The Great Lakes-St Lawrence River Basin Water Resources Compact

Final Report
August 15, 2007
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EXECUTIVE SUMMARY

The Great Lakes-St. Lawrence River Basin Water Resources Compact (Compact) is an agreement, to improve the management of the Great Lakes and its tributaries (Basin). It was developed by the eight Great Lake states as a means to legally implement and enforce an international agreement between the United States and two Canadian provinces to improve management of the basin's water supply. Primarily, the Compact (and international agreement) focus on concerns over future declines in water levels due primarily to water diversions and climate change.

Water scarcity is becoming a reality for one sixth of the population in the world. States in the northwest and the southern United States are currently suffering from water scarcity issues, which are projected to get worse in the upcoming years. The Great Lakes represent 20% of the world's surface freshwater and 95% of the United States' supply. With the emergence of international and national water crises, this Compact relies on a precautionary approach that promotes action to address potential threats to the health of the basin. Given that the Great Lakes are an invaluable economic and ecological resource to the region, managing its supply now can help sustain these resources and avoid local crises in the future.

Water is used in two ways in the Basin: diversions and direct consumption.

- *Diversions*
  Transfers of water out of the Basin into another watershed or between Great Lakes (intra-Basin diversions). Major diversions are for municipal drinking water, cooling of nuclear plants, and agriculture irrigation. The primary source for intra-Basin diversions is for shipment of cargo.

- *Direct consumption*
  Water withdrawn from the Basin and consumed at (or near) the point of withdrawal. The largest consumer in the Basin is agriculture, followed closely by municipalities. Other forms of direct consumption involve bottling of water or other beverages and commercial products, as well as industrial processes.

The Compact provides several solutions to manage these water uses, which generally fall into the two broad categories of management and regulation.

Management of the Basin involves three major streams: the water resource inventory, water user registration and water conservation and efficiency goals and programs.

- *Water resources inventory*
  Each state must develop and maintain an inventory of diversions and consumption rates using flow rates within their borders. This inventory will create a baseline for future understanding of the Basin.

- *Water user registration*
  Within five years of the effective date of the Compact, any person who withdraws a significant quantity of water or diverts water of any amount must register with its State. This will better facilitate tracking of diversions and consumption.

- *Water conservation and efficiency goals and programs*
  These goals and programs are attempts to minimize water use and create sustainable use of the water. The plans will be based on cumulative impact assessments of withdrawals, diversions, and consumptive uses of the waters from the Basin.

Regulation of the Basin puts strict limits on water use in an attempt to minimize future threats to the region. Thus the Compact prohibits all new or increased diversions from the Basin. It is possible to obtain certain limited exceptions to this particularly for local public water supply use and intra-basin transfers. These exceptions are narrow in scope however, as overall maintenance of healthy water levels is the goal of the Compact.

The current data on water supplies in the basin underscores the precautionary nature of this agreement. While Lake Superior is currently well below the historical average, the other lakes are near or above the long-term mean. This suggests that Basin-wide, the area is healthy in terms of average lake levels. Yet, new or increased diversions and consumption can lower lake levels and put stress on the Basin including: reduction of important wetlands, increased need to dredge the lake for shipping, habitat loss, and constraints on human usage.

Additionally, climate change could potentially have a substantial impact on water levels. It is predicted that changes in water levels could range between 0.76 to 8.14 feet. This equates to billions of gallons of lost water. Various climate models also predict increases in both temperature and precipitation. The ramifications of these changes are uncertain although increased precipitation should partially offset the effect on lake levels from increased temperatures. It should be noted however, that increased precipitation is not expected to raise lake levels in any significant manner.

The measurement of success of the Compact is essential for future protection of the Basin. Baseline measurements and inventories of flow rates and changes in climate will establish a common understanding of the biotic and abiotic features of the Basin. This understanding will help ameliorate the potential impacts in the area due to low lake levels.

While the Compact appears to be a useful step in improving the future management of the basin, there remain some questions about the appropriateness of the solutions offered in this agreement. One controversy that arises is with the use of water in exported agriculture and manufactured goods. Water that is used and absorbed into crops from the Great Lakes is outside the diversion restriction of the Compact as well. This water accounts for a large amount of the water consumed from the Lakes. It is unclear the threat these exports pose to the overall water levels of the Basin.

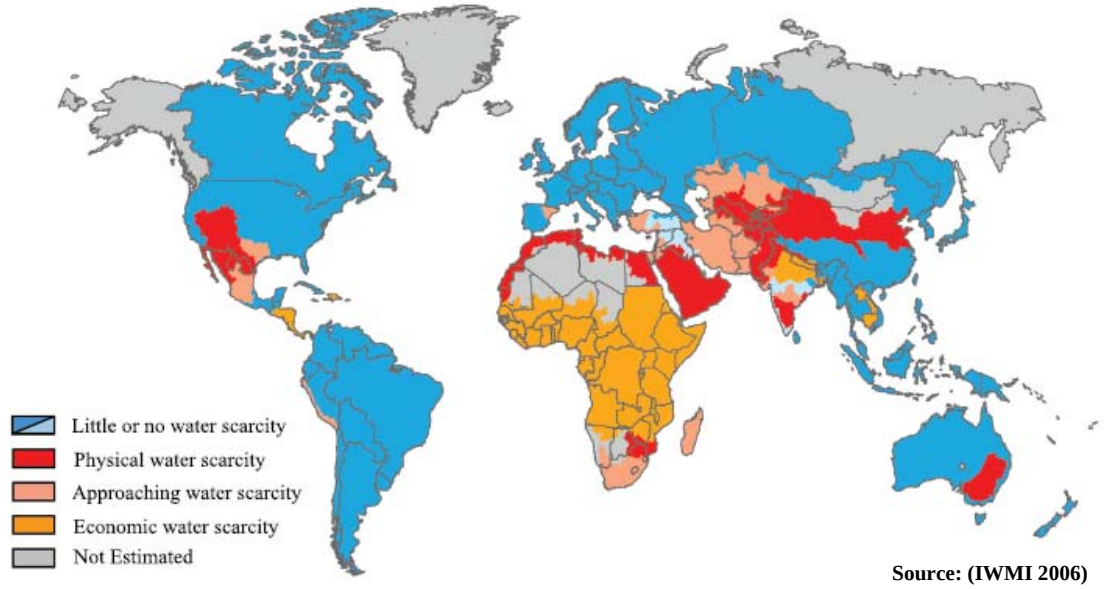
Based on this scientific analysis of the Compact it is recommended that a precautionary approach to water management be taken. A sustainable management system is necessary in order to overcome the uncertainty regarding the problems and solutions identified.

1. INTRODUCTION

The Great Lakes – St. Lawrence River Basin Water Resources Compact (Compact) is an agreement designed to improve management of water resources in the Great Lakes region. It was developed to addresses concerns regarding water supply, reduce scientific uncertainty and manage unchecked use. The Compact provides several solutions to these problems, which generally fall into two broad categories of management and regulation. Although there is some controversy concerning the associated scientific issues, the Compact relies on a precautionary approach that promotes action in the face of uncertain conditions. This action has been deemed necessary, as the Great Lakes are an invaluable economic and ecological resource, and management of its supply now will hopefully avoid crises in the future.

2. BACKGROUND

Water is a precious natural resource; it is essential for all life on Earth and is also an economic driver for industry, agriculture and energy production. Yet, freshwater is relatively scarce; 97% of the Earth's water supply is in the oceans which cover 70% of the Earth's surface (Molles 2002). Of course, without expensive desalination processes, saltwater is unusable for human consumption or agriculture. Only 3% of Earth's water supply is freshwater (Molles 2002), which can be found as groundwater, in icecaps and glaciers, rivers, swamps, and lakes (Gleick 1996). Note that many sources of freshwater, such as glaciers, icecaps, and some groundwater reserves are not easily accessed for human consumption. Given growing populations (and related demands for water food, industry, and power) and the distribution of the global freshwater supply, it is not surprising that many regions of the world are expected to be water stressed by 2025 (Figure 1).



Source: (IWMI 2006)

Figure 1: Global Water Scarcity

The Great Lakes, the largest source of fresh surface water in North America, contains 20% of the Earth's fresh surface water supply (EPA 1996; EPA 2002). They are comprised of five lakes: Superior, Michigan, Huron, Erie, and Ontario (Figure 2) and this Basin encompasses eight states and two Canadian provinces. This totals a land area of 201,460 square meters. The lakes represent 84% of the fresh surface water in North America, but 95% of the freshwater in the United States. As a whole, the United States is neither a water scarce nor a water stressed region – although areas, especially in the West and Southwest, suffer periodic water shortages.

Figure 2: Great Lakes - St. Lawrence River Basin

A breakdown of freshwater withdrawals in the United States reveals eight distinct categories: municipal supply, domestic consumption, irrigation, livestock, aquaculture, industrial, mining, and energy generation. In 2000, United States used an estimated total 408 billion gallons of water per day (Bgal/d) with fresh surface-water withdrawals accounting for 262 Bgal/d (Hutson, NL et al. 2004). Almost half of this freshwater withdrawn, approximately 195Bgal/d, is used for thermoelectric power, specifically for cooling power plants (Hutson et al. 2004). Much of this water is eventually returned to water bodies, albeit warmer than before. Freshwater use for irrigation is another large consumer, with withdrawals totaling 137 Bgal/d in 2000 (Hutson et al. 2004). Putting these nation-wide numbers in context, the Great Lakes region's major water uses

follow a similar trend. The primary uses are energy (10.4Bgal/d), industry (1.8 Bgal/d), and public supply (1.7 Bgal/d) (IJC 2000).

Examining water use in the United States and the Great Lakes region identifies potential prevalent water resource issues for the future. Globally, the collective population of water stressed or water scarce countries will increase from 460 million to 4 billion people by the year 2050 (Ambramoviz 1996). These severe water stresses, which are also expected to impact portions of the United States such as the desert southwest and the plains states could place additional demand on the available freshwater sources (Figure 1). Freshwater abundant regions like the Great Lakes must develop a water resource management program in order to deal with this future demand (Ambramoviz 1996).

3. THE COMPACT

The proposed Compact is an attempt to address the issue of water resource management in the region. It is part of a larger effort to implement a related international agreement between the United States and Canada, which arose after decades of water-related legislative progress.

3.1 Legislative History

The issue of water resource management in the United States emerged in 1972 with the passage of the Federal Water Pollution Control Amendment. After subsequent amendments in 1977, these amendments were collectively renamed the Clean Water Act (CWA). The CWA regulated discharges of pollutants into surface water in the United States. Beginning with the Great Lakes Charter of 1985, a council of Great Lakes Governors and Premiers coordinated a voluntary agreement through which the Great Lakes States and Provinces cooperatively managed the waters of the Great Lakes. In 1986, Congress granted the Great Lakes Governors special privileges for water resource management under the United States Federal Water Resources Development Act (WRDA) of 1986. The act requires the Governors' unanimous approval on any proposed out-of-basin diversion or export of water from the Great Lakes Basin.

Building upon this previous legislation, the Great Lakes Council signed the Great Lakes Charter Annex 2001. Signed by each council member, this was an agreement between the council members to prepare a Basin-wide binding agreement in order to "protect, preserve, restore and improve the Great Lakes for the use and benefit of its citizens" (Great Lakes Council 2001). The result was the 2005 Great Lakes Water Resources Agreement (Agreement), which was signed by all of the Great Lakes Governors and Premiers and is an international agreement between both Canada and the United States. The Agreement proposes to effectively manage the Basin's water supplies**,** and prevent future shortages. The Great Lakes face growing demand from the population within and outside the watershed for multiple uses, including public water supply, agriculture, manufacturing, industry, tourism and recreation (IJC 2000). The Agreement promotes an adaptive management strategy to conserve and maintain the water resources, as flexibility is necessary to address the evolution of scientific knowledge. The Compact is the United States' effort to formally implement this international agreement. A brief overview of the Compact follows.

3.2 The Compact

The Compact is an effort by the Great Lakes States to implement the Agreement within the United States. It must first be approved by the state legislatures of the eight Party States (Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan, Pennsylvania, and New York) and then sent to the United States Congress for final approval (Figure 3).

The Compact's major points of discussion are:

- Key definitions for terms used in the Compact (Appendix II).

- The Party States' general findings and purposes regarding the state of the Great Lakes and their management, as well as a commitment to science.

- The organizational structure for the implementation of the Compact, most importantly creating the Great Lakes-St. Lawrence River Basin Resources Council. The Council will be made up of the governors of the Party States, who each may appoint an alternate and an advisor. The powers and functions of related existing state and federal offices and agencies shall be preserved, and it will be the responsibility of the Council to coordinate their activities with these parties. Issues regarding Council votes, meetings, jurisdiction, immunities and privileges, and advisory committees are also addressed.

- The powers and duties of Council, which include: research and dissemination of data, development of plans and policies, investigations, court actions, and creation of contracts. In addition, the Council may also create rules and regulations for the implementation and enforcement of the Compact.

- Water management and regulation for the Basin. Management refers to the programs the Council will implement to cooperatively monitor and improve the use of water in the Basin. Regulation refers to specific restrictions and conditions the Council will implement regarding water use throughout the region.

    - *Management*
      Each state must develop and maintain a water resources inventory and report this information to the Great Lakes-St. Lawrence River database annually. Within five years of the effective date of the Compact, any person who withdraws a significant quantity of water or diverts water of any amount must register with its Party State. Each state must also develop water conservation and efficiency goals, as well as a related program, which will be reviewed by the Council and Regional[1] Body on a regular basis. Additionally, the Council, in cooperation with the Regional Body, must conduct periodic assessments of the cumulative impacts of withdrawals, diversions, and consumptive uses from the waters of the Basin.

    - *Regulation*
      Prohibits all new or increased diversions from the Basin, with limited conditional exceptions for local public water supply use and intra-basin transfers. These exceptions will often require Regional Review and in some cases approval from the Council. Whether or not a proposal is subject to Regional Review, a Party State must provide the Council and Regional Body with timely notice and opportunity to comment on any proposal which would result in substantially new or increased consumptive use.

- The Council must consult with federally-recognized Tribes for any proposal subject to Council or Regional review.

[1] "Regional" in the context of the Compact refers to the Party States and the Canadian provinces collectively.

- All Council meetings must be open to the public and minutes will be made public record and must employ additional procedures that ensure public participation, including providing public notification of all applications for regulatory exceptions and access to relevant documents. This establishes the role of public participation.

- All Party States pledge to support implementation of the provisions of the Compact. Conflicts between Party States will be settled through alternative dispute resolution.

- Procedures through which persons aggrieved by actions taken by the Council can receive administrative or judicial relief.

- The Compact does not wish to interfere with certain related existing rights and United States agreements.

Procedurally, each Party State must agree to the Compact in its entirety, and any change made to it by any party in its implementing legislation or by the United States Congress in its approval will not be effective unless approved to by all parties. Once the Compact is ratified within each state, it is the responsibility of the Governors to apply to the United States Congress for approval. Upon Congress' approval, the Compact will become binding and have the effect of a state statute for each of the eight Party States. The Council will become vested with the described powers and duties, and each Party State will be bound by the obligations agreed to under the Compact. The Compact will remain binding for each Party State, unless it is terminated, which may happen at any time by majority vote at the state level.

Only one of the eight Party States, Minnesota, has officially enacted the Compact. In both Illinois and New York, the bill has passed in both states' legislatures but has yet to be signed by their Governors. It is currently active in Indiana, Michigan, and Pennsylvania, and has yet to be introduced in Wisconsin and Ohio.

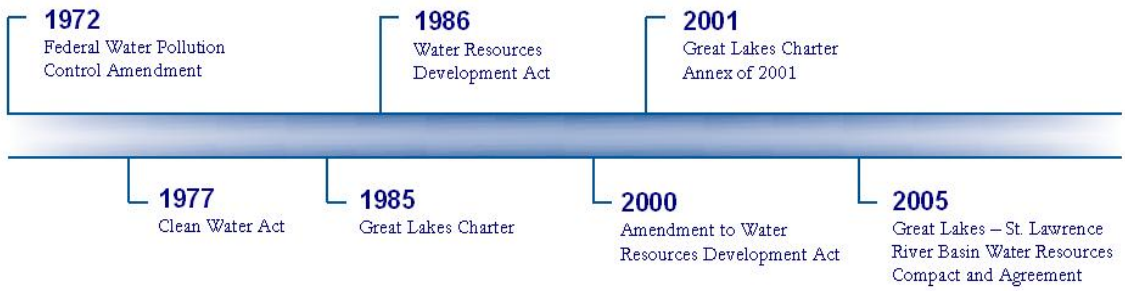


Figure 3: Timeline of water resource management policies for the Great Lakes Basin

4. WATER SUPPLY PROBLEM AND SOLUTIONS

The Great Lakes-St. Lawrence Basin is a complex freshwater system that is vulnerable to changes in lake levels. The Compact seeks to prevent widespread depletion of the Basin's water resources in the face of both potentially increased water demand and scientific uncertainties including climate change. As increased amounts of water are removed from the basin, lake levels eventually decline. Lowered lake levels can adversely affect the lake ecosystem, the local economy, and the drinking water supplies to many communities. Historic records on the water levels of the Great Lakes show fluctuations that are predominantly tied to climatic variation (Environment Canada 2000). The lake level response varies between lakes. For example, Lake Superior's water levels are near historic lows, while Lake Ontario is above its historic mean (Environment Canada 2000). Please see Appendix IV for historical lake level graphs for all lakes. At the Basin level, the Great Lakes water supplies are healthy (EPA 2002). The Compact, therefore, is not a response to a crisis, but rather a precautionary approach in the face of uncertainty.

4.1 Unchecked Water Use

This Compact seeks to manage water withdrawals from the Basin, including diversions and consumptive uses. The subtleties between both water uses are important and are managed differently within the Compact:

- Consumptive use refers to water withdrawn or withheld from the Basin that is not returned due to incorporation into products, lost to evaporation or other processes. The highest consumer in the Basin is agriculture followed closely by municipalities. Other forms of direct consumption involve commercial products and industrial processes.

- Diversions are transfers of water out of the Basin and into another watershed or between Great Lakes (intra-basin transfers). Diversions are typically used for municipal drinking water, cooling of nuclear plants, and agricultural irrigation. Intra-basin transfers in the form of canals are used primarily for shipment of cargo.

4.1.1 Current Uses and Impacts

According to the IJC (2000), the rate of water withdrawn from the Basin in 1993 was 56,914 million gallons per day. This is a large volume of water; for a visualization, a pool the length of a football field, 50 feet in width and 10 feet deep represents only one million gallons of water (USGS 2005). Of the water withdrawn, 4.6% was consumed and not returned to the Basin (IJC 2000) (Figure 4). Irrigation is the largest water consumer within the Basin. If these current consumptive rates remain stable, the St. Lawrence River outflows would decrease by 8% by 2030 (Botts and Krushelnicki 1987).

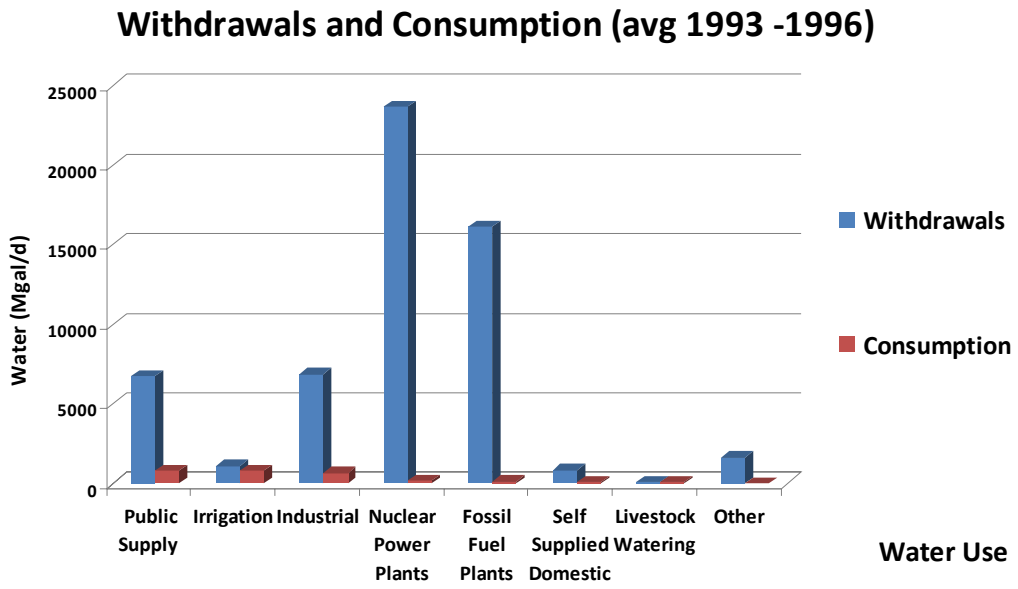


Figure 4: Withdrawals and Consumptive Uses within the Great Lakes (IJC 2000)

As shown in Table 1, there are 12 major diversions within the Great Lakes Watershed that move 12.4 billion gallons per day through the Basin (GLWI 2007). Diversions account for only 0.002% of the approximately 6 quadrillion gallons of water throughout the Basin (GLWI 2007). When broken down into flow direction categories, everyday, 3.7 billion gallons flow into the basin (0.06% of total), 2.1 billion gallons flow out of the basin (0.04% of total) and 6.6 billion gallons of water flow between the basins (0.11% of total) (Mortsch and Quinn 1996). Overall, the major diversions in the Basin account for a decrease in average lake levels of approximately 0.05 feet daily (GLWI 2007).

Diversion	Flow	Millions of Gallons Per Day	Location
Ogoki and Long Lac	In to Basin	3,606	Ontario, North of Lake Superior
Portage Canal	In to Basin	64.6	Wisconsin, west of Lake Michigan
Akron	In to and Out of Basin	0.32	Ohio, southwest portion of Lake Erie
Pleasant Prairie	Out of Basin	3.2	Wisconsin, west Lake Michigan
Chicago	Out of Basin	2,068	Illinois, southwest Lake Michigan
Forestport	Out of Basin	78	New York, southeast Lake Ontario
Detroit	Intra Basin	94	Michigan, west Lake Erie
London, Ontario	Intra Basin	71	Ontario, Lake Huron/Lake Ontario
Haldimand, Ontario	Intra Basin	1.3	Ontario, west Lake Ontario
Welland Canal	Intra Basin	5,946	Ontario, Lake Erie/Lake Ontario
New York State Barge Canal	Intra Basin	450	New York, south of Lake Ontario
Raisin River	Intra Basin	16	New York, St. Lawrence River

Table 1: Great Lakes Diversions (GLWI 2007)

Natural movement of water through the Great Lakes accounts for the majority of the water movement in the Basin (Manninen and Gauthier 1999) (Figure 5). The water flows through the lakes to the St. Lawrence River then out to the Atlantic Ocean. Human diversions are a much smaller magnitude (Table 1). This effect of current diversions remains relatively small but increased pressure due to population growth both in and out of the Basin, agricultural needs and global water scarcity could increase diversions and have increasing adverse effects on the lakes.

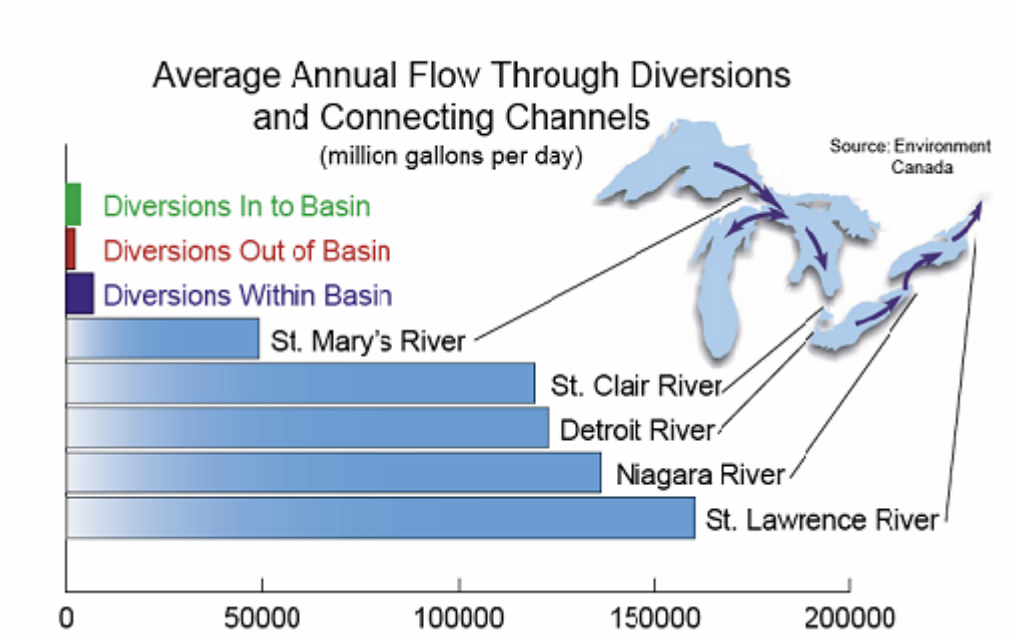


Figure 5: Comparison between human diversions (in color) versus natural flow rates in the Basin (in blue).

4.1.2 Impacts of Lower Water Levels

Relatively minor changes in the water level may cause problems for commercial industries, municipalities and native ecosystems. Consequences of lower water levels include, but are not limited to:

- Reduction of cargo loads on commercial ships. For cargo ships, a one-inch drop in water level accounts for a decrease in cargo weight of between 50 and 270 tons to maintain a safe buffer between the ship and the lake bottom (Mortsch and Quinn 1996).

- Dredging which is a potential remedy to the consequences of decreased lake levels (Brooker 1985; Newell, Seiderer et al. 1998). This action has notable and vast ecological consequences that are outside the examination of this paper.

- Docks, water intakes and other manmade structures depend on relatively constant water levels (IJC 2000). Low water levels could eventually require municipalities to incur expensive replacement or infrastructure costs if levels fall too low.

- Increase of pollution concentration as lake levels decrease which will be harmful for the domestic water supply and will negatively affect the health of plant and wildlife within the Great Lakes ecosystem (Sherry 1986; Abel 1989).

- Decrease in the acreage of wetlands that occur within the Basin. Wetlands are very important habitats in the Great Lakes, because they serve as flood control as well as habitat for native mussels (Associated Press 2007). As invasive species are already putting pressure on the local habitat, the absence of wetlands would further stress the

native species. As lake levels fall, these areas will begin to disappear and lose their ability to provide habitat and ecosystem services.

4.1.3 Solution: Water Use Regulation

To address the issues associated with future demands upon the Basin's water resources, the Compact regulates water use in a number of ways. Specifically, the Compact prohibits all new or increased diversions out of the Basin and requires Party States to set threshold levels for the regulation of new or increased withdrawals within the Basin.

The prohibition on diversions prevents water from being transferred out of the Basin into another watershed, or from one Great Lake watershed into that of another by multiple means including pipeline, canal or tanker truck. The Compact does contain limited, conditional exceptions for straddling communities, communities within a straddling county, and intra-basin transfers. In order to qualify for an exception, a proposal must meet certain criteria. Diverted water must be used solely for public supply purposes and all water, minus an amount for consumptive use, must be returned as natural or treated wastewater. Exceptions will often require regional review and in some cases approval from the Council.

In addition to prohibiting diversions, the Compact also requires Party States to manage and regulate new and increased withdrawals and consumptive uses. The Party States must set threshold levels to ensure that withdrawals do not result in significant impacts to the waters and water dependent natural resources within the Compact. This requirement must be met within ten years of the Compact or a default threshold will be applied.

The regulations described above do not apply in two additional circumstances. First, the Compact's definition of a diversion excludes water that is used to produce or manufacture products that will subsequently be transferred out of the Basin. In practice, this allows agricultural and beverage products, which incorporates significant amounts of water, to be produced within the Basin and shipped nationally and/or internationally. Secondly, diversions to the State of Illinois are governed by the Supreme Court decree in Wisconsin et al vs. Illinois et al, which means that diversions of Basin water within the state of Illinois are allowed unless prohibited by the terms of the Supreme Court decree

4.2 Scientific Uncertainty

Two of the primary concerns with future lake levels are the effects of climate change and new and increased demands on the Great Lakes water. Underlying both of these problems is the scientific uncertainty about the actual impacts these problems are likely to have on the Basin. The ambiguity of the pending water demand and the unknown effect of climate change coupled with a lack of relevant data for the watershed area can make effective management challenging. Therefore, the Compact aims to provide sustainable water management of diversions. It also aims to develop a scientific baseline to more thoroughly to understand the present and future hydrological balance within the Basin.

4.2.1 Climate Change

Climate change is one of the largest future threats to lake levels (Bertram and Stadler-Salt 2000). Although there is uncertainty about how climate change will affect the Lakes, there is a considerable body of scientific knowledge on the likely impacts. The National Oceanic and Atmospheric Administration (NOAA), one of the main management and research bodies in the Basin, has compiled four climate modeling scenarios that estimate future lake levels, surface water temperatures, changes in annual runoff, and changes in annual outflow changes within the Basin. The specific research institutes are: the Canadian Climate Center, the Goddard Institute for Space Studies, the Geophysical Fluid Dynamic Center, and Oregon State University (Mortsch and Quinn 1996).

These scenarios assume a future doubling of carbon dioxide over next century. Given this assumption, the climate change modeling in the Basin supports the fears of the Compact designers. Summarized in Table 2, below, the models show that over the next century, water temperatures could increase as much as 5.96 °C, with lake levels dropping as much as 1.16 meters. The greatest ambient temperature increases will occur in the winter with a range of 3.4 – 9.1°C. During the summer the range is between 2.7 – 8.6°C (Mortsch and Quinn 1996) (Table 2). Several additional possibilities could further exacerbate water levels. Intuitively, as temperatures rise, evaporation will increase, thus reducing lake levels. The timing of temperature rise will also have various effects, such as warmer winters decreasing the ice pack, which in turn decreases spring runoff(IPCC 2007). Furthermore, higher temperatures during the rainy season may potentially decrease overall precipitation amounts (IPCC 2007).

Climate Change Modeling Institutes	***Surface Temperature Increase (^{o}C)***	***Lake Level (ft)***
Canadian Climate Center	5.2	-3.81
Goddard Institute	5.96	-2.88
Geophysical Fluid Dynamic Center	4.86	-1.87
Oregon State University	3.68	-1.54
* Values denote averages across all lakes in the Basin.		
** All models assume a time lapse of 100 years. Source: (Mortsch and Quinn 1996)		

Table 2: Predicted changes in lake surface water temperature and lake levels in the Great Lakes Basin.

Scientific uncertainty lies in the potential increase in precipitation in the Basin area. IPCC climate modeling predicts that global circulation patterns will shift northward which equates to increased precipitation over the Great Lakes region (Figure 6). According to Figure 6, there is a predicted 15% increase in precipitation in the Basin over the next 50 years. This may decrease some of the impacts of rising temperatures and buffer lake level declines due to increased evaporation.

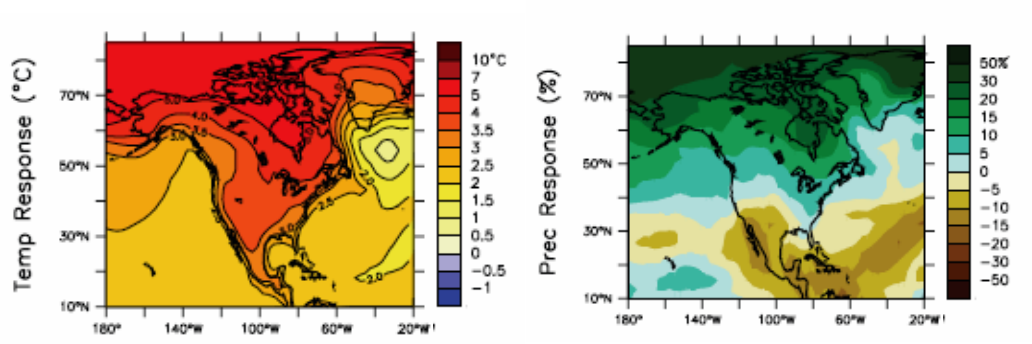


Figure 6: Temperature and precipitation predictions in North America for the next 50 years (IPCC 2007)

The imminence of a general warming trend is sufficient enough to warrant the precautionary measures of the Compact. Even if the climate models' assumptions are incorrect or the predictions are overstated, any warming may cause water level to drop resulting in serious impacts at small temperature changes. For instance, in the past few years incremental increases in water temperatures are the suspected cause of a near record low water level in Lake Superior (Associated Press 2007).

4.2.2 Lack of Data

Another important issue in the Basin that this Compact addresses is the overall lack of data, which contributes significantly to the overall uncertainty of the situation. Lake levels have been recorded and monitored over a long period of time. However, this represents one of the few complete data sets for the Basin. Historical consumptive uses, and diversion flow rates are recorded more sparsely and are usually more difficult obtain and interpret. Current data on many water quality characteristics and lake health parameters only create an incomplete picture of the Basin. The Compact legislates the creation of an accessible and complete database of diversion rates and uses.

A lack of basic data for a certain town or county's water use levels impedes the ability to make efficient decisions about water supply and whether water consumption should be limited. Accurate data is necessary to calculate whether lake levels are declining or are within the realm of normal fluctuations.

4.2.3 Impact of Water Use

The total cumulative affect of diversions out of the Basin is not fully understood, and is believed to be decreasing lake levels slightly. See the above section entitled Unchecked Water Use for further discussion.

4.2.4 Solution: Water Resource Management

In the face of the scientific uncertainties associated with climate change, lack of data, and the long term impacts of water use, the Compact employs a precautionary approach. This approach requires that the Council cooperatively monitor and improve water use within the Basin. Water resource management of the Lakes is proposed through three main components: a resources inventory, conservation and efficiency programs, and an assessment of cumulative impacts.

- *Water Resources Inventory*
  Each state must develop and maintain its own water resources inventory. This inventory must include data regarding use of resources, including the location, type, and quantity of withdrawals, diversions, and consumptive uses. Each state must also develop a common database for this information as well, which can accommodate exchange of data with other states/provinces. Within five years of the effective date of the Compact, any withdrawal greater than an average 100,000 gallons of water per day in any 30 day period, or a diversion of water out of the Basin in any amount, must be registered within its Party State's database. Each state will annually report the information it's gathered to a "Great Lakes-St. Lawrence River water use database repository," and this aggregated material will be made publicly available.

- *Water Conservation and Efficiency Programs*
  The Council must identify Basin-wide conservation and efficiency objectives based on goals as defined by the Compact. Each state must develop water conservation and efficiency goals consistent with those of the Basin, and implement a corresponding program for all Basin water users. Each state shall annually assess its program's efficacy, and report findings to the Council/Regional Body.

- *Assessment of Cumulative Impacts*
  The Council, in cooperation with the Regional Body, must conduct periodic assessments of the cumulative impacts of withdrawals, diversions, and consumptive uses from the waters of the Basin. These assessments shall use the most current and appropriate guidelines, consider the impacts of climate change as well as other significant threats to basin waters, and contribute to an adaptive management approach for the Basin.

5. SCIENTIFIC CONTROVERSIES

The scientific uncertainties that were discussed previously are also sources of scientific controversies. These topics are debated for the following reasons:

- Accuracies of climate change models
- Incomplete lake health data
- Incomplete water diversion data

In addition to these controversies, water recharge of the Basin, agricultural stress and virtual water, and how diversions are limited are sources of controversy.

5.1 Water Recharge of the Basin

An understanding and quantification of inflows and outflows to the lakes is necessary in order to manage for sustainable levels of water withdrawals. Despite this, parts of the Great Lakes hydrological cycle are still not well understood. Calculating inflows from precipitation is relatively straightforward, but the relationship between groundwater and surface water and how each source is recharged is not well understood, and can vary dramatically by locality (Grannemann, Hunt et al. 2000). An understanding of ground water is important because it is connected hydrologically to surface water flows in streams, lakes and wetlands (Grannemann, Hunt et al. 2000). These surface waters can percolate into groundwater basins, or conversely, in some locations, groundwater can seep into surface flows. During periods of low rainfall, ground water may also provide the only natural source of water that keeps streams flowing (Galloway and Pentland 2005). A better understanding of groundwater and surface water interactions would contribute to the sustainable management of withdrawals in the region.

5.2 Agricultural Stress and Virtual Water

Agriculture is the largest consumer of water in the Basin. On average, agriculture consumes 70 times more water than people use for domestic purposes and 40-90% of that water is lost to evaporation or stored in the crops as virtual water, water retained by the crops (SIWI 2004). The massive amounts of water used in the agricultural sector and the virtual water stored in the crops leave the Basin when the crops are exported. Virtual water currently does not qualify as a diversion.

5.3 Limiting Diversions

A related controversy to the issue of virtual water is whether the Compact should limit diversions at all. Considering the potential water challenges in North America and around the globe, perhaps the Great Lakes should be used as a water supply resource? Without access to the Great Lakes, the United States might be facing a water shortage in the Southwest (Maddock and Hines 1995). Although this legislation is precautionary for the Basin, it may have negative future

implications for the rest of the United States as one way to address a regional water shortage would be to allow out-of-basin transfers from the Great Lakes.

Beyond North America, there are also critical water challenges globally that this region could be tapped into to help address. According to Cosgrove and Rijsberman (2000), in the 20th century the world population tripled while water use increased six-fold. In addition, Vorosmarty et al (2000) state that current trends indicate global freshwater use is exceeding long-term accessible supply from 5 to 25%. The water crisis has caused many serious problems around the world. Currently 14,000 people die from diseases caused by global water crisis every day, 11,000 of which are children under the age of five (Stop Child Poverty 2007). One option is to consider how "virtual water" trades and agricultural production can be improved to help conserve water globally. Currently, the United States is a net exporter of virtual water in the form of food and agriculture and the Great Lakes region could be a source for the export of resources to heavily populated and drought-prone regions. Furthermore, producing less water intensive crops or using technological methods such as vertical farming, where farms, located in or near urban areas, are stacked vertically like floors in a high rise building, might mitigate the possible water shortage problems, as well as quality issues associated with agriculture.

6. MEASURING THE SUCCESS OF THE SOLUTIONS

The Great Lakes waters provide for the domestic needs of 30 million people. The Basin also supports a diverse economy in both the United States and Canada, which generates over $200 billion a year in economic activity (EPA 2002). It is reasonable that the Great Lakes Council wants to protect this natural resource. In part, protection requires that the solutions posed by the Compact be successful and to prove success the solutions must be measurable.

While the goal of the Compact are clear -- to protect the water quantity in the Basin from future threats such as withdrawals, diversion and climate change -- the indicators for success in addressing these threats have yet to be determined. While the effect of climate change may be too difficult to accurately gauge, diversions and withdrawals can be measured

6.1 Diversion and Withdrawal Flow Rates

Diversions and withdrawals can be measured by flow rates. By measuring changes in the flow rate, as well as groundwater levels, the results can serve as a baseline for comparison (Bertram and Stadler-Salt 2000). Water flow measurements are evaluated through high velocity flow meters at the site of the withdrawals or diversion. These industrial flow meters provide the flow rate and quantity of water entering and exiting the Basin. The main indicator in this section is the various flow rates (in cfs) and the corresponding quantity of the water being exchanged. Establishment of diversion and withdrawal rates and the locations for diversions or withdrawals are necessary to create sustainable water conservation management plans. It is important that water is measured where it enters and exits the Basin, instead of further along the pipes, as this gives the exact reading of the water use. Varying gauge placement configurations could underestimate water use as some may be lost in pipes en route. Therefore, placement of the gauges could alter the measurements (Pennsylvania Department of Environmental Protection 1996).

Protecting hydrologic and ecosystem integrity is the optimal goal. Accurate flow rate and water level baseline data will help establish where efforts need to be focused to ensure continuing integrity. It is necessary for the Council to establish baseline measurements of certain indicators so future change can be tracked with confidence.

6.2 Resource Inventory and Water Conservation Programs

As stated previously, the Compact divides water management into two sections, the resource inventory of water use and water conservation and efficiency programs. Both of these are mandated by the Compact. Water resource inventories will primarily be compilations of the flow rate measurements, but could be expanded to contain other indirect sampling types including: demand studies and predictive modeling. The intent is that these indicators, coupled with the water flow measurements, create a useful scientific database that can be studied by scientists to better understand the Basin.

Water conservation and efficiency programs are outlined in Section 1, Article 4 of the Compact. They include:

- Improved water dependent resources protection
- Restoring hydrologic and ecosystem integrity
- Retaining quantity of surface water and groundwater
- Sustainable use
- Efficiency of use
- Reduction of water loss and waste.

A cumulative impact assessment is a major administrative indicator of the effectiveness of the Compact. It creates a framework that all parties must follow to collectively assess the impacts of withdrawals and climate change in the Basin.

6.3 Climate Change Assessments

The Council must understand the potential impacts of climate change, so that appropriate management and regulatory measures can be implemented and progress measured. Regional, as well as national and international climate models exist (Mortsch and Quinn 1996). These indicators include: rate of climate increase, possible changes in precipitation, and changes in flow rates of the diversions and the St. Lawrence Seaway (Mortsch and Quinn 1996; GLWI 2007). Climate modeling is an emerging field and predictions are inherently variable. Baseline development for these indicators and close subsequent monitoring is particularly important, as it will help validate certain climate models, eliminate uncertainty, and create a clearer prediction.

6.4 Challenges to Assessment

The Compact faces potential problems with the measurements and final calculations of the scientific indicators. Proper methodology must be established to effectively collect the data for each indicator. NOAA, the Canadian Hydrological Service, the United States Army Corps of Engineers, and many academic researchers currently studying in the Basin could act as advisors to the Council on proper or previously successful methodology. Possible issues that the Council must account for include: the size of the basin, population density, and the hurdles that international and multi-departmental collaboration present.

The size of the Basin is similar to the area of the United Kingdom. This massive area of land and water makes establishing universal baselines challenging. Spanning four different biomes, each biome faces different conditions -- seasons, temperature, and precipitation -- that impact regional baselines. The Basin includes major urban centers with high population density to very rural or wilderness areas with little population. This poses an administrative challenge by ensuring accurate data collection in the low population density areas. Collaboration is the main administrative issue that will need to be addressed in future examination of this act. Scientific challenges of an international initiative include such minor details as incompatibility of the metric and imperial measurement systems.

6.5 Collaborative Assessment

There are possible collaboration opportunities with other Great Lake initiatives that the Council could take advantage of to improve the collection of scientific data. The Great Lake Water Quality Act of 1972 represents a current initiative in the Great Lake Basin to monitor the water quality of the lakes. This act has over 80 indicators that will be examined, inventoried and studied to ascertain changes in water quality (Bertram and Stadler-Salt 2000; Environment Canada and EPA 2007). Possible collaboration would be prudent as many indicators, such as ice duration, increases in extreme storms, first emergence of water lilies in Basin wetlands, lake water levels, extent of hardened shoreline, and water diversions are also applicable to the monitoring of the Compact (Bertram and Stadler-Salt 2000).

Finally, future considerations must be taken into account for all indicators. The water levels of the Great Lakes are close to the historical average, creating baseline indicators are necessary to help monitor any changes in the Basin and adhere to the legislation in the Compact. Many of these scientific issues suggested will need to be addressed through clear administrative implementation with the exception of climate modeling. The hope is that modeling will get increasingly more precise as a better understanding of the connection between the water level fluctuations in the Basin, the effects of water exchanges on these levels and climate change are better understood.

7. CONCLUSION/SUMMARY OF FINDINGS

The Great Lakes-St Lawrence River Basin contains North America's largest freshwater resource, and faces uncertain impacts due to climate change and development pressures both within and outside the Basin. The Compact takes a precautionary approach to managing this water resource, proposing a prohibition on diversions out of the Basin (with limited exceptions) and coordination between the Party States to assess and manage the water resources of the Basin.

The nature of the basin, which straddles eight states, two provinces and two countries, requires a cooperative approach to management. The process, however, is complicated by the number of jurisdictions involved, and the ratification of the Compact by all Party States, in addition to the federal government, will likely present some challenges.

Contained in the Compact are several inherent controversies, the most salient issue is the apparent hypocrisy in how the Compact approaches water distribution. In times of water scarcity, there is an underlying fear of potential competition for the Great Lakes resources from outside sources. However, other pressures, such as those from industry and agriculture from within the Basin, are not subject to the same levels of regulation, despite currently having a much larger impact.

Additionally, while there is a prohibition of water diversions outside of the Basin, water that is exported out of the Basin as a processed good such as bottled water is deemed exempt from the Compact. Other potential contentions are the high levels of uncertainty surrounding the science of climate change, the rate of recharge and future demand. This makes it difficult to predict how effective the Compact can be in protecting the water resources of the Great Lakes and St. Lawrence River.

The Compact proposes a contemporary approach to water resource management through the provision of cumulative impact assessment, cooperative and adaptive management, data collection and sharing, public participation, tribal consultation and consideration of the impacts of climate change. The cooperative approach to management and data collection could yield significant benefits, but it is uncertain whether the prohibition on diversions outside the Basin combined with water efficiency plans within the Basin, will be sufficient to mitigate the potential combined pressures of development and climate change.

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Appendix I: Acronyms and Short forms

Agreement	The 2005 Great Lakes Water Resources Agreement
Bgal/d	Billion gallons per day
Basin	The Great Lake and St. Lawrence Seaway Hydrological Basin
cfs	Cubic feet per second
CWA	Clean Water Act
Compact	Great Lakes-St. Lawrence River Basin Water Resources Compact
IJC	International Joint Commission
IPCC	Intergovernmental Panel on Climate Change
NOAA	The National Oceanic and Atmospheric Administration
Party States	Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan, Pennsylvania and New York
Regional Body	Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan, Pennsylvania, New York, Ontario, Quebec
WRDA	United States Federal Water Resources Development Act

Appendix II – Great Lakes Basin Compact Definitions

(Section numbers refer to the Compact)

Adaptive Management - a Water resources management system that provides a systematic process for evaluation, monitoring and learning from the outcomes of operational programs and adjustment of policies, plans and programs based on experience and the evolution of scientific knowledge concerning Water resources and Water Dependent Natural Resources.

Agreement - the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement.

Applicant - a Person who is required to submit a Proposal that is subject to management and regulation under this Compact. **Application** has a corresponding meaning.

Basin or **Great Lakes—St. Lawrence River Basin** - the watershed of the Great Lakes and the St. Lawrence River upstream from Trois-Rivières, Québec within the jurisdiction of the Parties.

Basin Ecosystem or **Great Lakes—St. Lawrence River Basin Ecosystem** - the interacting components of air, land, Water and living organisms, including humankind, within the Basin.

Community within a Straddling County - any incorporated city, town or the equivalent thereof, that is located outside the Basin but wholly within a County that lies partly within the Basin and that is not a Straddling Community.

Compact - the Great Lakes - St. Lawrence River Basin Compact.

Consumptive Use - that portion of the Water Withdrawn or withheld from the Basin that is lost or otherwise not returned to the Basin due to evaporation, incorporation into Products, or other processes.

Council - the Great Lakes—St. Lawrence River Basin Water Resources Council, created by this Compact.

Council Review - the collective review by the Council members as described in Article 4 of this Compact.

County - the largest territorial division for local government in a State. The County boundaries shall be defined as those boundaries that exist as of December 13, 2005.

Cumulative Impacts - the impact on the Basin Ecosystem that results from incremental effects of all aspects of a Withdrawal, Diversion or Consumptive Use in addition to other past, present, and reasonably foreseeable future Withdrawals, Diversions and Consumptive Uses regardless of who undertakes the other Withdrawals, Diversions and Consumptive Uses. Cumulative Impacts can result from individually minor but collectively significant Withdrawals, Diversions and Consumptive Uses taking place over a period of time.

Decision-Making Standard - the decision-making standard established by Section 4.11 for Proposals subject to management and regulation in Section 4.10.

Diversion - a transfer of water from the Basin into another watershed, or from the watershed of one of the Great Lakes into that of another by any means of transfer, including but not limited to a pipeline, canal, tunnel, aqueduct, channel, modification of the direction of a water course, a tanker ship, tanker truck or rail tanker but does not apply to Water that is used in the Basin or a Great Lake watershed to manufacture or produce a Product that is then transferred out of the Basin or watershed. **Divert** has a corresponding meaning.

Environmentally Sound and Economically Feasible Water Conservation Measures - those measures, methods, technologies or practices for efficient water use and for reduction of water loss and waste or for reducing a Withdrawal, Consumptive Use or Diversion that i) are environmentally sound, ii) reflect best practices applicable to the water use sector, iii) are technically feasible and available, iv) are economically feasible and cost effective based on an analysis that considers direct and avoided economic and environmental costs and v) consider the particular facilities and processes involved, taking into account the environmental impact, age of equipment and facilities involved, the processes employed, energy impacts and other appropriate factors.

Exception - a transfer of Water that is excepted under Section 4.9 from the prohibition against Diversions in Section 4.8.

Exception Standard - the standard for Exceptions established in Section 4.9.4.

Intra-Basin Transfer - the transfer of Water from the watershed of one of the Great Lakes into the watershed of another Great Lake.

Measures - any legislation, law, regulation, directive, requirement, guideline, program, policy, administrative practice or other procedure.

New or Increased Diversion - a new Diversion, an increase in an existing Diversion, or the alteration of an existing Withdrawal so that it becomes a Diversion.

New or Increased Withdrawal or Consumptive Use - a new Withdrawal or Consumptive Use or an increase in an existing Withdrawal or Consumptive Use.

Originating Party - the Party within whose jurisdiction an Application or registration is made or required.

Party State - a state participating to this Compact.

Person - a human being or a legal person, including a government or a non-governmental organization, including any scientific, professional, business, non-profit, or public interest organization or association that is neither affiliated with, nor under the direction of a government.

Product - something produced in the Basin by human or mechanical effort or through agricultural processes and used in manufacturing, commercial or other processes or intended for intermediate or end use consumers. (i) Water used as part of the packaging of a Product shall be considered to be part of the Product. (ii) Other than water used as part of the packaging of a Product, Water that is used primarily to transport materials in or out of the Basin is not a Product or part of a Product. (iii) Except as provided in (i) above, Water which is transferred as part of a public or private supply is not a Product or part of a Product. (iv) Water in its natural state such as in lakes, rivers, reservoirs, aquifers, or water basins is not a Product.

Proposal - a Withdrawal, Diversion or Consumptive Use of Water that is subject to this Compact.

Province - Ontario or Québec.

Public Water Supply Purposes - water distributed to the public through a physically connected system of treatment, storage and distribution facilities serving a group of largely residential customers that may also serve industrial, commercial, and other institutional operators. Water withdrawn directly from the Basin and not through such a system shall not be considered to be used for Public Water Supply Purposes.

Regional Body - the members of the Council and the Premiers of Ontario and Québec or their designee as established by the Agreement.

Regional Review - the collective review by the Regional Body as described in Article 4 of this Compact.

Source Watershed - the watershed from which a Withdrawal originates. If Water is withdrawn directly from a Great Lake or from the St. Lawrence River, then the Source Watershed shall be considered to be the watershed of that Great Lake or the watershed of the St. Lawrence River, respectively. If Water is Withdrawn from the watershed of a stream that is a direct tributary to a Great Lake or a direct tributary to the St. Lawrence River, then the Source Watershed shall be considered to be the watershed of that Great Lake or the watershed of the St. Lawrence River, respectively, with a preference to the direct tributary stream watershed from which it was Withdrawn.

Standard of Review and Decision - the Exception Standard, Decision-Making Standard and reviews as outlined in Article 4 of this Compact.

State - one of the states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio or Wisconsin or the Commonwealth of Pennsylvania.

Straddling Community - any incorporated city, town or the equivalent thereof, wholly within any County that lies partly or completely within the Basin, whose corporate boundary existing as of the effective date of this Compact, is partly within the Basin or partly within two Great Lakes watersheds.

Technical Review - a detailed review conducted to determine whether or not a Proposal that requires Regional Review under this Compact meets the Standard of Review and Decision following procedures and guidelines as set out in this Compact.

Water - ground or surface water contained within the Basin.

Water Dependent Natural Resources - the interacting components of land, Water and living organisms affected by the Waters of the Basin.

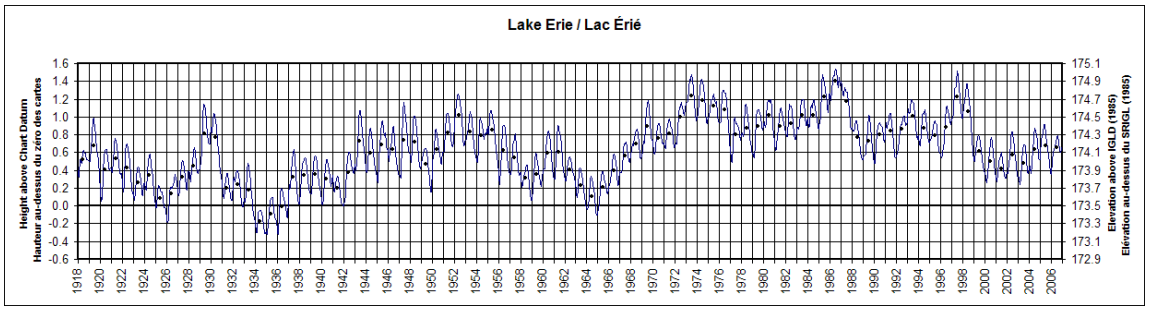
Waters of the Basin or Basin Water - the Great Lakes and all streams, rivers, lakes, connecting channels and other bodies of water, including tributary groundwater, within the Basin.

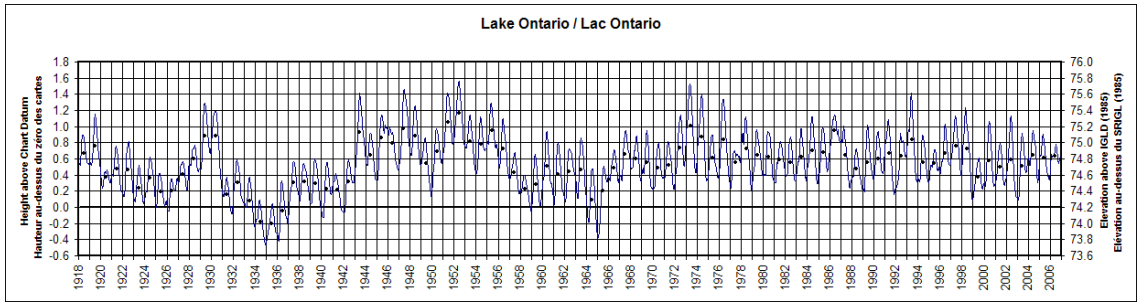
Withdrawal - the taking of water from surface water or groundwater. **Withdraw** has a corresponding meaning.

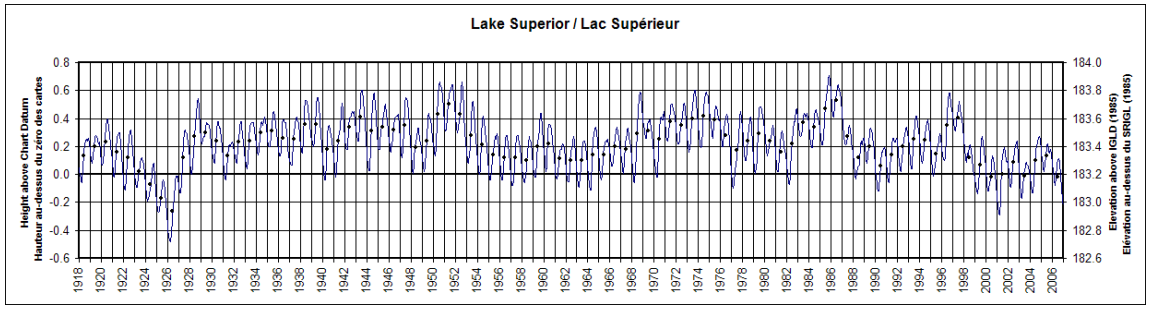
Appendix III- Additional Resources for the Great Lakes Basin

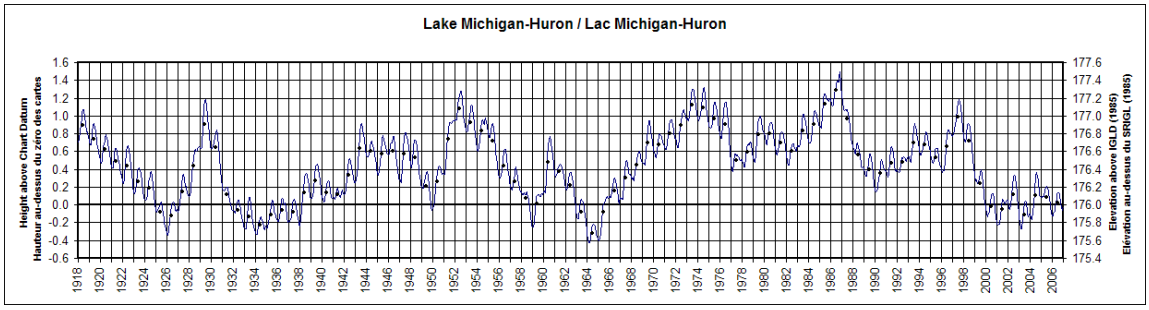
- http://www.mnr.gov.on.ca/mnr/water/greatlakes/Compact.pdf
  - Link to the actual Great Lakes Basin Compact provided by the Ontario government.
- http://www.glc.org
  - The Great Lakes Commission. This commission is a binational agency that promotes the orderly, integrated and comprehensive development, use and conservation of the water and related natural resources of the Great Lakes basin and St. Lawrence River.
- http://www.glerl.noaa.gov/
  - The National Oceanic and Atmospheric Administration – Great Lakes Environmental Research Laboratory.
- http://www.epa.gov/grtlakes/
  - The Great Lakes site for the Environmental Protection Agency.
  - http://www.epa.gov/glnpo/atlas/glat-ch1.html
    - The Great Lakes Atlas, developed by the EPA
- http://www.on.ec.gc.ca/greatlakes/Home-WS7E5E6AF1-1_En.htm
  - Resources on the Great Lakes from Environment Canada.
- http://www.ijc.org/php/publications/html/finalreport.html#3
  - Protection of the Waters of the Great Lakes. Final Report to the Governments of Canada and the United States at the time of the initial compact.
- http://www.ijc.org/php/publications/pdf/ID1598.pdf
  - Report offered by the International Joint Commission's Great Lakes Science Advisory Panel. Addresses emerging threats for the 21st century.
- http://www.miseagrant.umich.edu/symposium/papers/DIVERS.pdf
  - Diversions and Consumptive Uses of Great Lakes Waters: A Framework for Decision Making. Written by Professors Steven Wright and Jonathan Bulkley of the University of Michigan.

Appendix IV: Historical Hydro Graphs from Environment Canada









(Environment Canada 2000)