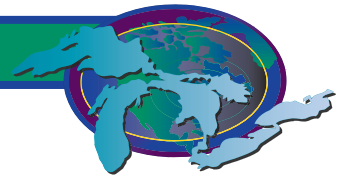

## Drinking Water Quality

Indicator #4175

### Overall Assessment

| | |
|---|---|
| Status: | **Good** |
| Trend: | **Unchanging** |
| Rationale: | **Based on the information provided in the annual Consumer Confidence/Water Quality Reports and the Ontario annual reports from the Drinking Water Systems, the overall quality of the finished drinking water in the Great Lakes basin can be considered good. Because very few violations of federally, provincially, or state regulated Maximum Contaminant Levels, Maximum Acceptable Concentrations, or treatment techniques occurred, the Water Treatment Plants are, in fact, employing successful treatment techniques. The potential risk of human exposure to the noted chemical and/or microbiological continents, and any associated health effect, is generally low.** |

### Lake-by-Lake Assessment

*Each lake was categorized with a* not assessed *status and an* undetermined *trend, indicating that assessments were not made on an individual lake basis.*

### Purpose

- To evaluate the chemical and microbial contaminant levels in source water and in treated water
- To assess the potential for human exposure to drinking water contaminants and the effectiveness of policies and technologies to ensure safe drinking water

### Ecosystem Objective

The ultimate goal of this indicator is to ensure that all drinking water provided to the residents of the Great Lakes basin is protected at its source and treated in such a way that it is safe to drink without reservations. As such, the treated water should be free from harmful chemical and microbiological contaminants. This indicator supports Great Lakes Quality Agreement Annexes 1, 2, 12, and 16 (United States and Canada 1987).

### State of the Ecosystem

Background

The information provided by the United States for this report focuses mainly on finished, or treated, drinking water. This format was chosen as the focus for U.S. reporting in order to adapt to the recommendations of the *Environmental Public Health Indicators Project* (Centers for Disease Control and Prevention 2006). Additionally, the U.S. is in the process of establishing an inclusive national drinking water database which will include raw (source) water data, thus providing an extensive array of information to all Water Treatment Plants (WTPs), Drinking Water Systems (DWSs), researchers, and the general public. The information provided by Canada focuses on both finished and raw water.

In the U.S., the Safe-Drinking Water Act Reauthorization of 1996 requires all drinking water utilities to provide yearly water quality information to their consumers. To satisfy this obligation, U.S. WTPs produce an annual Consumer Confidence/Water Quality Report (CC/WQR). These reports provide information regarding source water type (i.e., lake, river or groundwater), the availability of a source water assessment and a brief summary of the DWS's susceptibility to potential sources of contamination, the water treatment process, contaminants detected in the finished water, any violations that occurred, and other relevant information. For this indicator report the CC/WQRs were collected from 59 WTPs (Figure 1) for the operational year 2004 (2005 when available). Furthermore, the U.S.-based Safe Drinking Water Information System (SDWIS) was also used as a means to verify information presented in the reports and to provide any other relevant information when CC/WQRs were not available.

The data used for the Canadian component of the report were provided by the Ontario Ministry of the Environment (OMOE) and included results from two program areas. Data collected as part of the Drinking Water Surveillance Program (DWSP) were provided for the period 2003-2004. DWSP is a voluntary partnership program with municipalities that monitors drinking water quality. Ontario's Drinking Water Systems Regulation (O. Reg. 170/03), made under the Safe Drinking Water Act, 2002, requires

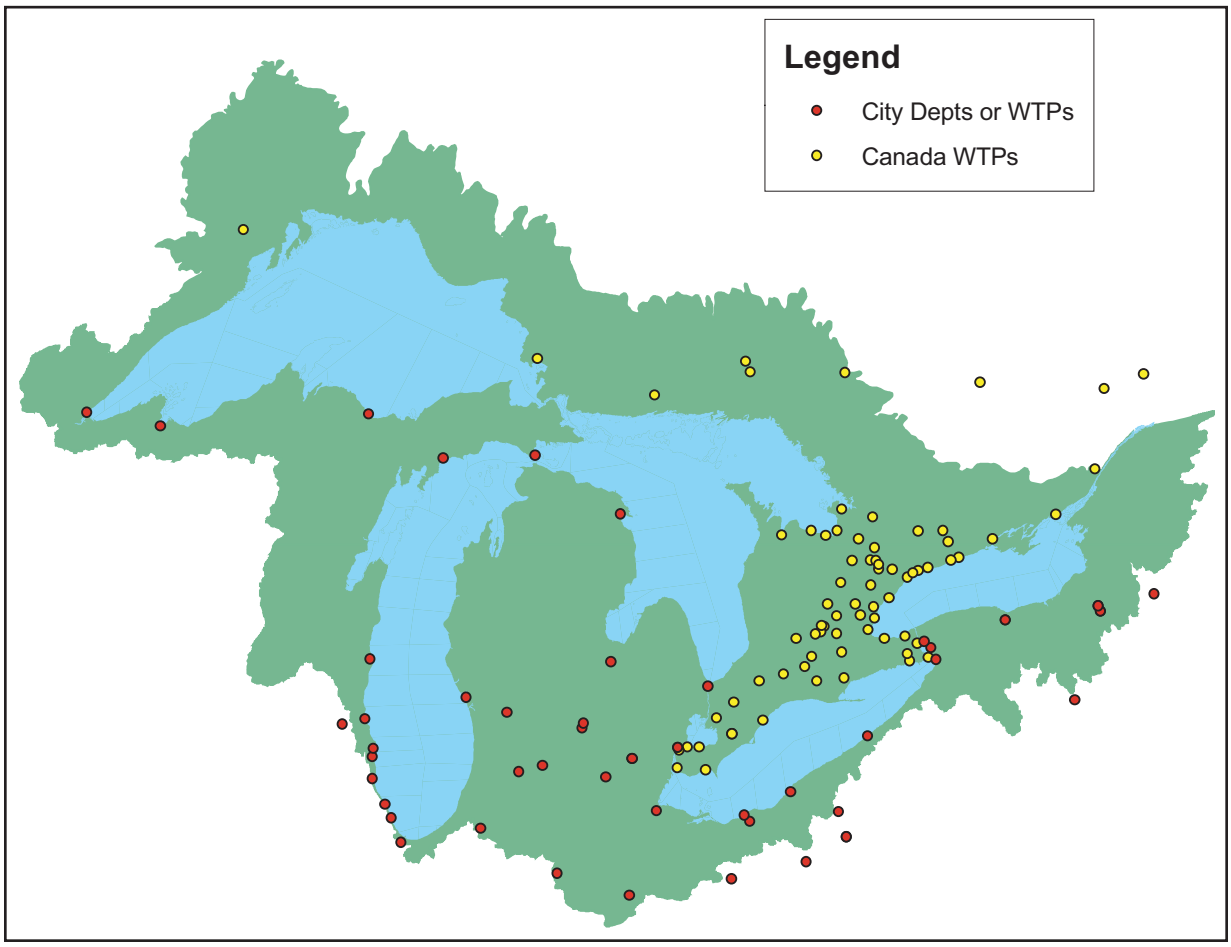


**Figure 1.** Location of municipalities served by the 59 U.S. and 74 Canadian Drinking Water Systems whose data were analyzed for this indicator report.
Source: U.S. Environmental Protection Agency and Environment Canada

that the owner of a DWS prepare an annual report on the operation of the system and the quality of its water. DWSs must provide OMOE with their drinking water quality data. Data from January to June 2004, collected as part of this regulatory framework from 74 DWSs (Figure 1), were also provided for analysis.

There are several sources of drinking water within the Great Lakes basin which include the Great Lakes themselves, smaller lakes and reservoirs, rivers, streams, ponds, and groundwater (i.e., springs and wells). These systems are vulnerable to contamination from several sources (chemical, biological, and radioactive). Substances that may be present in the source water include microbial contaminants (e.g., viruses and bacteria), inorganic contaminants (e.g., salts and metals), pesticides and herbicides, organic chemical contaminants (including synthetic and volatile organic chemicals), and radioactive contaminants. After collection, the raw water undergoes a detailed treatment process prior to being sent to the distribution system where it is then dispersed to consumer taps. The treatment process involves several basic steps, which are often varied and repeated depending on the condition of the source water. Raw water can affect the finished water that is consumed. Good quality raw water is an important part of a multi-barrier approach to assuring the safety and quality of drinking water.

Status of Drinking Water in the Great Lakes Basin

Ten drinking water parameters were chosen to provide the best assessment of drinking water quality in the Great Lakes basin. They include several chemical parameters, microbiological parameters, and other indicators of potential health hazards. These parameters are regulated by an established standard, which when exceeded, has the potential to have serious affects on human health. The U.S. Environmental Protection Agency (U.S. EPA) defines this regulated standard as the Maximum Contaminant Level (MCL), or the highest level of a contaminant that is allowed in drinking water. The Ontario drinking water standards are

described by the Maximum Acceptable Concentration (MAC), which is established for parameters that, when present above a certain concentration, have known or suspected health effects, and the Interim Maximum Acceptable Concentration (IMAC), which is established for parameters either when there is insufficient toxicological data to establish a MAC with reasonable certainty, or when it is not feasible, for practical reasons, to establish a MAC at the desired level.

*Chemical Contaminants*
The chemical contaminants of concern include atrazine, nitrate, and nitrite. Exposure to these contaminants above the regulated standards has the potential to negatively affect human health.

Atrazine: This widely used, organic herbicide can enter source water though agricultural runoff and wastewater from manufacturing facilities. Consumption of drinking water that contains atrazine in excess of the regulated standard for extended periods of time can potentially lead to health complications. The U.S. EPA has set the MCL for atrazine at 3 ppb and the Ontario drinking water standards specify the IMAC to be 5 ppb, which is the lowest level at which WTPs/DWSs could reasonably be required to remove this contaminant given the present technology and resources.

In the U.S., atrazine was infrequently detected in finished water supplies, and it was only found in finished water originating from Lake Erie, rivers, and small lakes and reservoirs. When detected, it was found at levels that did not exceed the MCL. Violations of monitoring requirements were reported for two WTPs for failure to monitor atrazine and other contaminants; one between February and June 2004 and the other during July 2004. As indicated by the annual CC/WQRs, there is a low risk of human exposure to atrazine from drinking water.

In Ontario, data from the 2003-2004 DWSP indicated that 22% of the water samples collected had a trace amount of atrazine present. However, the highest level detected was only 0.59 ppb (about one order of magnitude less than the IMAC), which was identified from a raw water source located within an agricultural watershed.

Nitrogen: Nitrogen is a naturally occurring nutrient that is also used in many agricultural applications. However, in natural waters most nitrogenous material tends to be converted into nitrates, which when ingested at levels exceeding the MCL or MAC, can cause serious health effects, particularly to infants. The U.S. EPA has set the MCL for nitrate at 10 ppm and nitrite at 1 ppm, and the province of Ontario has set the MAC for nitrate at 10 ppm and nitrite at 1 ppm.

In the U.S., nitrate was detected in over 70% of the finished water supplies which originated from WTPs using all sources of water except Lake Huron in 2004 or 2005. However, it was never found at levels that exceeded the MCL. Therefore, while there is some risk of exposure to nitrate, it is not likely to lead to serious health complications.

In Ontario, over 90% of the water samples contained nitrates. However, the highest level detected was 9.11 ppm, from a ground water sample. There is a risk of exposure to nitrates, especially in agricultural areas, but it is not likely to cause health complications because detected levels never exceeded the Ontario contamination standard.

In the U.S., nitrite was rarely detected in finished water supplies. It was only found in finished water for WTPs which use rivers, small lakes or reservoirs as source water. As such, there is only a small potential for human exposure to nitrite from drinking water. No MCL or monitoring regulation violations were reported for nitrites.

Over 50% of the water samples contained a measurable amount of nitrite according to the Ontario drinking water system reports. However, the highest value for this contaminant only reached 0.365 ppm, which is lower than both the Ontario MAC and the highest value detected in the previous year (0.434 ppm).

*Microbiological Parameters*
The microbiological parameters evaluated include total coliform, *Escherichia coli (E. coli), Giardia,* and *Cryptosporidium*. These microbial contaminants are included as indicators of water quality and as an indication of the presence of hazardous and possibly fatal pathogens in the water.

Total Coliform: Coliforms are a broad class of bacteria that are ubiquitous in the environment and in the feces of humans and animals. The U.S. EPA has set an MCL for total coliform at 5% of the total monthly samples, but for water systems that collect fewer than 40 routine samples per month, no more than one sample per month can be positive for total coliforms. Canada has set a

MAC of zero colony forming units (cfu) for DWSs. Both Canada and the U.S. require additional analysis of positive total coliform samples to determine if specific types of coliform, such as fecal coliform or *E. coli,* are present.

Escherichia coli (E. coli): *E. coli* is a type of thermo-tolerant (fecal) coliform bacteria that is generally found in the intestines and fecal waste of all animals, including humans. This type of bacteria commonly enters source water through contaminated runoff, which is often the result of precipitation. Detection of *E. coli* in water strongly indicates recent contamination by sewage or animal waste, which may contain many types of disease-causing organisms. It is mandatory for all WTPs to inform consumers if *E. coli* is present in their drinking and/or recreational water (U.S. waters only).

In the U.S., the presence of total coliform was detected in finished water from WTPs using all source water types, except Lake Superior. It was repeatedly detected in finished water from WTPs using Lake Michigan, groundwater, rivers, and small lakes and reservoirs as source water. Between July 2004 and October 2005, there were four violations with regard to total coliform levels exceeding the MCL. Repeat samples were collected at the same location as the positive total coliform bacteria sample and at nearby locations to determine if the original positive sample indicated a localized water problem or a sampling or testing error. However, samples from two of these WTPs tested positive for either fecal coliform or *E. coli.* Additionally, violations of monitoring requirements of U.S. EPA's Total Coliform Rule (TCR) were reported in one WTP for not collecting enough repeat samples after coliform bacteria were detected in the monthly routine samples. Although there is a potential for exposure to total coliform, it is not likely to be a human health hazard in itself. However, the presence of coliform bacteria, especially at levels exceeding the MCL, indicates the possibility that microbial pathogens may be present, and this can be hazardous to human health.

In Ontario, total coliform was detected in many of the raw water samples, but only a few treated water samples contained this contaminant. *E. coli* was identified in small amounts in raw water samples which originated mostly from small lakes and rivers. However, the presence of *E. coli* was not identified in finished water, indicating that the treatment facilities were working adequately to remove both of these microbiological parameters.

*Giardia* and *Cryptosporidium*: These parasites exist in water, and when ingested, may cause gastrointestinal illness in humans. The U.S. treated water standards, which control the presence of these microorganisms in the treated water, dictate that 99% of *Cryptosporidium* should be physically removed by filtration. In addition, *Giardia* must be 99.9% removed or inactivated by filtration and disinfection. These regulations are confirmed by the levels of post-treatment turbidity and disinfectant residual levels. Ontario has also adopted removal/inactivation regulations for *Giardia* and *Cryptosporidium*, but there are no data to report at this time.

In the U.S., neither *Giardia* nor *Cryptosporidium* were detected in finished water supplies from any of the WTPs. However, several of the CC/WQRs discussed the presence of these microorganisms in the source waters (Lake Erie, Lake Huron, Lake Michigan, Lake Ontario, small lakes/reservoirs). The presence of these organisms in raw water, but not in finished water, indicates that current treatment techniques are effective at removing these parasites from drinking water. Nevertheless, implementing measures to prevent or reduce microbial contamination from source waters should remain a priority. Even a well-operated WTP cannot ensure that drinking water will be completely free of *Cryptosporidium.* Furthermore, very low levels of *Cryptosporidium* may be of concern for severely immuno-compromised people, because exposure can compound their illness.

The annual CC/WQRs indicate that there is a potential for consumers to be exposed to the aforementioned microbiological contaminants. However, total coliform was the most common microbiological contaminant detected. Furthermore, there were very few if any confirmed detections of the more serious contaminants including, *E. coli, Giardia,* and *Cryptosporidium,* in the finished water from U.S. WTPs. As a result, it is not likely that consumption of drinking water containing these contaminants will lead to any serious health complications.

*Treatment Technique Parameters*

The treatment technique parameters evaluated include turbidity, total organic carbon (TOC) in the U.S., and dissolved organic carbon (DOC) in Canada. These parameters do not pose a direct danger to human health, but they often indicate other health hazards.

Turbidity: Turbidity is a measure of the cloudiness of water and can be used to indicate water quality and filtration efficiency. Higher turbidity levels, which can inhibit the effectiveness of the disinfection/filtration process and/or provide a medium for microbial growth, are associated with higher levels of disease-causing microorganisms such as viruses, parasites and some

bacteria. A significant relationship has been demonstrated between increased turbidity and the number of *Giardia* cysts and *Cryptosporidium* oocysts breaking through filters. U.S. EPA's surface water treatment rules require WTPs using surface water, or ground water under the direct influence of surface water, to disinfect and filter their water. In the U.S., turbidity levels must not exceed 5 Nephelolometric Turbidity Units (NTU) at any time. WTPs that filter must ensure that the turbidity go no higher than 1 NTU and must not exceed 0.3 NTU in 95% of daily samples in any month. Ontario has set the aesthetic objective for turbidity at 5.0 NTU, at which point turbidity becomes visible to the naked eye.

In the U.S., turbidity data are difficult to assess due to the different requirements and regulations for WTPs depending on the source water and treatment technique used. However, there were no MCL or monitoring regulations violations reported from January 2004 to October 2005.

In Ontario, the 2003-2004 DWSP report indicated that 78 raw water samples, many of which originated from Lake St. Clair and the Detroit River, exceeded the aesthetic objective. One treated water sample exceeded the aesthetic objective with a turbidity level of 11.1 NTU.

Total Organic Carbon: Although the presence of total organic carbon (TOC) in water does not directly imply a health hazard, the organic carbon can react with chemical disinfectants to form harmful byproducts. WTPs remove TOC from the water by using treatment techniques such as enhanced coagulation or enhanced softening. Conventional WTPs with excess TOC in the raw water are required to remove a certain percentage of the TOC depending upon the TOC amount and the alkalinity level of the raw water. The U.S. EPA does not have an MCL for TOC.

In the U.S., TOC was detected in finished water from WTPs using all source water types, except Lake Superior. However, TOC data were difficult to assess due to the varying formats of CC/WQRs and the way data were presented. As such, it was difficult to quantitatively evaluate and compare the TOC levels reported by each WTP. Violations of monitoring requirements and/or failure to report the results were reported for one WTP from July to September 2005.

Dissolved Organic Carbon: Dissolved organic carbon (DOC) can indicate the potential for water deterioration during storage and distribution. Acting as a growth nutrient, increased levels of carbon can aid in the proliferation of biofilm, i.e., microbial cells that attach to the surface of pipes and multiply to form a layer of film or slime which can harbor and protect coliform bacteria from disinfectants. High DOC levels can also indicate the potential for problems from the formation of chlorination by-products. The use of coagulant treatment or high pressure membrane treatment can be used to reduce DOC. The aesthetic objective for DOC in Ontario's drinking water is 5 ppm.

In Ontario, there were 110 DOC violations identified from raw water samples, 11.4 ppm being the highest level. However, no treated water sample contained DOC levels exceeding the aesthetic objective. Most of the high DOC results came from raw water originating from small rivers and lakes.

Taste and Odor: While taste and odor do not necessarily reflect any health hazards, these water characteristics affect consumer perceptions of drinking water quality.

In the U.S., there were no reports of offensive taste or odors associated with the finished drinking water as indicated by the 2005 CC/WQRs.

In Ontario, there has been an increase in the number of reports associated with offensive taste and odor over the past several years. However, specific data are unavailable, and it is difficult to quantitatively evaluate and compare results. Many drinking-water systems have now installed granular activated carbon filters to decrease the effect and intensity of these taste and odor events, which are due, in part, to the increased occurrences of blue-green algae in the Great Lakes (OMOE 2004).

*Summary*

Based on the information provided in the annual CC/WQRs and the Ontario annual reports from the DWSs, the overall quality of the finished drinking water can be considered good. However, over the past several years there has been an increase in the quantity of contaminants found in raw source water in the Great Lakes basin. The overall potential risk of human exposure to the noted chemical and/or microbiological contaminants, and any associated health effects, is generally low, because very few violations of federally, provincially, or state regulated MCLs, MACs, or treatment techniques occurred. This indicates that the WTPs/DWSs

are employing successful treatment techniques.

**Pressures**

The greatest pressure to the quality of drinking water within the Great Lakes basin would be degraded runoff. Several causes for a reduction in quality would include the increasing rate of industrial development on or near water bodies, low-density urban sprawl, and agriculture (both crop and livestock operations). Point source pollution, from wastewater treatment plants for example, can also contribute to the contamination of raw water supplies and can be considered an important pressure. Additionally, there is an emerging set of pressures derived from newly introduced chemicals and chemicals of emerging concern (i.e., pharmaceuticals and personal care products, endocrine disruptors, antibiotics and antibacterial agents). Invasive species might also affect water quality, but to what extent is still unknown.

**Management Implications**

A more standardized, updated approach to monitoring contaminants and reporting data for drinking water needs to be established. Even though U.S. EPA has established an extensive list of contaminants and their MCLs, newer parameters of concern might not be listed due to available resources or technology. Additionally, state monitoring requirements may differ, requiring only a portion of this list to be monitored. Standardized monitoring and reporting would make trend analysis easier, and thus provide a more effective assessment of the potential health hazards associated with drinking water.

Furthermore, a more extensive monitoring program must be implemented in order to successfully correlate drinking water quality with the status of the Great Lakes basin. Although the CC/WQRs provide useful information regarding the quality of finished drinking water, they merely depict the efficiency of the WTP rather than the overall quality of the region. Additionally, by solely focusing on treated water, WTPs that rely on several types of source water will not provide accurate data with regard to contaminant origin. Therefore, in order to properly assess the state of the ecosystem, source water data would need to be reviewed.

**Comments from the author(s)**

A concern for future efforts would be the adherence of a consistent guideline for identifying usable data while also providing adequate geographical coverage. In the U.S., data from DWSs serving a population of 50,000 or great was used, while data from all DWSs in Ontario serving a population of 10,000 or greater was analyzed. Furthermore, focusing on this criterion for DWSs only provides a fragmented view of the drinking water patterns in the Great Lakes basin. By sporadically including additional DWSs to expand the geographical coverage area, biased results may be introduced.

**Acknowledgments**

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