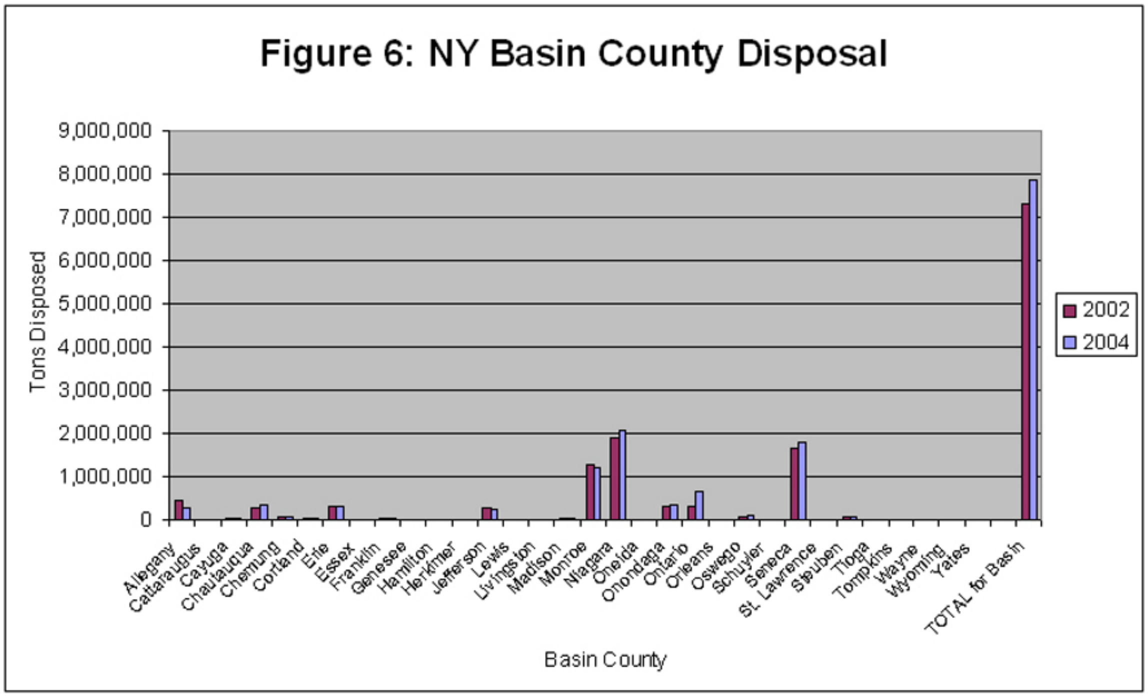

Figure 6. New York Basin County Disposal.
Source: New York State Department of Conservation Capacity data for Landfills and Waste to Energy Facilities.

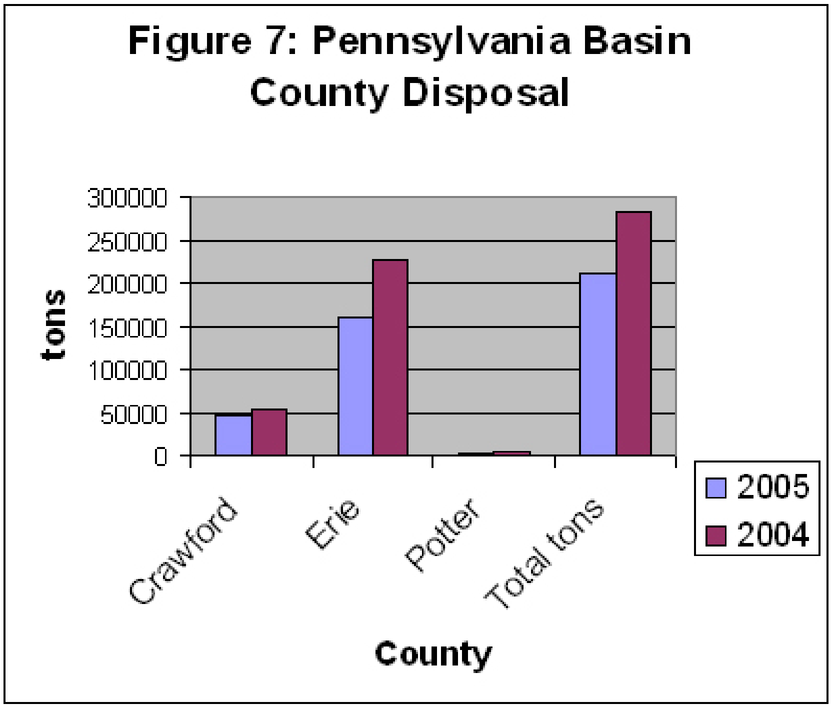

Figure 7. Pennsylvania Basin County Disposal.
Source: Pennsylvania Department of Environmental Protection Landfill Disposal Data.

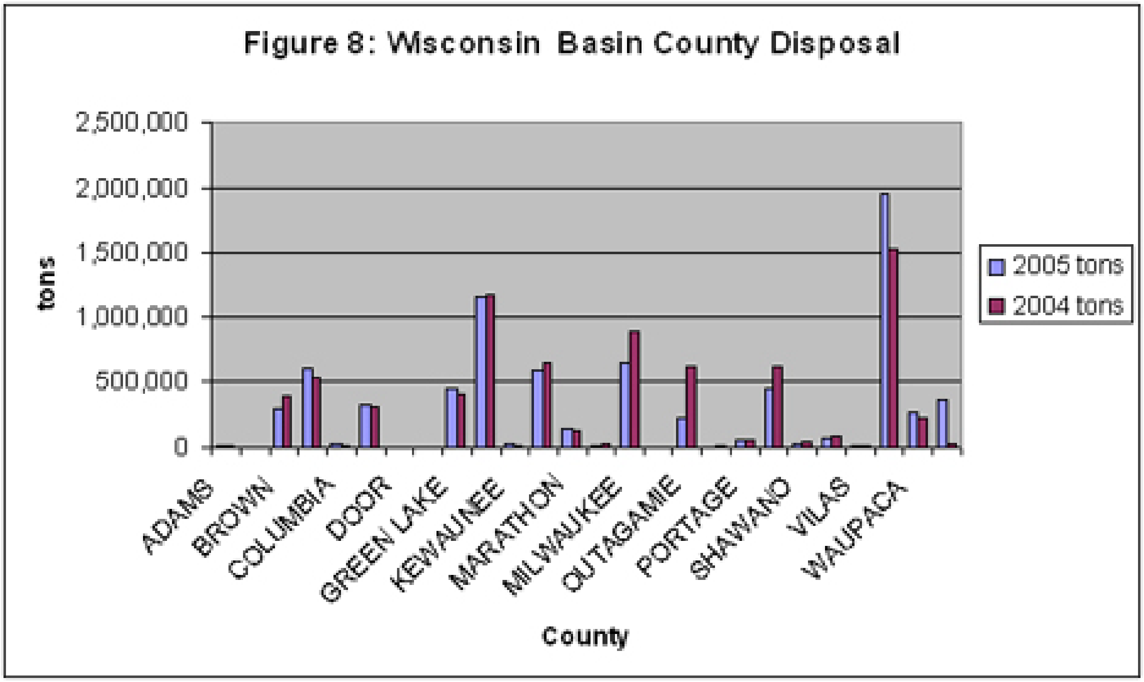

Figure 8 Wisconsin Basin County Disposal
Source: Wisconsin Department of Natural Resources, Landfill Tonnage Report.

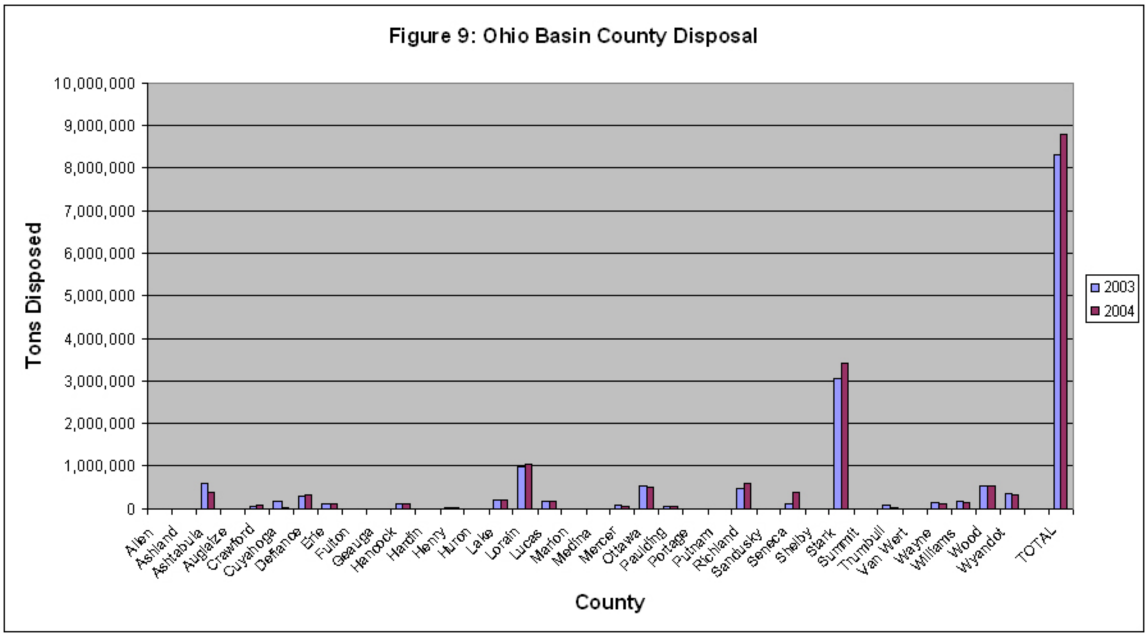

Figure 9. Ohio Basin County Disposal.
Source: Ohio Environmental Protection Agency, 2003 and 2004 Facility Data Reports.

Nutrient Management Plans

Indicator # 7061

Assessment: Not Assessed

Purpose

- To determine the number of Nutrient Management Plans; and
- To infer environmentally friendly practices that help to prevent ground and surface water contamination.

Ecosystem Objective

This indicator supports Annexes 2, 3, 11, 12 and 13 of the Great Lakes Water Quality Agreement. The objective is sound use and management of soil, water, air, plants and animal resources to prevent degradation of the environment. Nutrient Management Planning guides the amount, form, placement and timing of applications of nutrients for uptake by crops as part of an environmental farm plan.

State of the Ecosystem

Background

Given the key role of agriculture in the Great Lakes ecosystem, it is important to track changes in agricultural practices that can lead to protection of water quality, the sustainable future of agriculture and rural development, and better ecological integrity in the basin. The indicator identifies the degree to which agriculture is becoming more sustainable and has less potential to adversely impact the Great Lakes ecosystem. As more farmers embrace environmental planning over time, agriculture will become more sustainable through nonpolluting, energy efficient technology and best management practices for efficient and high quality food production.

Status of Nutrient Management Plans

The Ontario Environmental Farm Plans (EFP) identify the need for best nutrient management practices. Over the past 5 years farmers, municipalities and governments and their agencies have made significant progress. Ontario Nutrient Management Planning software (NMAN) is available to farmers and consultants wishing to develop or assist with the development of nutrient management plans.

In 2002 Ontario passed the Nutrient Management Act (NM Act) to establish province-wide standards to ensure that all land-applied materials will be managed in a sustainable manner resulting in environmental and water quality protection. The NM Act requires standardization, reporting and updating of nutrient management plans through a nutrient management plan registry. To promote a greater degree of consistency in by-law development, Ontario developed a model nutrient management by-law for municipalities. Prior to the NM Act, municipalities enforced each nutrient management by-law by inspections performed by employees of the municipality or others under authority of the municipality.

In the United States, the two types of plans dealing with agriculture nutrient management are the Comprehensive Nutrient Management Plans (CNMPs) and the proposed Permit Nutrient Plans (PNP) under the U.S. Environmental Protection Agency's (USEPA) National Pollution Discharge Elimination System (NPDES) permit requirements. Individual States also have additional nutrient management programs. An agreement between USEPA and U.S. Department of Agriculture (USDA) under the Clean Water Action plan called for a Unified National Strategy for Animal Feeding Operations. Under this strategy, USDA-Natural Resources Conservation Service has leadership for the development of technical standards for CNMPs. Funds from the Environmental Quality Incentives Program can be used to develop CNMPs.

The total number of nutrient management plans developed annually for the U.S. portion of the basin is shown in Figure 1. This includes nutrient management plans for both livestock and non-livestock producing farms. The CNMPs are tracked on an annual

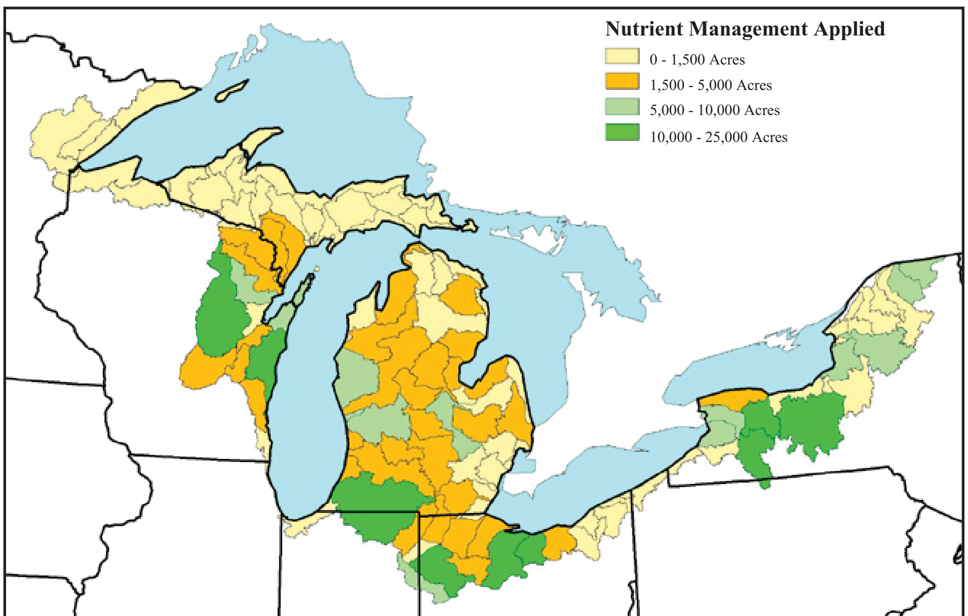

Figure 1. Annual U.S. Nutrient Management Systems total number of nutrient management plans developed annually for the U.S. portion of the basin, 2003.
Source: U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), Performance and Results Measurement System

basis due to the rapid changes in farming operations. This does not allow for an estimate of the total number of CNMPs. USEPA will be tracking PNP as part of the Status's NPDES program.

Figure 2 shows the number of Nutrient Management Plans by Ontario County for the years 1998-2002, and Figure 3 shows cumulative acreage of Nutrient Management Plans for the Ontario portion of the basin. The Ontario Nutrient Management Act is moving farmers toward the legal requirement of having a nutrient management plan in place. Prior to 2002 the need for a plan was voluntary and governed by municipal by-laws. The introduction of the Act presently requires new, expanding, and existing large farms to have a nutrient management plan. This has brought the expectation, which is reflected in Figure 2, that there will be on-going needs to have nutrient management plans in place.

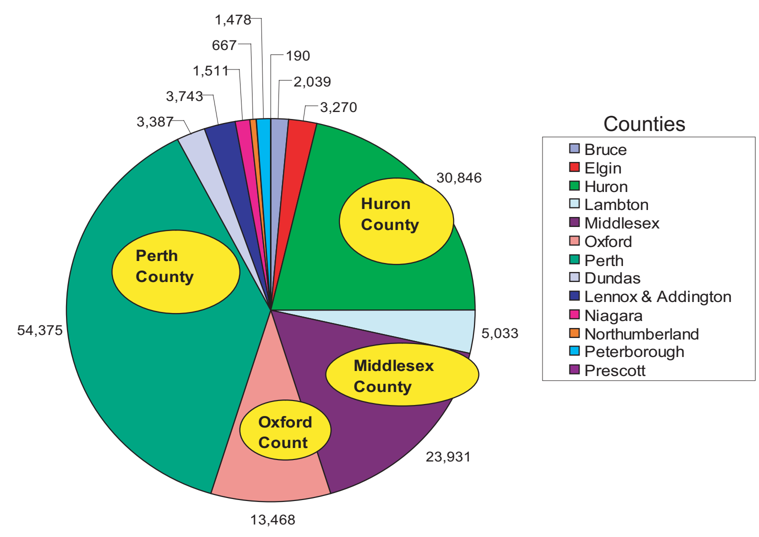

Figure 3. Cumulative acreage of Nutrient Management Plans for selected Ontario Counties in the basin. Over 75% NMP acreages found in Huron, Perth, Oxford and Middlesex Counties.
Source: Ontario Ministry of Agriculture and Food

Having completed a NMP provides assurance farmers are considering the environmental implications of their management decisions. The more plans in place the better. In the future there may be a way to grade plans by impacts on the ecosystem. The first year in which this information is collected will serve as the base line year

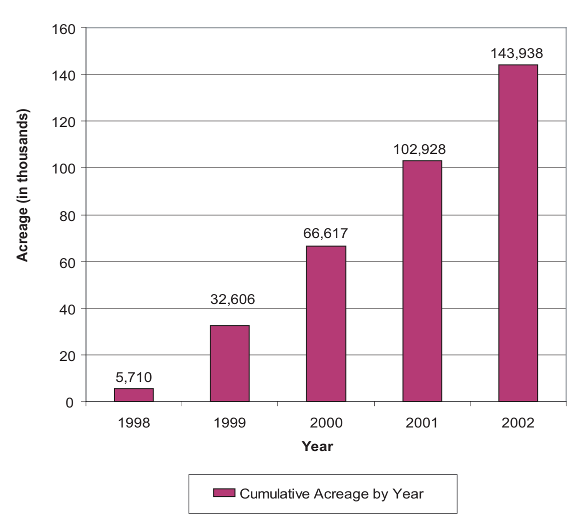

Figure 2. Nutrient Management Plans by Ontario County, 1998-2002.
Source: Ontario Ministry of Agriculture and Food

Pressures
As livestock operations consolidate in number and increase in size in the basin, planning efforts will need to keep pace with changes in water and air quality standards and technology. Consultations regarding the provincial and U.S. standards and regulations will continue into the near future.

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Ruth Shaffer, U.S. Department of Agriculture, Natural Resource Conservation Service, ruth.shaffer@mi.usda.gov; and
Roger Nanney, Resource Conservationist, U.S. Department of Agriculture, Natural Resource Conservation Service.

Authors' Commentary
The new Nutrient Management Act authorizes the establishment and phasing in of province-wide standards for the management of materials containing nutrients and sets out requirements and responsibilities for farmers, municipalities and others in the business of managing nutrients. It is anticipated that the regulations under this act will establish a computerized NMP registry; a tool that will track nutrient management plans put into place. This tool could form a part of the future "evaluation tool box" for nutrient management plans in place in Ontario. The phasing in requirements of province-wide standards for nutrient management planning in Ontario and the eventual adoption over time of more sustainable farm practices should allow for ecosystem recovery with time.
The USDA's Natural Resources Conservation Service has

formed a team to revise its Nutrient Management Policy. The final policy was issued in the Federal Register in 1999. In December 2000, USDA published its Comprehensive Nutrient Management Planning Technical Guidance (CNMP Guidance) to identify management activities and conservation practices that will minimize the adverse impacts of animal feeding operations on water quality. The CNMP Guidance is a technical guidance document and does not establish regulatory requirements for local, tribal, State, or Federal programs. PNPs are complementary to and leverage the technical expertise of USDA with its CNMP Guidance. USEPA is proposing that Concentrated Animal Feeding Operations, covered by the effluent guideline, develop and implement a PNP. There is an increased availability of technical assistance for U.S. farmers via Technical Service Providers, who can provide assistance directly to producers and receive payment from them with funds from the Environmental Quality Incentives Program.

Last Updated
State of the Great Lakes 2005

Integrated Pest Management

Indicator # 7062

Assessment: Not Assessed

Purpose

- To assess the adoption of Integrated Pest Management (IPM) practices and the effects IPM has had toward preventing surface and groundwater contamination in the Great Lakes basin by measuring the acres of agricultural pest management applied to agricultural crops to reduce adverse impacts on plant growth, crop production and environmental resources.

Ecosystem Objective

A goal for agriculture is to become more sustainable through the adoption of more non-polluting, energy efficient technologies and best management practices for efficient and high quality food production. The sound use and management of soil, water, air, plant, and animal resources is needed to prevent degradation of agricultural resources. The process integrates natural resource, economic, and social considerations to meet private and public needs. This indicator supports Article V1 (e) - Pollution from Agriculture, as well as Annex 1, 2, 3, 11, 12 and 13 of the Great Lakes Water Quality Agreement.

State of the Ecosystem

<u>Background</u>

Pest Management is controlling organisms that cause damage or annoyance. Integrated pest management is utilizing environmentally sensitive prevention, avoidance, monitoring and suppression strategies to manage weeds, insects, diseases, animals and other organisms (including invasive and non-invasive species) that directly or indirectly cause damage or annoyance. Environmental risks of pest management must be evaluated for all resource concerns identified in the conservation planning process, including the negative impacts of pesticides in ground and surface water, on humans, and non-target plants and animals. The pest management component of an environmental conservation farm plan must be designed to minimize negative impacts of pest control on all identified resource concerns.

Agriculture accounts for approximately 35% of the land area of the Great Lakes basin and dominates the southern portion of the basin. Although field crops such as corn and soybeans comprise the most crop acreage, the basin also supports a wide diversity of specialty crops. The mild climate created by the Great Lakes allows for production of a variety of vegetable and fruit crops. These include tomatoes (for both the fresh and canning markets), cucumbers, onions and pumpkins. Orchard and tender fruit crops such as cherries, peaches and apples are economically important commodities in the region, along with grape production for juice or wine. The farmers growing these agricultural commodities are major users of pesticides.

Research has found that reliance on pesticides in agriculture is significant and that it would be impossible to abandon their use in the short term. Most consumers want to be able to purchase inexpensive yet wholesome food. Currently, other than organic production, there is no replacement system readily available at a reasonable price for consumers, and at a lesser cost to farmers, that can be brought to market without pesticides. Other research has shown that pesticide use continues to decline as measured by total active ingredient, with broad-spectrum pest control products being replaced by more target specific technology, and with lowered amounts of active ingredient used per acre. Reasons for these declines are cited as changing acreages of crops, adoption of integrated pest management (IPM) and alternative pest control strategies such as border sprays for migratory pests, mating disruption, alternative row spraying and pest monitoring.

With continued application of pesticides in the Great Lakes basin, non-point source pollution of nearshore wetlands and the effects on fish and wildlife still remains a concern. Unlike point sources of contamination, such as at the outlet of an effluent pipe, nonpoint sources are more difficult to define. An estimated 21 million kg of pesticides are used annually on agricultural crops in the Canadian and American Great Lakes watershed (GAO 1993). Herbicides account for about 75% of this usage. These pesticides are frequently transported via sediment, ground or surface water flow from agricultural land into the aquatic ecosystem. With mounting concerns and evidence of the effects of certain pesticides on wildlife and human health, it is crucial that we determine the occurrence and fate of agricultural pesticides in sediments, and in aquatic and terrestrial life found in the Great Lakes basin. Atrazine and metolachlor were measured in precipitation at nine sites in the Canadian Great Lakes basin in 1995 (OMOE 1995). Both were detected regularly at all nine sites monitored. The detection of some pesticides at sites where they were not used provides evidence of atmospheric transport of pesticides.

Cultural controls (such as crop rotation and sanitation of infested crop residues), biological controls, and plant selection and breeding for resistant crop cultivars have always been an integral part of agricultural IPM. Such practices were very important and widely used prior to the advent of synthetic organic pesticides. Indeed, many of these practices are still used today as components of pest management programs. However, the great success of modern pesticides has resulted in their use as the dominant pest control practice for the past several decades, especially since the 1950s. Newer pesticides are generally more water soluble, less strongly adsorbed to particulate matter, and less persistent in both the terrestrial and aquatic environments than the older contaminants, but they have still been found in precipitation at many sites.

Status of Integrated Pest Management

The Ontario Pesticides Education Program (OPEP) provides farmers with training and certification through a pesticide safety course. Figure 1 shows survey results for 5800 farmers who took pesticide certification courses over a three-year period (2001-2004). Three sustainable practices (alter spray practices/manage drift from spray, mix/load equipment in order to protect surface and/or groundwater, and follow label precautions) and the farmers' responses are shown. Results suggest that in 2004 more farmers "do or plan to do now" these three practices after being educated about their respective benefits. These practices have significant value for reducing the likelihood of impairing rural surface and groundwater quality. Figure 2 shows the acres of pest management practice applied to cropland in the U.S. Great Lakes basin for 2003.

Pressures

Pest management practices may be compromised by changing land use and development pressures (including higher taxes); flooding or seasonal drought; and lack of long-term financial incentives for adoption of environmentally friendly practices. In order for integrated pest management to be successful, pest managers must shift from practices focusing on purchased inputs (using commercial sources of soil nutrients (i.e. fertilizers) rather than manure) and broad-spectrum pesticides to those using targeted pesticides and knowledge about ecological processes. Future pest management will be more knowledge intensive and focus on more than the use of pesticides. Federal, provincial and state agencies, university Cooperative Extension programs, and grower organizations are important sources for pest management information and dissemination. Although governmental agencies are more likely to conduct the underlying research, there is significant need for private independent pest management consultants to provide technical assistance to the farmer.

Management Implications

All phases of agricultural pest management, from research to field implementation, are evolving from their current product-based orientation to one that is based on ecological principles and processes. Such pest management practices will rely more on an understanding of the biological interactions that occur within every crop environment and the knowledge of how to manage the cropping systems to the detriment of pests. The optimum results would include fewer purchased inputs (and therefore a more sustainable agriculture), as well as fewer of the human and environmental hazards posed by the broad-spectrum pesticides so widely used today. Although pesticides will continue to be a component of pest management, the following are sig-

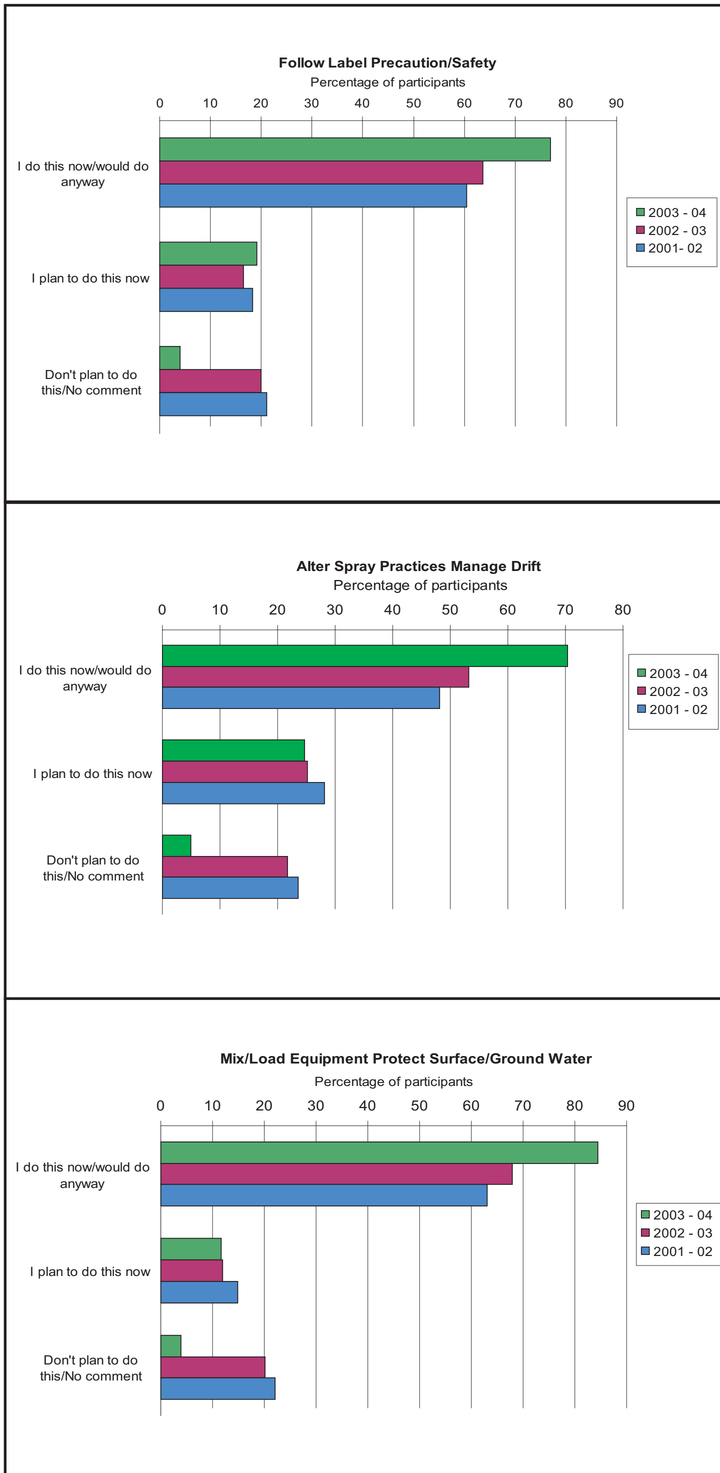

Figure 1. Ontario selected grower pesticide safety training course evaluation results from 2001-2004.
Source: Ontario Ministry of Agriculture and Food, Ontario Ministry of the Environment (OMOE) and the University of Guelph

nificant obstacles to the continued use of broad-spectrum pesticides: pest resistance to pesticides; fewer new pesticides; pesticide-induced pest problems; lack of effective pesticides; and human and environmental health concerns.

Based upon these issues facing pesticide use, it is necessary to start planning now in order to be less reliant on broad-spectrum pesticides in the future. Society is requiring that agriculture become more environmentally responsible through such things as the adoption of Integrated Pest Management. This will require effective evaluations of existing policies and implementing programs for areas such as Integrated Pest Management. To reflect these demands there is a need to further develop this indicator. The following types of future activities could assist with this process:

- Indicate and track future adoption trends of IPM best management practices;
- Analyze rural water quality data for levels of pesticide residues;
- Evaluate the success of the Ontario Pesticide Training Course, such as adding and evaluating survey questions regarding IPM principles and practices to course evaluation materials; and
- Evaluate the number of farmers and vendors who attended, were certified, or who failed the Ontario Pesticides Education Program.

Note: Grower pesticide certification is mandatory in Ontario and in all Great Lakes States, and it applies to individual farmers as well as custom applicators.

Acknowledgments

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Ruth Shaffer United States Department of Agriculture, Natural Resources Conservation Service, ruth.shaffer@mi.usda.gov; and Roger Nanney, Resource Conservationist, United States Department of Agriculture, Natural Resources Conservation Service.

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State of the Great Lakes 2005

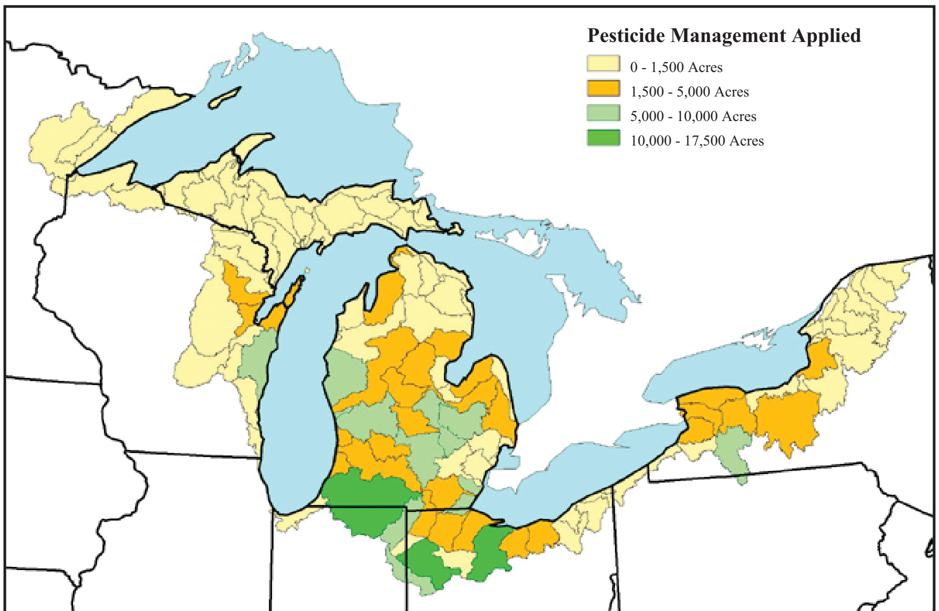

Figure 2. Annual U.S. Pesticide Management Systems Planned for 2003.
Source: U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), Performance and Results Measurement System

Vehicle Use
Indicator # 7064

Overall Assessment

Status:	**Poor**
Trend:	**Deteriorating**
Primary Factors Determining Status and Trend	**Population growth and urban sprawl in the Great Lakes Basin has led to an increase in the number of vehicles on roads, fuel consumption, and kilometers spent on the road by residents. Vehicle use is a driver of fossil fuel consumption, deteriorating road safety, and ecological impacts such as climate change and pollution.**

Purpose
To assess the amount and trends in vehicle use in the Great Lakes Basin (GLB) and to infer the societal response to the ecosystem stressed caused by vehicle use.

Ecosystem Objective
This indicator supports Annex 15 of the Great Lakes Water Quality Agreement. An alternative objective is to reduce stress on the environmental integrity of the Great Lakes region caused by vehicle use.

State of the Ecosystem
A suite of indicators monitoring vehicle use, the number of registered vehicles licensed, and fuel consumption is measured by governments in Canada and the United States to capture trends linked to fossil fuel consumption, deteriorating road safety, and ecological impacts such as climate change and pollution. Figure 1 shows the estimated total distance travelled by vehicles on roads in Ontario during 1993-2003 and the number of licensed vehicles registered in Ontario for the same period. The number of registered vehicles in Ontario rose 21% from over 6.3 million in 1990 to 7.6 million in 2004. More significant, however, is the estimated 122 million vehicle kilometers travelled (VKT) in Ontario, up 62% from 75 million in 1993. The greatest increase in VKT occurred between 1999 and 2000 (an increase of 39%). From this data, it is evident that Canadians in the Great Lakes Basin are increasingly spending more time on the road.

Looking to the U.S., Figure 2 shows the estimated trends in registered vehicles, licensed drivers, and vehicle kilometers travelled in the Great Lakes States from 1994 to 2004. The number of registered vehicles increased approximately 11% during this time period, while the number of licensed drivers only increased 8%. These increasing trends are somewhat lower than national averages in the U.S., showing increases of 20% and 13%, respectively. Just as in Ontario, VKT increased at a greater rate than the number of registered vehicles or licensed drivers. VKT increased in the Great Lakes States approximately 20% from 1994 to 2004, as compared to a 24% national U.S. increase. In 2004, U.S. residents in the Great Lakes States gained 7% more kilometres per vehicle than were driven in 1994.

A snapshot of the total registered vehicles in Ontario points abundantly to a societal dependence on private vehicles. Of the total registered vehicles in Ontario, passenger vehicles continually dominate road traffic, accounting for 74% of the total registered vehicles in 2004. As anyone who has driven on basin highways might guess, commercial freight traffic was the runner-up, accounting for 14% of road traffic in the same year. Notably, trucking flows of inter-provincial trade through Quebec and Ontario (both directions) also accounted for $41 billion worth of commodities or 30 per cent of total inter-provincial trade in Canada.

The movement of people is undoubtedly a driving force behind the economic profitability of the GLB. However, the tradeoffs of unsustainable modes of transport are evident. In Canada, road transportation, including private vehicles, represented 77% of total transportation in terms of energy use in 2004. As a result, energy-related GHGs rose by 25%, from 135.0 megatonnes to 168.8 megatonnes. In that same time period, the number of vehicles rose 8% faster than the number of people (Canada, 2005). In Ontario, sale of motor gasoline increased by 22% between 1989 and 2004 (Figure 3), on par with the national average. Gasoline sales rose from more than 12 billion litres to more than 15 billion litres between 1990 and 2003, with diesel fuel sales in Ontario alone doubling during the same period, from more than 12 million to almost 15 million litres. In the Great Lakes States, fuel (gasoline and gasohol) consumption for vehicles increased by 17% from 1994 to 2004, as compared to a 24% increase nationally in the U.S. It is noteworthy to point out that use of ethanol blended fuels (gasohol) in the Great Lakes States increased 160% over this time period. Gasohol now comprised approximately 39% of fuel consumption in the Great Lakes States. The increased demand for fuel in both countries is driven by a rise in number of vehicles on highways, increased power of automobile engines, and the growing popularity of sports utility vehicles and large-engine cars (Ménard, 2006)

Over the last decade, consumers have also shown a strong preference for high-performance vehicles. Since 1999, the production of Sport Utility Vehicles (SUVs) has dominated the automotive industry, surpassing the output of both minivans and pickup trucks nation wide. For the period of January to September 2004, SUVs accounted for 18% of total light-duty vehicle manufacturing, which assembles passenger cars, vans, minivans, pickup trucks and SUVs in Canada (Magnusson, 2005). In the Great Lakes States, the registrations of private and commercially owned trucks, which include personal passenger vans, passenger minivans, and sport-utility vehicles, have increased approximately 50% from 1994 to 2004. Private and commercially owned trucks now comprise about 37% of all registered vehicles in the Great Lakes States. Although the fuel economy of the average new car has improved more than 76% since 1975, the automotive industry has traded off fuel consumption improvements in new vehicles for more powerful engines. This improved performance reduced the fuel economy that otherwise could have been achieved, meaning, cars collectively get worse gas mileage today than they did in the mid-1980's (NRC, 1992)—the effects of which are experienced with diminished air quality locally.

Pressures

Suburban development has become the predominant form of growth in the Great Lakes Basin. The mixed assessment in the GLB urban air quality can be directly linked to the increase in traffic congestion. Presently, transportation GHG emissions are increasing at a slower rate than activity because of the more efficient travel of people and goods. However, all modes of transport are still greatly dependent on GHG-intensive hydrocarbons to provide them with energy. As a major driver of ecological stress, vehicles are the single largest domestic source of the smog-causing greenhouse gas (GHG) emissions. These emissions include nitrogen oxides (NOx) and volatile organic compounds (VOCs) as well as carbon monoxide (CO), all which contribute contaminants to air and water systems (MOE, 2005). Such pollutants have been connected with respiratory problems and premature death. There is strong evidence that atmospheric deposition is a source of pollutants in storm water runoff, and that this runoff reaches streams, rivers and other aquatic resources (IJC, 2004). Congestion caused by automobiles and vehicle-related development also degrades the liveability of urban environments by contributing noise, pollution, and fatalities. Positive trends in road use may also lead to further fragmentation of natural areas in the basin.

Management Implications

There is a need to reduce the volume and congestion of traffic in the GLB. While progress has been made through less polluting fuels and emission reduction technologies, and economic tools such as the tax incentives that encourage the purchase of fuel-efficient vehicles (e.g. Tax for Fuel Conservation), issues of urban sprawl must also be managed. Recent studies by the U.S. EPA found that infill development and re-development of older suburbs could reduce VKT per capita by 39% to 52% (depending on the metropolitan area studied) (Chiotti, 2004). The success of current strategies will assist managers and municipalities protect natural areas, conserve valuable resources (such as agriculture and fossil fuels), ensure the stability of ecosystem services, and prevent pollution. Under the Kyoto Protocol, Canada is committed to reducing its GHG emissions by 6% below 1990 levels by the year 2010, even though the government may consider new targets.

Over the next 30 years, the number of people living in Ontario is expected to grow by approximately four million, the majority of which are expected to reside in the GLB. In the Golden Horseshoe Area alone, 2031 forecasts predict that the population of this area is to grow by an additional 3.7 million (from 2001) to 11.5 million. The McGuinty government has invested in the several initiatives (including, Bill 26, the Strong Communities Act, 2004) in order to manage regional growth and development, and municipalities and regions within the GLB are developing their own plans within the common mandate.

Improving public transit is the first investment priority, however there is an acknowledgment that improving population growth forecasts, intensifying land use, revitalizing urban spaces, diversifying employment opportunities, curbing sprawl, protecting rural areas, and improving infrastructure are all part of the solution. Urban development strategies must be supported by positive policy and financial frameworks that allow municipalities to remain profitable, while creating affordable housing and encouraging higher density growth in the right locations. Further research, investment and action are needed to explore multi-modal corridors and modes for transporting goods in the basin.

Comments from the author(s)

It should be noted that Canadian Vehicle Kilometres Travelled (VKM) data is based on a voluntary vehicle-based survey conducted by Transport Canada. The measure of vehicle-kilometres travelled does not take into account occupancy rates, which affect the sustainability of travel.

It also should be noted that U.S. motor fuel data come from the records of State agencies that administer the State taxes on motor fuel are the underlying source for most of the data presented in these tables. Over the last several years, there have been numerous changes in State fuel tax laws and procedures that have resulted in improved fuel tax compliance, especially for diesel fuel.

The improved compliance has resulted in increased fuel volumes being reported by the States to FHWA. The trends shown in the tables reflect both improvements in tax compliance and changes in consumption.

U.S. VKT data - These data are derived from the Highway Performance Monitoring System (HPMS). The HPMS is a combination of sample data on the condition, use, performance and physical characteristics of facilities functionally classified as arterials and collectors (except rural minor collectors) and system level data for all public roads within each State.

Although data about VKT, registered vehicles, and fuel consumption was only available up to 2004, the authors feel this indicator should be updated in future to examine potential shifts in vehicle-use behaviours based on the recent rise in gasoline prices, which began climbing in late 2002. A 2005 report by Transport Canada, based on partial data, suggest that gas prices post-Hurricane Katrina had an impact on fuel consumption nationally.

Acknowledgments
Authors: Katherine Balpataky, Environment Canada, Burlington; and Todd Nettesheim, U.S. EPA, Great Lakes National Program Office, Chicago, IL.

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List of Tables

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Data Source: U.S. Department of Transportation. Federal Highway Administration. Office of Highway Policy Information. Highway Statistics Publications.

Figure 3. Petroleum Consumption in Ontario.
Data source: Statistics Canada's Energy Statistics Handbook. 2006

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Variable	Level		Variation from 1990 to 2003		% share of energy consumed		% contribution to change
	1990	2003	value	%	1990	2003	
Primary energy consumption in terajoules							
Motor gasoline	432,446	539,230	106,784	25	15	16	22
Diesel fuel	169,466	248,437	78,971	47	6	8	16

Table 1. Primary energy consumption of Motor Gasoline and Diesel Fuel, Canada, 1990 and 2003.
Source: Report on energy supply-demand in Canada, Statistics Canada Catalogue No. 57-003-XIB, 1990 and 2003; population estimates, CANSIM Table 051-0001; Real GDP, CANSIM Table 384-0013.

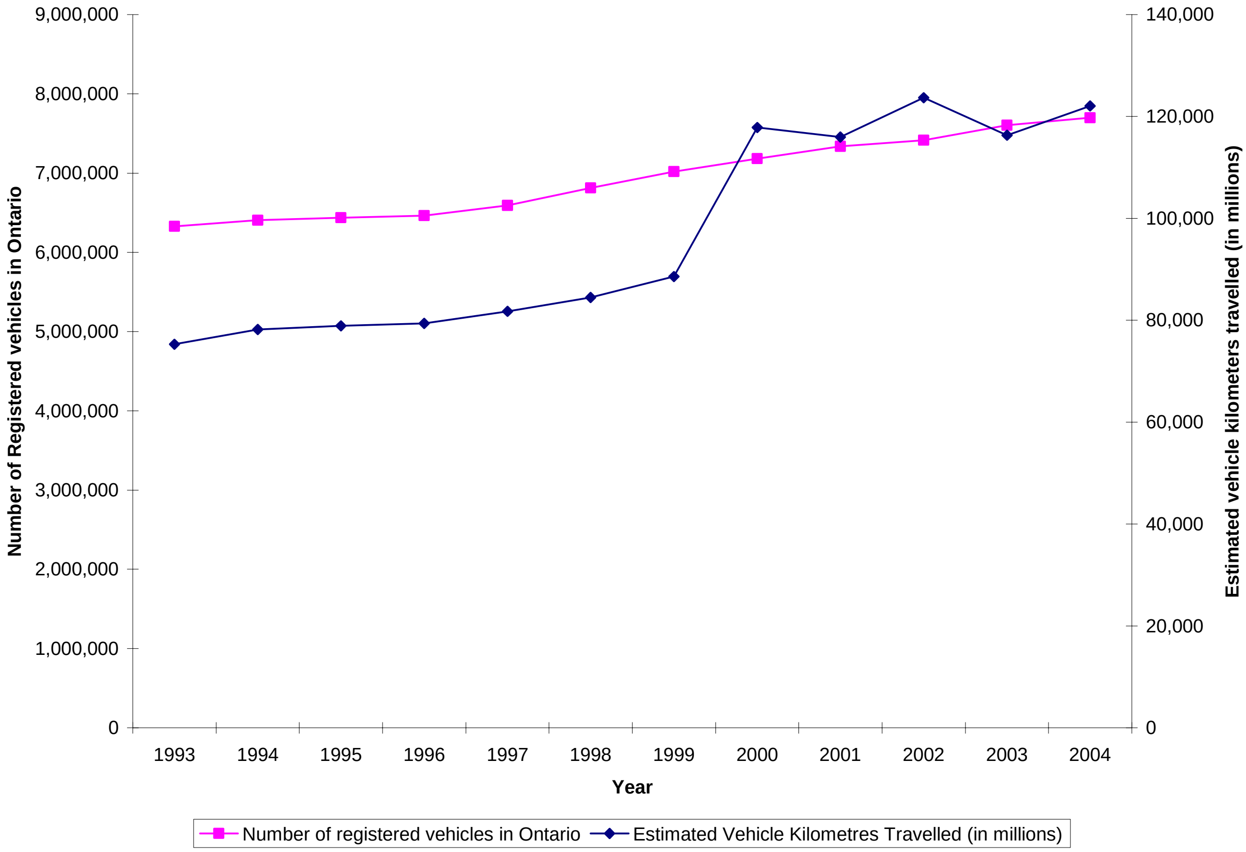

Figure 1. Number of Licensed Vehicles and Vehicle Kilometres Travelled in Ontario.
Data Source: Statistics Canada *Canadian Vehicle Survey*

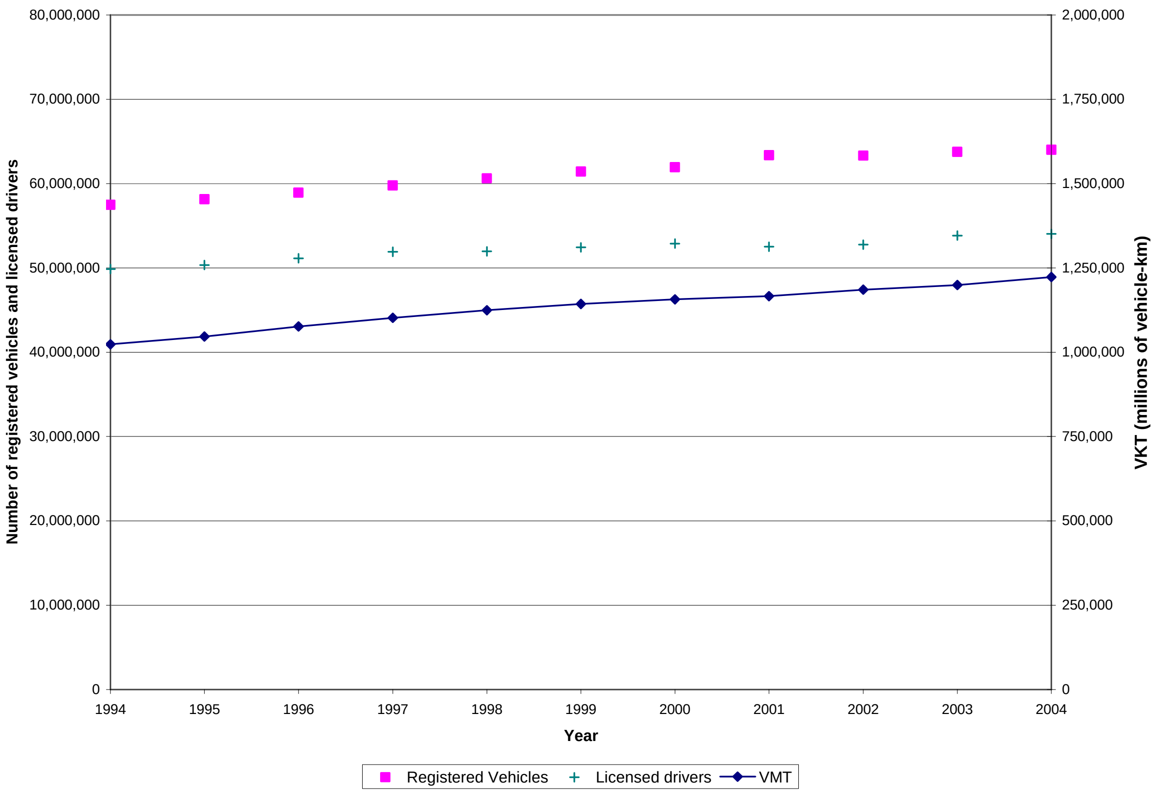

Figure 2. Number of Registered Vehicles, Licensed Drivers and Vehicle Kilometres Travelled in Great Lakes States.
Source: U.S. Department of Transportation. Federal Highway Administration. Office of Highway Policy Information. Highway Statistics Publications.

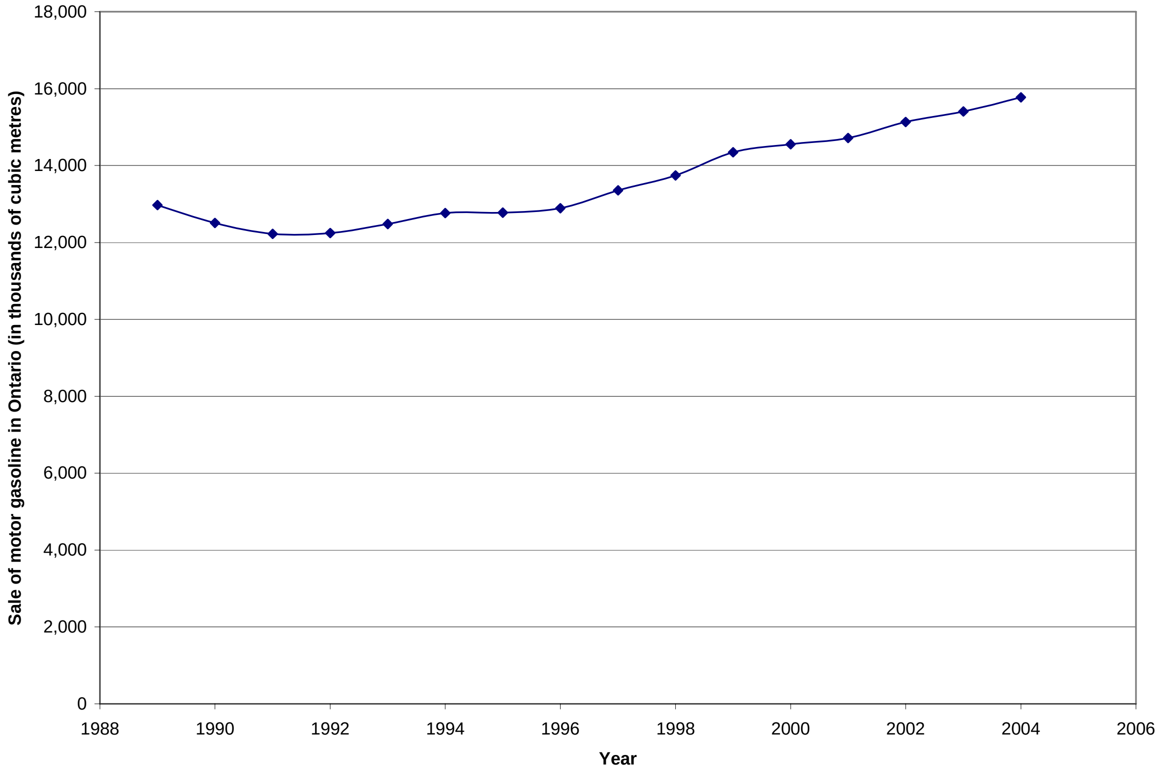

Figure 3. Petroleum Consumption in Ontario.
Data source: Statistics Canada's Energy Statistics Handbook. 2006

Wastewater Treatment and Pollution
Indicator # 7065

Note: This is a progress report towards implementation of this indicator.

Overall Assessment

Status:	**Not Assessed**
Trend:	**Undetermined**
Primary Factors Determining Status and Trend	**Data to support this indicator have not been summarized according to quality control standards. Compilation of a comprehensive report on wastewater treatment and pollution in the Great Lakes will require a substantial amount of additional time and effort.**

Lake-by-Lake Assessment
A lake-by-lake assessment is not available at this time as data summarization is incomplete and not available for analysis on a lake-by-lake basis.

Purpose *(proposed)*
- To measure the proportion of the population served by municipal sewage treatment facilities
- To evaluate the level of municipal treatment provided
- To measure the percent of collected wastewater that is treated; and
- To assess the loadings of metals, phosphorus, Biochemical Oxygen Demand (BOD), and organic chemicals released by wastewater treatment plants into the water courses of the Great Lakes basin.

Ecosystem Objective
The purpose of this indicator is to assess (1) the reduction of pressures induced on the ecosystem by insufficient wastewater treatment networks and procedures and (2) to further the progression of wastewater treatment towards sustainable development.

This indicator is also intended to (3) assess the scope of municipal sewage treatment and the commitment to protecting freshwater quality in the Great Lakes basin. The quality of wastewater treatment determines the potential adverse impacts to human and ecosystem health as a result of the loadings of pollutants discharged into the Great Lakes basin.

State of the Ecosystem
<u>Background Information</u>
Wastewater refers to the contents of sewage systems drawing liquid wastes from a variety of sources, including municipal, institutional and industrial, and stormwater discharges. After treatment, wastewater is released into the environment from a treatment plant as effluent into receiving waters such as lakes, ponds, rivers, streams and estuaries.

Wastewater contains a large number of potentially harmful pollutants, including some that are the result of biological activity as well as others that are part of the over 200 identified chemicals from industries, institutions, households, and other sources. Wastewater systems are designed to collect and treat these wastes using various levels of treatment to remove pollutants prior to discharge, ranging from no treatment to very sophisticated and thorough treatments. Despite treatment, effluents released from wastewater systems can still contain pollutants of concern, since even advanced treatment systems do not necessarily remove all pollutants and chemicals.

The following constituents, mostly associated with human waste, are present in all sewage effluent to some degree:

- biodegradable oxygen-consuming organic matter (measured as biochemical oxygen demand or BOD);
- suspended solids (measured as total suspended solids or TSS);
- nutrients, such as phosphorus (usually measured as total phosphorus) and nitrogen-based compounds (nitrate, nitrite, ammonia, and ammonium, which are measured either separately or in combination as total nitrogen);
- microorganisms (which are usually measured in terms of the quantity of representative groups of bacteria, such as fecal coliforms or fecal streptococci, found in human wastes);
- sulphides;
- assorted heavy metals; and
- trace amounts of other toxins and emerging chemicals of concern that have yet to be consistently monitored for in wastewater effluents.

Municipal Wastewater Effluent (MWWE) is one of the largest sources of pollution, by volume, discharged to surface water bodies in Canada (CCME, 2006). Reducing the discharge of pollution through MWWE requires a number of interventions ranging from source control to end of pipe measures.

<u>Levels of Treatment in the U.S. and Canada</u>
The concentration and type of effluent released into the receiving body of water depends heavily on the type of sewage treatment used. As a result, information regarding the level of treatment that was used on wastewater is integral in assessments of potential impacts on water quality. In both the United States and Canada, the main levels of wastewater treatment used include primary, secondary, and advanced or tertiary.

In primary wastewater treatment, solids are removed from raw sewage primarily through processes involving sedimentation. This process typically removes roughly 25-35% of solids and related organic matter (U.S. EPA 2000).

In the U.S., pretreatment may also occur preliminary to primary treatment, in which contaminants are reduced and large debris is removed from industrial wastewater before it is discharged to municipal treatment systems to undergo regular treatment. U.S. federal regulations require that Publicly Owned Treatment Works (POTW) Pretreatment Programs include the development of local pretreatment limits in situations where industrial pollutants could potentially interfere with municipal treatment facility operations or contaminate sewage sludge. The U.S. EPA can authorize the states to implement their own Pretreatment Programs as well. Of the eight states that are part of the Great Lakes basin, Michigan, Minnesota, Ohio and Wisconsin currently hold an approved State Pretreatment Program, (U.S. EPA, NPDES 2006).

Secondary wastewater treatment includes an additional biological component in which oxygen-demanding organic materials are removed through bacterial synthesis enhanced with oxygen injections. About 85% of organic matter in sewage is removed through this process, after which the excess bacteria are removed, (U.S. EPA 1998). Effluent can then be disinfected with chlorine prior to discharge in an effort to kill potentially harmful bacteria. Subsequent dechlorination is also often required to remove excess chlorine that may be harmful to aquatic life.

Secondary treatment effluent standards are established by the EPA and have technology-based requirements for all direct discharging facilities. These standards are expressed as a minimum level of effluent quality in terms of biochemical oxygen demand measurements over a five-day interval (BOD5), total suspended solids (TSS) and pH. Secondary treatment of municipal wastewater is the minimum acceptable level of treatment according to U.S. federal law unless special considerations dictate otherwise (U.S. EPA 2000).

Advanced, or tertiary, levels of treatment often occur as well and are capable of producing high-quality water. Tertiary treatment can include the removal of nutrients such as phosphorus and nitrogen and essentially all suspended and organic matter from wastewater through combinations of physical and chemical processes. Additional pollutants can also be removed when processes are tailored for those purposes.

Data on the level of treatment utilized in the United States are available from the Clean Water Needs Survey (CWNS). This cooperative effort between the U.S. EPA and the states resulted in the creation and maintenance of a database with technical and cost information on the 16,000 publicly owned wastewater treatment facilities in the nation. According to the results of the 2000 CWNS, the total population served by POTWs in the U.S. portion of the Great Lakes basin was 17,400,897 in 2000. Of this number, 0.7% received treatment from facilities that do not discharge directly into Great Lakes waterways and dispose of wastes by other means, 14.1% received secondary treatment, and 85.3% received treatment that was greater than secondary, making advanced treatment the type used most extensively. Please see Figure 1 for the complete distribution of population served according to level of treatment by major lake and river basins within the U.S. Great Lakes watershed. These values do not include a possible additional 12,730 people who were reportedly served by facilities in New York for which watershed locations are unknown within the CWNS database. Although the facilities are in counties at least partially within the U.S. portion of the Great Lakes region, their location within Great Lakes watersheds can not be easily verified.

Wastewater Treatment Plants (WTPs) in Ontario also use primary, secondary, and tertiary treatment types. The processes are very similar, if not the same to those used in the U.S. (described above), but Canadian regulatory emphasis is placed on individual effluent quality guidelines as opposed to mandating that a specific treatment type be utilized across the province.

A complete distribution of population served according to level of treatment is not available in the Great Lakes basin for Ontario at this time. However, for a general understanding, a distribution of the population served by each treatment type for all of Canada is available in Figure 2.

Tertiary or advanced treatment is the most common type of sewage treatment across the basin, which can be inferred from the combined trends demonstrated in both Figures 1 and 2. This indicates the potential for high effluent water quality, which can only be verified through analysis of regulatory and monitoring programs.

Condition of Wastewater Effluent in Canada and the United States:
Regulation, Monitoring, and Reporting

Canada does not regulate effluent conditions through treatment level requirements, but instead sets specific limits for each individual WTP, no matter which type of treatment is used. In the U.S., effluent limits are standardized by the Federal Government, but the states have the power to make alterations as long as minimum guidelines are met.

Each federally managed wastewater treatment plant (WTP) in Canada must also follow guidelines given by the Federal Government. Effluent guidelines for wastewater from Federal facilities are to be equal to or more stringent than the established standards or requirements of any Federal or Provincial regulatory agency (Environment Canada, 2004). The guidelines indicate the degree of treatment and the effluent quality applicable to the wastewater discharged from the specific WTP. Use of the Federal guidelines is intended to promote a consistent wastewater approach towards the cleanup and prevention of water pollution and ensure that the best practicable control technologies are used (Environment Canada, 2004).

Table 1 lists the pollutant effluent limits specified for all federally approved WTPs in Ontario. The effluents discharged to the receiving water should receive treatment such that an effluent of minimum quality is achieved. In general, compliance with the numerical limits should be based on 24 hour composite samples (Environment Canada, 2004).

In Ontario, wastewater treatment and effluents are monitored through a Municipal Water Use Database (MUD) through Environment Canada. This database uses a survey for all municipalities to report on wastewater treatment techniques. Unfortunately, the last complete survey is from 1999 and this data are not sufficient to use for this report. The most up to date municipal water use survey will be released within the next few months and would useful to examine the treatment results within Canada. Unfortunately, the survey is not yet available, and other methods have been chosen to examine wastewater treatment in Ontario, which are explained in the *Attempted Eperimental Protocols* section of this progress report.

The U.S. regulates and monitors wastewater treatment systems and effluents through a variety of national programs. The U.S. EPA's Office of Wastewater Management promotes compliance with the Clean Water Act through the National Pollutant Discharge Elimination System (NPDES) Permit Program. These permits regulate wastewater discharges from POTWs by setting effluent limits, monitoring and reporting requirements, and they can lead to enforcement actions when excessive violations occur. The U.S. EPA can authorize the states to implement all or part of the NPDES program, and all US states in the Great Lakes region are currently approved to do so provided they meet minimum federal requirements, (U.S. EPA, NPDES 2006). This distribution of implementation power can create difficulties when specific assessments are attempted across regions spanning several states.

Large scale national assessments of wastewater treatment have been completed in the past by using BOD and dissolved oxygen (DO) levels as indicators of water quality. Since DO levels have been proved to be related to BOD output from wastewater discharges (increased BOD loadings lead to greater depletion of oxygen and lower DO levels in the water), historical DO records can be a useful indicator of water quality responses to wastewater loadings. According to a national assessment of wastewater treatment completed in 2000, the U.S. Great Lakes basin had a statistically significant improvement in worst-case DO levels after the Clean Water act (U.S. EPA 2000). The study's design estimates also showed that the national discharge of BOD_5 in POTW effluent decreased by about 45%, despite a significant increase of 35% in the population served and the influent loadings. This improving general trend supported assumptions made in the 1996 CWNS Report to Congress that the efficiency of BOD removal would increase due to the growing proportion of POTWs using advanced treatment processes across the nation.

Although specific case studies do exist, unfortunately comprehensive studies such as the examples listed above have not been conducted for pollutants other than BODs, and have not been completed to an in-depth level for the Great Lakes region.

An extensive investigation of the Permit Compliance System (PCS) database is one way such a goal can be accomplished. This national information management system tracks NPDES data including permit issuance, limits, self-monitoring, and compliance. The PCS database can provide the information necessary to calculate the loadings of specific chemicals present in wastewater effluent from certain POTWs in the U.S. portion of the Great Lakes basin, providing the relevant permits exist.

Attempted Experimental Protocol for Calculating Pollutant Loadings from Wastewater Treatment Plants to the Great Lakes

This calculation was attempted for the U.S. and Canadian portion of the G.L. basin during the compilation of this report, and although an extensive amount of data are available and have been retrieved, their summarization to an appropriate level of quality control is substantially difficult and is not complete at this time. The protocol followed thus far is outlined below.

The initial procedure for mining the U.S. data from the PCS database began with the compilation of a list of all the municipal wastewater treatment facilities located within the Great Lakes basin. The determination of which pollutants were most consistently permitted for across the basin followed, and the effluent loadings data for all facilities that monitored for those parameters were obtained for 2000 and 2005. These pollutant parameters were often referred to by various common names in the database, which additionally complicated extraction of concise data. The resulting mass of data was extremely large and could not be feasibly summarized due to internal inconsistencies such as difference in units of measurement, monitoring time frames, extreme outliers, and apparent data entry mistakes.

In an effort to decrease the amount of U.S. data requiring analysis at a more precise level, (as a result of the problems mentioned above,) several specific facilities throughout the basin were chosen to hopefully serve as representative case studies off which total loadings estimates could be calculated. These facilities were chosen by two sets of criteria. The first was according to location within the basin, to ensure that all states and each Great Lake were represented. The second criteria was the greatest average level of effluent flow, as the selected facilities could potentially have the greatest impact due to sheer volume of effluent, and these values could also be used to calculate loadings in cases where pollutant measurements were gathered as a concentration as opposed to by quantity (as was often the case). Fifteen facilities were eventually selected for further analysis, and corresponding effluent measurements for basic pollutants were extracted from the PCS database. Calculation of percent change in pollutant loadings and the number of violations from 2000 to 2005 was attempted for these data, but results are not available yet due to the data quality issues described earlier.

With total effluent loadings being so difficult to calculate independently from database records, government generated historical records of effluent limit violations can provide some insight into the performance of U.S. Great Lakes wastewater treatment facilities. The Enforcement and Compliance History Online (ECHO) is a publicly accessible data system funded by the EPA that was used to obtain violation information by quarter over a three year time span for the group of 15 U.S. facilities previously selected for loadings calculations.

The resulting compliance data are presented in Figure 3 according to each pollutant for which violations of permitted effluent levels occurred during the 12 possible quarters under investigation from 2003-2006. This information is further separated out into quarters that demonstrated basic violations of effluent limits and those that had a significant level of non-compliance with permitted effluent limits. Chloride, fecal coliform, and solids violations were the most common, with copper, cyanide, and mercury having higher numbers of violations as well. Chloride, copper, mercury, and solids violations showed the most significant non-compliance with permitted levels.

In Ontario, wastewater treatment plants must report on the operation of the system and the quality of the wastewater treatment procedures on an annual basis to satisfy the requirements of the Ontario Ministry of Environment and the Certificate of Approval. Each report fulfills the reporting requirements established in section 10(6) of the Certificate of Approval made under the *Ontario Water Resources Act* (R.S.O. 1990, c. O.40). As a result of these requirements, effluent limit violations for BOD, phosphorus, and suspended solids should be available for future analysis. Data are too extensive to summarize at this time to a sufficient level of quality control.

Since results from the Municipal Water Use Database were not available at this time, the data used for the Canadian component of this report were provided by 10 municipalities in the Great Lakes basin. Municipalities were randomly chosen based on their proximity to the great lakes and their population of over 10,000. Most of the chosen municipalities had about one to three wastewater treatment plants, which compiled to 24 treatment plants being examined in total for this indicator report. Data from 2005 annual reports for each wastewater treatment plant were used to analyze wastewater treatment procedures and associated effluent quality for this indicator, with special focus on four specific pollutant parameters. These include BOD, phosphorus and suspended solids, all of which are indicators of potential health hazards.

These parameters are regulated by most wastewater treatment plants, which when exceeded, have the potential to have serious effects on human health. Current targets exist to minimize environmental and health impacts. For example, Ontario WTPs have a target of 50% for the removal of BOD and limits must not exceed 20mg/L in a 5 day span. The target for the removal of suspended solids is 70%, with a limit of 25 mg/L in a 24 hour sample period. And although some nutrients are essential for plant production in all aquatic ecosystems, an oversupply of nutrients, particularly from municipal wastewater effluents, can lead to the growth of large algal blooms and extensive weed beds (Environment Canada 2001). Resulting wastewater effluent limits for phosphorus in Ontario have been set at 1.0mg/L accordingly. Completed results corresponding to the exceedences of these limits are not available for Ontario at this time.

Pressures

There are numerous challenges to providing adequate levels of wastewater treatment in the Great Lakes basin. These include: facility aging, disrepair and outdatedness; population growth that stresses the capabilities of existing plants and requires the need for more facilities; new and emerging contaminants that are more complex and prolific than in the past; and new development that is located away from urban areas and served by decentralized systems (such as septic systems) that are much harder to regulate and monitor. The escalating costs associated with addressing these challenges continue to be a problem for both U.S. and Canadian municipalities, (U.S. EPA, 2004 and Government of Canada, 2002).

Management Implications

Despite demonstrated significant progress with wastewater treatment across the basin, substantial problems remain with regards to nutrient enrichment, sediment contamination, heavy metals, and toxic organic chemicals that still pose threats to the environment and human health. It is therefore important to continually invest in wastewater treatment infrastructure improvements, so any current achievements in water pollution control are not overwhelmed by the demands of future urban population growth and so other remaining concerns can be addressed such as polluted urban runoff and untreated municipal stormwater. These sources have emerged as prime contributors to local water quality problems throughout the basin (Environment Canada, 2004). WTPs are having difficulties keeping up with demands created by urban development which cause an increasing amount of bypass into the Great Lakes. The governments of Canada and Ontario and municipal authorities, working under the auspices of the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA), have been developing and evaluating new stormwater control technologies and sewage treatment techniques to resolve water quality problems (Environment Canada, 2004). Under the new COA, Canada and Ontario will continue to build on this work, implementing efficient and cost effective projects to reduce the environmental damage of a rapidly expanding urban population (Environment Canada, 2004).

Municipal wastewater effluent (MWWE) is currently managed through a variety of policies, by-laws and legislation at the federal, provincial/territorial and municipal levels (CCME, 2006). This current variety of policies unfortunately creates confusion and complex situations for regulators, system owners and operators. As a result, the Canadian Council of Ministers of the Environment (CCME) has established a Development Committee to develop a Canada-wide Strategy for the management of MWWE by November 2006. An integral part of the strategy's development will be to consult with a wide variety of stakeholders to ensure that management strategies for MWWE incorporate their interests, expertise and vision. The strategy will address a number of governance and technical issues, resulting in a harmonized management approach (CCME, 2006).

The presence of emerging chemicals of concern in wastewater effluent is another developing issue that requires attention. Current U.S. State and municipality permit requirements are based on state water quality laws that are developed according to pollutants anticipated to exist in the community. This is also true for the WTP in Ontario. This means the existence of new potentially toxic substances can be overlooked. So even in areas with a high degree of municipal wastewater treatment, pollutants such as endocrine-disrupting substances can inadvertently pass through wastewater treatment systems and into the environment. These substances are known to disrupt or mimic naturally occurring hormones and may have an impact on the growth, reproduction, and development of many species of wildlife. Additional monitoring for these pollutants and corresponding protection and regulation measures need to be investigated and implemented.

The methodologies used in the U.S. national assessments of wastewater treatment could potentially be reproduced and used to detect loadings trends and performance measures for additional pollutants in the Great Lakes. The QA/QC safeguards included in such methods could lead to very useful analyses of watershed-based point source controls. Sufficient resources in terms of time and funding need to be allocated in order to accomplish this task.

Comments from the author(s)
The actual proportion of the entire population receiving treatment can not be calculated until a definite population for the Great Lakes basin can be obtained for the same time period. Several different population estimates exist for the region, but they were compiled according to county in the U.S., and therefore represent a skewed total for the population that actually resides within the boundaries of the Great Lakes watershed. GIS analysis of census data needs to be completed in order to obtain a more accurate value for the Great Lakes population.

In Canada, only one year was assessed due to lack of available data. In future years, data from the Environment Canada MWWS survey would be useful to use, but the survey is currently only updated to 1999, which unfotunately would not be useful for this report. The newest survey will be out within the next year and it should be examined in future assessments for this indicator.

Several problems exist in the calculation of effluent loadings. For example, actual flow through effluent is not consistently monitored for in the U.S. Although influent levels are obtainable for every facility, there is no way to ensure that the effluent is comparable, since a substantial volume may be removed during treatment processes. Since effluent flow is sometimes necessary to calculate loadings from concentration values of pollutants, precise estimates of total loadings to Great Lakes waters may be next to impossible to obtain on a large scale.

Another future effort towards the implementation of this indicator would be to use a consistent guideline when analyzing wastewater treatment in both the U.S. and Canada. In the U.S. portion of the basin, data were compiled from several different databases, with population information derived from a separate source than effluent monitoring reports. For Ontario, data from randomly chosen municipalities serving a population of 10,000 or greater were available for analysis. Focusing on this criterion for wastewater treatment can only provide a fragmented view of the treatment patterns in the Canadian Great Lakes basin; however, by using a consistent wastewater treatment analysis guideline, bias results would be avoided.

Furthermore, a more organized monitoring program must be implemented in order to successfully correlate wastewater treatment quality with the status of the Great Lakes basin. Although the wastewater treatment plants provide useful monitoring information regarding the quality of wastewater, they only state the quality of that specific municipality, rather than the overall quality of the great lakes. Implementation of a more standardized, updated approach to monitoring contaminants in effluent and reporting data for wastewater treatment is needed to address this issue. Additionally, the difference in monitoring requirements between Canada and the U.S. make it difficult to assess the quality of wastewater treatment on a basin-wide scale. A standardized reporting format and inclusive database, accessible to all municipalities, researchers, and the general public, should be established for binational use. This would make trend analysis easier, and thus provide a more effective assessment of the potential health hazards associated with wastewater treatment for the Great Lakes as a whole.

Considering all the difficulties encountered while attempting to adequately summarize the vast amount of U.S. effluent monitoring data contained in the PCS database, the logical solution would be to request an application that could automate accurate calculations. Interestingly, such an application previously existed that was capable of producing effluent data mass loadings reports from the PCS database, but it was discontinued due to the modernization of the PCS system that is currently underway. While the PCS system is being updated, adequate resources have not been available to extend this overhaul to the previously mentioned application as of yet, and the lack of substantial use of the application in the past raised concern over its cost-effectiveness. Additionally, incorporating this component into the current modernization could take years due to various logistical problems, including the inherent quality assurance controls needed for PCS metadata before potential loadings results could be accepted as reliable, high quality data (personal communication with James Coleman, 2006).Despite these problems, the reinstatement of such a tool would solve the data summarization needs presented in this indicator report and could lead to an effective, comprehensive, and time-efficient analysis of pollutant loadings to the Great Lakes from wastewater treatment plants.

Acknowledgments
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Source: Municipal Water Use Database Web site:
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Figure 3. Total number of quarters with reported effluent limit violations by pollutant for selected U.S. facilities
Caption: Data was compiled from 15 different facilities according to the total number of quarters that were in non-compliance of at least one pollutant effluent limit permit during 2003-2006.
* = combination of violations for 5-day BOD listed as total % removal and total
** = combination of violations for fecal coliform listed as general and broth totals
*** = combination of violations for cyanide listed as A and CN totals
**** = combination of violations for total nitrogen listed as N and as NH3
***** = combination of violations for solids as listed as total settleable, total dissolved, total suspended, and suspended % removal

Source: U.S. EPA. "Enforcement & Compliance History Online (ECHO)." *Compliance and Enforcement.* September 2006. U.S. EPA, Office of Enforcement and Compliance Assurance. http://www.epa.gov/echo/index.html (Accessed September27, 2006).

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Pollutant Effluent	Limit
5 day Biochem Biochemical Oxygen Demand	20 mg/L
Suspended Solids	25 mg/L
Fecal Coliforms	400 per 100 mL (after disinfection)
Chlorine Residual	0. 50 mg/L minimum after 30 minutes contact time
pH	6 to 9
Phenols	20 micrograms/L
Oils & Greases	15 mg/L
Phosphorus (Total P)	1 .0 mg/L
Temperature	Not to alter the ambient water temperature by more than one degree Centigrade (1ºC).

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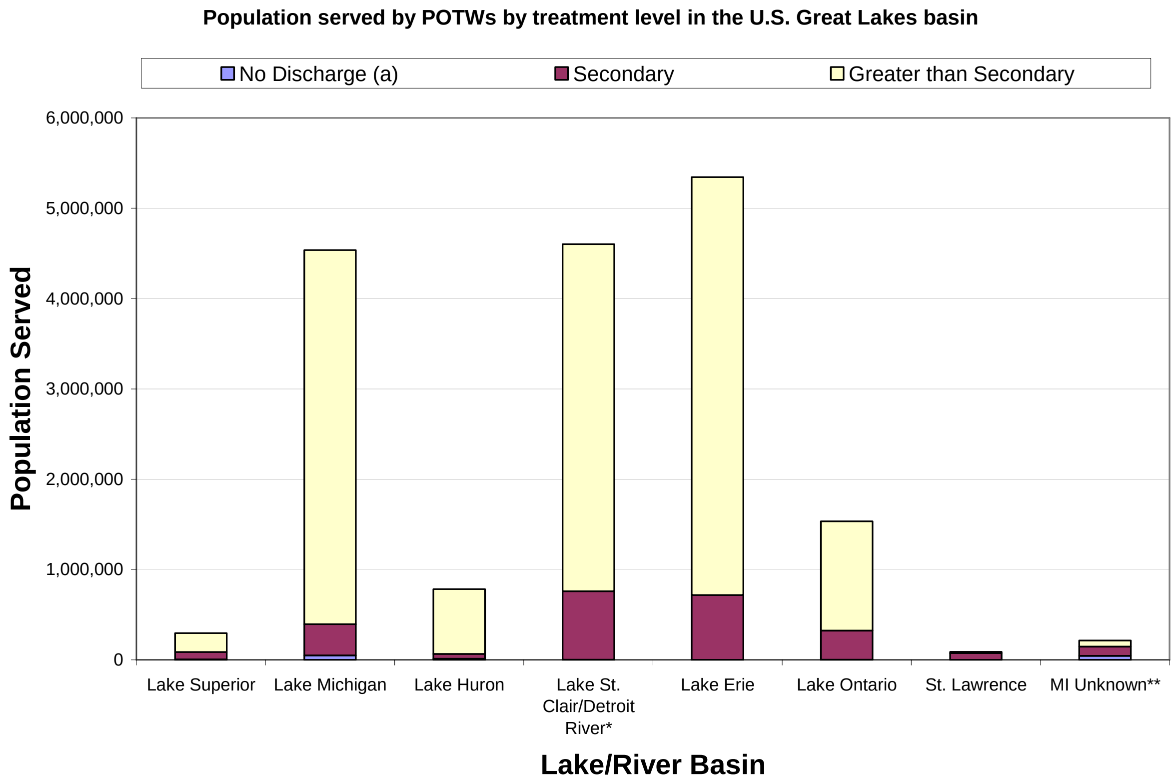

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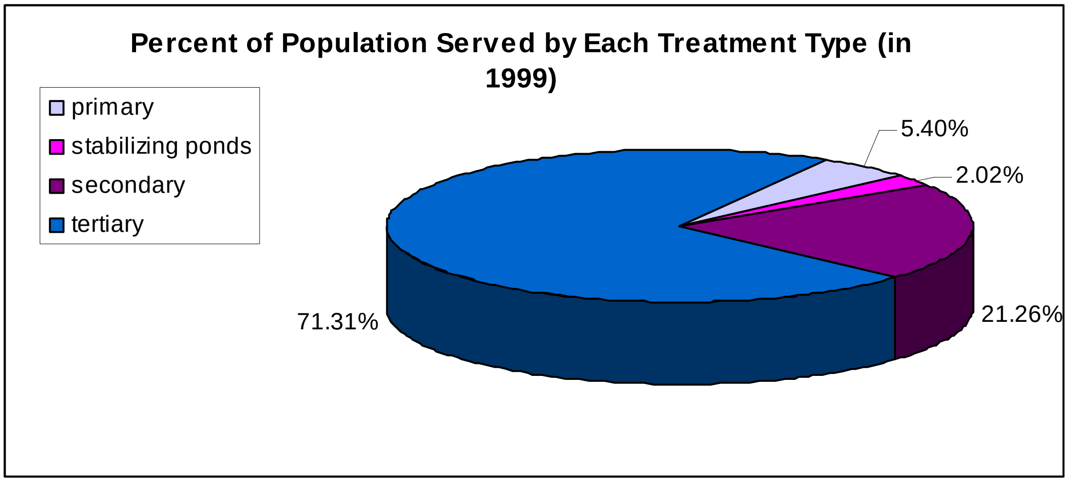

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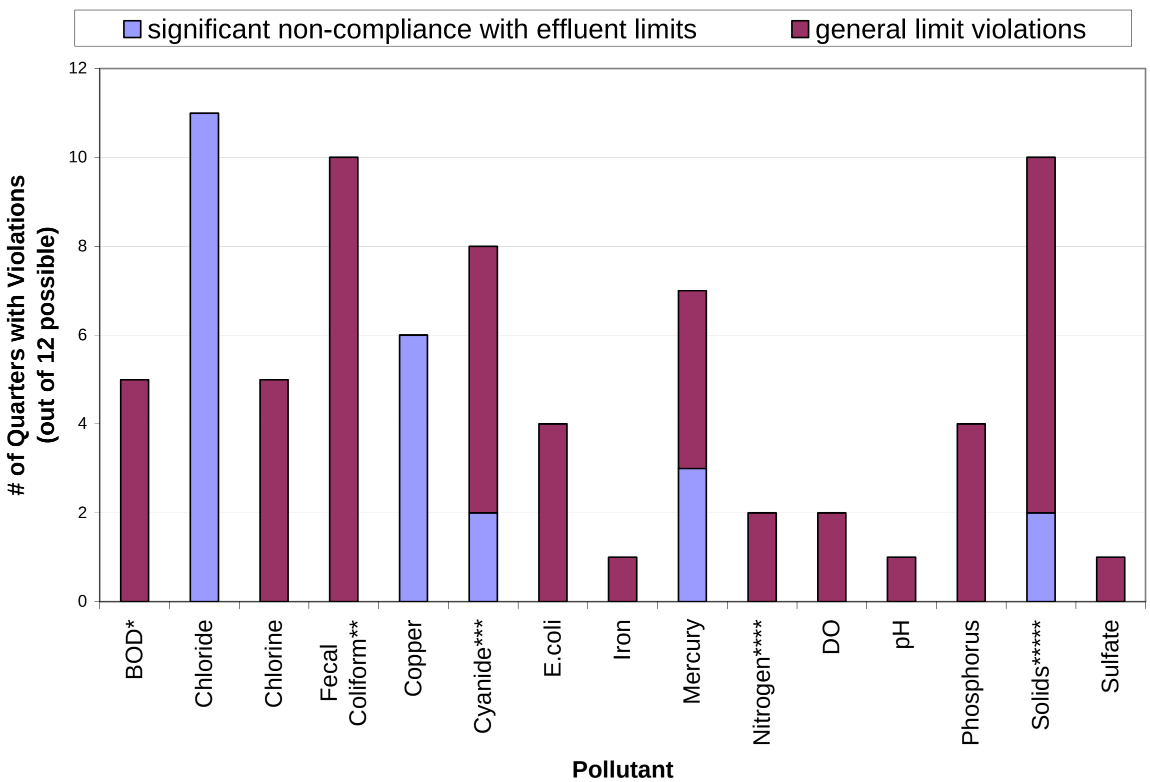

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