The Future of water use in the Great Lakes Basin considering the Great Lakes-St. Lawrence River Basin Water Resources Compact

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Abstract

The Great Lakes-St. Lawrence River Basin Water Resources Compact was recently passed in order to protect the Great Lakes ecosystem and halt diversions outside the basin. While this is a positive step toward water conservation and protection in its focus on protecting the basin's ecosystem, the Compact does not clearly state a limit on use of water from the Great Lakes. Instead, it allows for flexibility in future applications of the compact with acknowledgment that current situations can change. All eight states bordering the Great Lakes must create a water conservation plan, report consumptive use, and agree before any new diversion outside the basin is created. However, increasing stresses placed on freshwater supplies by rapid development, increased irrigation, and climate change may increase the likelihood that Great Lake states would agree to additional diversions. In order to predict if the Compact will adequately stabilize water levels in the Great Lakes, this research compares a range of annual inflow levels to consumptive use within the basin and diversions outside the basin per state or province. Current rates are sustainable, but when applied to future scenarios the Compact could allow for more water to leave the basin than enter it, causing deterioration of the lakes themselves. The results of this research could be used to justify the need for stricter local and national water conservation regulations and less development on arid land in the western United States.

Introduction

World population and consumption of resources are at an all time high. The increase in population is putting stress on the world's finite fresh water supplies, especially in areas where there isn't much water to begin with. The Great Lakes hold over eighteen percent of the world's fresh water[1] and over eighty-four percent of North America's surface fresh water.[2] Under fear that the world will turn to the Great Lakes for water, leading to their demise, the states that surround the lakes have recently formed the Great Lakes-St. Lawrence River Basin Water Resources Compact.

In 2008 the United States federal government and all eight states surrounding the Great Lakes signed into law the Great Lakes-St. Lawrence River Basin Water Resources Compact.[3] The purpose of this compact is to ensure the future stability of the Great Lakes ecosystems by

[1] Annin, 4
[2] Sponberg, 1
[3] Sponberg, 1

conservation practices and protection against future diversions. The Compact is a law preventing all water diversions out of the Great Lakes Basin, except under very limited conditions to nearby communities. The effectiveness of the Compact on keeping water levels from depleting in the Great Lakes has not yet been tested, but it is going to face more and more stress as water use around the world rises. This paper will examine the strengths and weaknesses of the Great Lakes—St. Lawrence River Basin Water Resources compact concerning diversions both locally and further under increasing water supply demands in the United States and worldwide. Finally, this paper will model whether water-balance in the Great Lakes will be maintained, especially considering the new impacts of the Compact.

Hypothesis:

The Great Lakes-St. Lawrence River Basin Water Resources Compact will not be able to keep diversions and consumptive use of Great Lakes Water at a level low enough to avoid negatively affecting the Great Lakes because of pressures from communities within and surrounding the basin.

Literature Review

World Water Supply

Although the world appears to hold a plentiful amount of water only about three percent is fresh water. Two-thirds of the world's freshwater is trapped in ice.[4] Usable freshwater is located in rivers, lakes, and underground aquifers. About a fourth of the world's population relies on groundwater while the rest rely on rivers and lakes, which are more vulnerable to pollution.[5] The water in lakes and rivers is also used to support industries such as fishing, transportation, and tourism all while supporting an interactive ecosystem.

[4] Jackson, 1029
[5] Jackson 1030

Over a tenth of the world's population already does not have access to drinkable fresh water.[6] Unless water efficiency can improve quicker than population growth we will face mass water shortages, but even water efficiency may not be enough. Water levels can possibly change because of climate change and water use will increase with an increase in irrigated crops which will be needed to feed the growing population.[7]

Population is at an all time high in the world with over 6.5 billion people. Although population growth is slowing in many developed nations, population is still growing rapidly in other areas. Walter Reid, a population scientist, reported that, "the most troubling development regarding population trends and their environment impact is the fact that the greatest population growth is now occurring in environmentally fragile areas…where water is scarce and the soil is generally poor."[8] Reid continues to comment on the dangers of limited resources, especially water, by revealing that slow depletion of water leads to longer runs of high poverty and low health rates. Studies from The Millennium Ecosystem Assessment also suggest that the current consumption rates and usage of water are unsustainable.[9]

Great Lakes

The Great Lakes consist of five lakes between the United States and Canada, all created by glaciers. The lakes include Lake Erie, Lake Huron, Lake Michigan, Lake Ontario, and Lake Superior. The St. Lawrence River is the main connecting body of water between the Atlantic Ocean the lakes. The basin (the light grey area in Figure 1) includes any area where water on the surface flows naturally back into the basin. For example, the Great Lakes Basin area is narrow on the southwestern tip of Lake Michigan because most surface water along that coast flows naturally into the Mississippi River, not Lake Michigan.

[6] Gleick, 1998 (qtd. in Wood 2003)
[7] Wood, 2003
[8] Qtd in Dahl, 601
[9] Dahl, 601-602

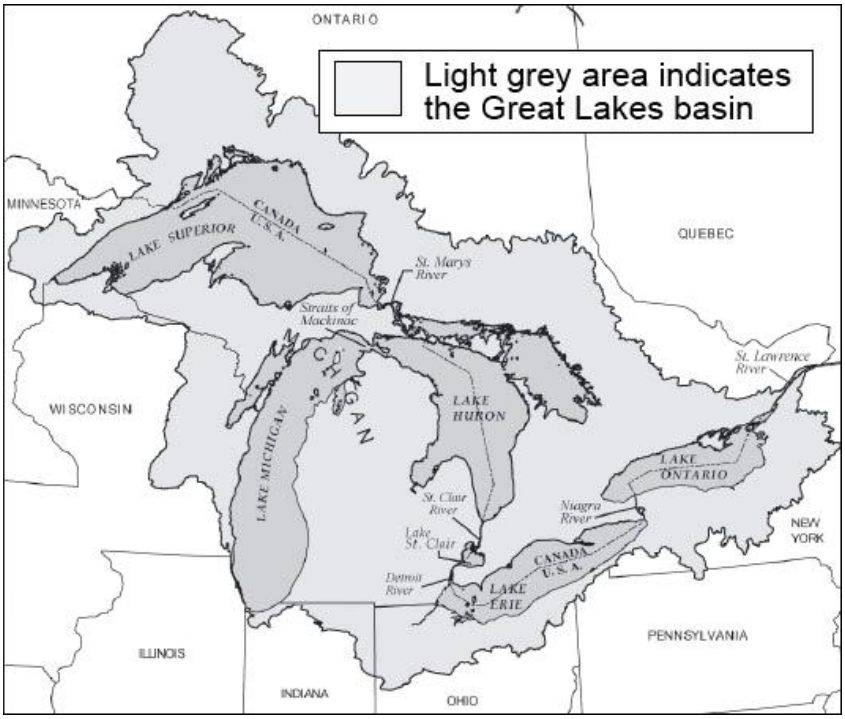

Figure 1: Great Lakes Basin Map: U.S. Department of the Interior[10]

Currently there are four diversions into the Great Lakes and six diversions within the lakes. However, the diversions that raise the most concern about over use of water in the Great Lakes are the four diversions of water outside the basin.[11] A diversion of water is any man-made alteration of the flow of water. A diversion out of Great Lakes basin sends water from a naturally inflowing tributary to a different water basin, usually for municipal, agricultural, or industrial needs.

The largest current diversion out of the Great Lakes Basin is in Chicago through the Illinois River. The diversion is capped at 2,078 millions of gallons per day by the Supreme Court and currently averages at 2,068mgd.[12] Chicago is also the largest city on the shore of any Great Lake. Chicago engineered a system of canals to reverse the flow of the Illinois River so that it would flow to the Mississippi River instead of into Lake Michigan. Therefore, the water is lost to the Great Lakes Basin and added instead to the Mississippi Basin. The original intent of this was to send pollution and sewage out of the city and away from drinking water sources,

[10] http://www.mackinac.org/images.aspx?ID=9147
[11] Annin, 63
[12] Great Lakes Institute, "Water Balance"

and since then it has grown as a way to provide water for Chicago and its growing suburbs. It is also used to keep water levels high enough in the canal to allow safe passage of cargo ships. This diversion is protected by the Supreme Court. Chicago is still connecting more and more suburbs outside the basin to its diversion.[13] Concerns have been made about Chicago connecting suburbs into its water system and going above its water diversion limit of 2,078mgd but being unable to disconnect those communities as they grow. However, if this occurred, it would be a breach of the Supreme Court imposed limit and other states could once again object to the diversion. The recent increase of the dangerous invasive species Asian Carp in the Illinois River and the threat of the carp entering the Great Lakes has opened new opposition to this diversion. It is unlikely that a diversion of this nature, and the extreme action of reversing a river's flow, will ever happen in the United States again.

The other diversions outside the Great Lakes basin are Forestport, New York, Pleasant Prairie, Wisconsin, and Akron, Ohio (which also has a diversion back into the lake). [14] All of these diversions are much smaller and are in straddling counties on the basin. The Great Lakes Compact allows these existing diversions, but limits their expansion, and they can be questioned if found harmful to the lakes.

Forestport is an old canal diversion out of Lake Ontario of about 78mgd. The diversion in Akron was built in 1998 and diverts water out of a Lake Erie tributary, but diverts the same amount of water back into Lake Erie through the Ohio River watershed. Pleasant Prairie currently diverts 3.2mgd out of Lake Michigan for drinking water and the used wastewater is sent into the Mississippi River Basin. However, Pleasant Prairie must divert all water from this diversion back into Lake Michigan by the end of this year (2010) or may have to stop the diversion.[15]

[13] Annin, 85-94
[14] Annin, 64
[15] GLWI, "Diversions"

History of Legislation of the Great Lakes

Limiting diversions is not the first action governments have taken to protect the Great Lakes. Over 140 programs and laws exist in the U.S. concerning the Great Lakes.[16] Most of these relate to pollution, trade, and transportation issues. Water diversions out of the Great Lakes were not strongly regulated until the Great Lakes—St. Lawrence River Basin Water Resources Compact, although a few attempts at legislation were made.

Limiting diversions is not the first action governments have taken to protect the Great Lakes. The Great Lakes fall under the eastern United States' riparian doctrine. Any individual who owns land adjacent to a body of water has rights to the use of that water as long as their use is "responsible," meaning it does not damage the riparian rights of other landowners along that body of water.[17] The riparian doctrine is purposefully vague like many of our federal laws and much of it is upheld by court rulings. Most compacts concerning water allocation occur in the West where water sources are subject to a different law. In the West water allocation priorities are given to whoever put that water to use first. Scientist Tina Adler states the advantage this gives the Great Lakes Compact, "Unlike standards for water use in other areas of the country, the Great Lakes standards would be guided by what's good for the lakes' ecosystem, instead of by local economic pressures or whoever managed to claim the water first."[18]

In 1909 Canada and the United States signed the Boundary Waters Treaty and created the International Joint Commission (IJC), which began a long history of legislation directly focused on the Great Lakes. The Boundary Waters Treaty was meant to ease disputes over the use of boundary waters between the two countries. This vague law and the IJC served the areas needs for a long time, until 1972. The treaty made an agreement between the United States and Canada that neither country would pollute the lakes to the extent that it would harm the health of the lakes or harm the property of the other country. The ICJ had powers of an oversight committee and is still active in protecting the Great Lakes today. [19]

[16] Adler, 174
[17] Mather, 278-282
[18] Adler, 179
[19] Gilbertson, 201

In 1972 the "Great Lakes Water Quality Agreement" was created to specifically protect Great Lakes' water quality, especially against eutrophication by excess phosphorus.[20] In 1978, it was ratified to focus on toxic substances as a whole. Soon after, politicians and activists used the agreement to push broader issues of protecting the Great Lakes watershed and ecosystems. [21]

Diversions began to become a focus of Great Lakes legislation in the mid-1980s with the creation of the Great Lakes Charter and Water Resources Development Act. The Great Lakes Charter was created in 1985 and was a non-binding international agreement stating that any state or province should inform the other states and provinces of their intent to allow a large water diversion. The Council of Great Lakes Governors was created to oversee this legislation, and it focused mostly on intra-basin diversions.[22] It also created a database of consumptive uses of water within the Great Lakes Basin and introduced state enforced regulations of Great Lakes water use.[23] The Water Resources Development Act of 1986 (WRDA) was a binding agreement between all the governors of the eight Great Lakes States. It required that any diversion of Great Lakes Water outside the Great Lakes Basin have approval from all eight governors.[24] According to professor Timothy Heinmiller the WRDA had greater power than the Great Lakes Charter because it formed a system where states had veto power for diversions similar to the IJC in 1909.[25] The problem with the WRDA was that it was too vague to effectively enforce legislation. It was only a few pages long. Under the ICJ (International Joint Commission) there were twelve intrabasin diversion proposals to the council, none of which were outright denied. From 1986 to 2007 only four proposals were brought to consideration under the WRDA and only one of those was denied.[26] Although most of these diversions were approved, very few made it to the stage of a formal proposal which may be more telling of the Great Lakes Region's resistance to water diversions.

The Great Lakes Charter, WRDA, and eventually the Compact were enacted because basin-states felt threatened by the growing water needs of the west and around the world. For example, a Canadian engineer Tom Kierans wanted to create the GRAND Canal project in the

[20] Gilbertson, 202-203
[21] Gilbertson, 202-203
[22] Heinmiller, 655-675.
[23] Annin, 71-74
[24] Annin, 79
[25] Heinmiller, 661
[26] Heinmiller, 664

1960s, which diverted mass amounts of water through and out of Lake Huron into the West. The "Proposed Powder River-Midwest Coal Slurry Pipeline" in the 1980s would have sent water from the Great Lakes to Wyoming and sent coal-slurry back to the lakes. Finally, the NOVA project made it clear that stronger legislation was needed. The Nova Group wanted to package up water in bulk and ship it to water-scarce southeast Asia for a small profit. None of these projects were successful because of Great Lakes States' resistance, but they spurred the Great Lake States into action to protect the lakes from diversions.

Water Balance in the Great Lakes

Water balance for bodies of water account for all inflows and outflows for a specific body of water, as well as examining how much water is stored.[27] According to the United States Geological Survey there are four natural contributing factors to inflow: precipitation, run-off, ground-water, and inflow from tributaries or connecting channels. Natural outflows are through channels and evaporation.[28] Humans add additional inflow through diversions into the Great Lakes, such as Ogoki and Long Lac into Lake Superior from Ontario.[29] Humans also increase outflow through consumptive use and diversions. Naturally, water balance keeps the Great Lakes ecosystem stabilized, but human activities can alter the natural water balance and thus upset the ecosystem and alter water levels.

Water levels in the Great Lakes naturally fluctuate. Levels fluctuate with the seasons due to seasonal variations in precipitation, which affects all aspects of inflow. Water levels also change due to changes in climate. For example, many models focused on future climate change predict that precipitation in the Great Lakes region will increase, but with increase in overall temperatures, so will evaporation.[30]

Although natural water balance is important for the Great Lakes, currently only a tiny fraction of water in the lakes is renewed through inflow or altered by outflow. Retention time in the lakes for water is years.[31] Therefore, we must be especially careful about increasing outflow

[27] Neff and Killian
[28] Neff and Killian
[29] GLWI, "Water Balance"
[30] GLWI, "Water Balance"
[31] GLWI, "Water Balance"

through consumptive use and diversions because that water is replaced very slowly, and this effect may be exaggerated by global climate change in the near future.

Currently, consumptive use of Great Lakes water is not generally incorporated into water-balance equations because the amount is negligible compared to the basin as a whole.[32] The Great Lakes-St. Lawrence River Basin Water Resources Compact aims to keep it that way.

Limited Global Freshwater Resources: Case Studies

The Aral Sea, what is left of it, is an example of what can happen if diversions and consumptions go too far. Diversions for irrigation purposes have caused the Aral Sea to lose over seventy five percent of its volume.[33] The Aral Sea is located in Central Asia. It was once the fourth largest inland sea and had a booming fishing economy before water diversions by the Soviet Union escalated in the area. The water was diverted by the Soviet Union in order to water cotton crops in Uzbekistan and Turkmenistan.[34] What is left of the Aral Sea is too salty to support much fish life, as it tripled in salinity levels as water levels declined.[35] The empty sea bed is now a desert and what is left of the sea is split into two bodies of water, often referred to as the Large Aral Sea and the Small Aral Sea.[36] Peter Annin, a well-known Great Lakes scholar relates what happened in the Aral Sea to the future of the Great Lakes, "Maybe the rapid decimation that occurred at the Aral Sea is not possible, but a slower, more methodical bleeding of the ecosystem is harder to rule out…. A disaster is still a disaster whether it takes forty years or a century to occur."[37]

There are many concerns of diminishing water sources in the United States as well. Although man-made, Lake Lanier in Georgia is now the primary source of freshwater for the state, including the metropolis of Atlanta.[38] "Georgia recklessly let Atlanta grow too big too fast without considering the consequences, such as water shortages," is a comment by the previous governor of Florida, Charlie Crist. A combination of population growth and a yearlong drought

[32] Neff and Nicholas
[33] Sterling, 7
[34] Mieszkowski, 31
[35] Wescoat, 124
[36] Annin, 26
[37] Annin, 36
[38] Water War

in 2008 into 2009 have caused the lake to drop at least fifteen feet in level. There is a constant tension and argument now on whether the water should stay in Atlanta, be used to help Georgia farmers, or continue to Florida and Alabama whose industries are also dependent on water that ultimately comes from Lake Lanier.[39] There simply is not enough water to continue supporting all the areas previously dependent on Lake Lanier. On the positive side, precipitation levels through winter 2009 and spring 2010 are predicted to be high. As a response, more water is currently being released from Lake Lanier to help quench water needs, but water inflow of Lake Lanier is not stable enough to provide a predictable water supply for the region. [40]

The Southwest United States is suffering from water shortages as well because of its rapidly growing population and naturally dry climate. The Colorado River is used to provide water to much of the Southwest so that by the time it follows its natural course to Mexico the river is nearly dry, causing international tensions.[41] Like the Great Lakes, the Colorado River also is subject to an interstate water compact. The Colorado River Compact was created in 1922 and finally ratified in 1963, but unfortunately has not found success in protecting the river. The major problem with the compact is that it overestimated the amount of water that flowed into the Colorado River.[42] Other rivers have had successful interstate compacts concerning water.

The Great Lakes—St. Lawrence River Basin Water Resources Compact has successfully addressed some of the problems with previous compacts although many problems may still arise in the Compact's execution.

Great Lakes Compact

The Great Lakes—St. Lawrence River Basin Water Resources Compact was drafted December 13, 2005, building upon much previous legislation. It is divided into nine articles. It is also supplemented with the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement which includes the international cooperation of Quebec and Ontario.

Article I of the Compact lists relevant definitions and the purposes of the compact. It declares that the Great Lakes' water is held in public trust by the Great Lakes states and

[39] Water War
[40] Morris
[41] Miewszkowski
[42] Smith and Freemuth, 183

acknowledges that "future diversions and consumptive uses of Basin Water resources have the potential to significantly impact the environment, economy, and welfare of the Great Lakes—St. Lawrence River region."[43] Purposes include continued shared knowledge of the lakes and prevention of deterioration, such as could be caused by diversions. Unfortunately, this groundwork for the Compact does not quantify acceptable water levels, nor define what deterioration of the lakes would constitute. If this is left to the individual states, they could come up with various, even conflicting, working definitions.

Article II creates the Great Lakes—St. Lawrence River Basin Water Resources Council composed of the Great Lake states' governors to carry out the compact. Article III entitled "General Powers and Duties" expands upon what is stated in Articles I and II. It states that all council members shall collect scientific data and report their water usage, management, and conservation. Each state gets equal say; it does not depend on the amount of Great Lakes shoreline they have. Since the council is composed of the governors there is less chance of conflict with state laws, aiding in the effectiveness of this Compact. The Great Lake states have already begun to develop consumption and withdrawal measurements and databases. Michigan, Ohio, and a few of the other states have also created water use rules stricter and more precise than what the Compact calls for.[44]

Article IV "Water Management and Regulation" is the most extensive article in the compact--it addresses water diversions. It creates a five year plan in which all the states must develop a water resources inventory and report all use of water resources. The states must also register all diversions or consumptions over 100,000 gallons per day, including previously enacted ones. This includes areas such as Pleasant Prairie in Wisconsin. After five years, starting in 2013, a report must be completed annually. States may investigate the reports of their fellow compact members, but allocating funds for the inventory report and investigations come from individual state budgets. The Compact and its council do not have the ability to allocate funds to enforce this law. Funds can also be allocated from the federal government. In October, the Great Lakes Council requested a $475 million allocation from Congress.[45]

A two year plan in section 4.2 calls for all Parties (states) to enact a water conservation or efficiency program. The states, however, decide whether or not the program will be mandatory

[43] Great Lakes—St. Lawrence River Basin Water Resources Compact 1.3.1d
[44] Ohio DNR
[45] Council of Great Lakes Governors

or voluntary, making the effectiveness of this part of the Compact difficult to quantify. This could also affect the ability of a state to get a diversion approved by all the states in the Compact. Therefore, a state with a weak conservation and efficiency program will be less likely to get a diversion approved. Unfortunately, this could also lead to states such as Michigan (which lies completely within the Great Lakes Basin) creating weaker plans because they will not need to apply for inter-basin diversions.

Section 4.5 lists the four steps necessary in making a proposal for a diversion, withdraw, or consumptive use. All proposals are subject to regional review, including consultation from the two involved Canadian provinces, Ontario and Quebec. The time frame for review is around ninety days. First, the state in which the diversion would occur in, herein referred to as the Originating Party, decides whether or not the diversion request qualifies for regional review. Before it subjects the proposal to regional review, the state must conduct a technical review of the proposal. After regional notification, it is required that the proposal undergoes a public review provided by the Regional Body. The Regional Review then makes a "Declaration of Finding." If they cannot agree, they can either wait up to a month to submit their declaration, or, if unable to agree during that time period, they can submit separate opinions. The Declaration of Finding can either be:

i. Meets the Standard of Review and Decision
ii. Does not meet the Standard of Review and Decision
iii. Would meet the Standard of Review and Decision if certain conditions were met.[46]

After the Declaration of Finding is stated by the Regional Review, the Council (all the governors) will vote on the proposal.

Section 4.8 strongly states that "All New or Increased Diversions are prohibited, except as provided for in this article."

Section 4.9 explains what those exceptions are. "Straddling communities" are located in a county within the Great Lakes Basin and partially within the basin itself. They may submit a proposal for a diversion. A diversion will only be allowed for "straddling communities" if the water is "used solely for Public Water Supply Purposes" and if all water withdrawn is eventually returned to the basin. The clause stating that the diverted water may only be used for "public

[46] Great Lakes—St. Lawrence River Basin Water Resources Compact 4.5b

water supply purposes" may lead to the denial of diversion request in areas hoping that the increased water supply will lead to economic growth and new business. Any proposal over 100,000 gallons per day (on average per ninety days) must also meet the "Exception Standard" listed in section 4.9.4. These additional standards include extensive conservation plans and the condition that no other viable water options for that area exist. The Exception Standard also includes stricter standards in how the water must be returned to the Basin in that no outside water will be accepted for this return flow except if it is in a combined wastewater treatment output or proves it will not introduce invasive species into the Basin. Most importantly, the community submitting the proposal must show strong evidence that the diversion will not cause environmental harm to the Basin. Any proposal over 5,000,000 gallons per day is subject to the Regional Review described section 4.5.

The second exceptions for diversions are "intra-basin transfers." The conditions are similar to "straddling community" diversions. The final possible diversion category is "straddling counties." Straddling counties include communities within those counties that partially lie in the Basin, but the community applying for the diversion does not lie within the Basin itself. Any size diversion in this type of area is subject to Regional Review and must follow the "Exception Standard." This exception standard states that the diversion must be the only reasonable alternative and will only be allowed in reasonable quantities. Like previous exceptions, all water must be returned to the lake. A special point indicates, "Caution shall be used in determining whether or not the Proposal meets the conditions."[47]

A summary of all three possible types of diversions under the Compact and their conditions for approval are listed in the table below:

[47] Great Lakes—St. Lawrence River Basin Water Resources Compact 4.9.3e

Table I: Diversion Requirements in the Great Lakes Compact

	<100,000gal/day	>100,000gal/day	>5,000,000gal/day
Straddling Communities	all water is returned with min. allowance for consumptive use	Meet exception standard	Regional Review and approval
Intra-Basin Transfers	Discretion of the state	Meet exception standard, except may be returned to any Great Lake Watershed	Regional Review and approval
Straddling Counties	Meet exception standard, management by state, no reasonable alternatives, Regional Review and Council approval, no danger to Basin Ecosystem		

Section 4.10 allows states to review and adjust levels of withdrawals and consumptive uses in order that cumulatively they do not negatively affect the Basin's ecosystem. While this addresses keeping diversions low within a state, overall the level of diversions may overreach sustainable use of the Great Lakes, but it will be harder to negotiate how to lower diversions among all the states. Arguments may arise between states with large diversions or those with many small ones over which state should have to reduce the amount of water they are diverting. Hardin's theory of "Tragedy of the Commons" may come into play here. According to Hardin, each state will look to its own self-interest when it comes to using Great Lakes water.[48] For example, during the creation of the Compact, Michigan pushed for less strict regulations on consumptive use and more regulation on diversions, because they have the most need for consumptive use and no need for diversions outside the basin.[49] Illinois pushed for the exclusion of their large diversion for Chicago from Compact regulation. If each state works for its own self-interest, it will impact negotiations to reduce water usage across the whole basin, thus making the Compact less effective. Each state will use a larger amount of water for their own economic benefit while expecting others to limit their water usage. The Compact itself seeks to avoid the "tragedy of the commons" by discouraging free-riding states. The fact that the states voluntarily worked together to create the Compact also shows a dedication to regional well-being. It also supports Noah Hall's concept of horizontal federalism where the Great Lakes

[48] Hardin
[49] Annin

region works together because of "enlightened self-interest."[50] The creation and passage of the Great Lakes-St. Lawrence River Basin Water Resources Compact and additional laws support Elinor Ostrom's theory that governing of common pool resources does not have to desolve into tragedy of the commons or become a product of a coercive government.[51] Following Ostrom's theory, under which the philosophy of the Compact was made, the Compact should be successful in protecting the collective Great Lakes region.

The Decision-Making Standard laid out in the next section sets principles for the reviews and adjustments in Section 4.10. The diversions must continue to follow all the rules in the previous section as well as take into consideration future developments and affects and show efficient use of diverted water. If the community that submits the proposal includes improvement projects for the basin and future plans to minimize impacts, those may be taken into consideration as well.

The rest of Article 4 addresses more specific issues and iterates that the "Standard of Review and Decision shall be used as a minimum standard."[52] Even when groundwater is a concern, the Compact will use the surface Basin boundary as a line for diversions. Each Great Lake has its own watershed including connecting channels, except for Lake Michigan and Lake Huron that function as one watershed. Transfers out of the Basin in large containers, such as NOVA's actions to supply water to Southeast Asia, constitute a diversion not allowed by the Compact under any conditions. Bottled water companies are not affected by this law because water is exported in smaller containers. Currently, bottled water is a large industry in the Great Lakes, over 300 million gallons of bottled water a day are taken from the Great Lakes and exported in Michigan alone.[53] There is some concern that the industry will continue to grow unregulated in the Great Lakes area. States, however, have the authority to create state laws regulating bottled water activities within their boundaries. Water needed for transportation, such as ballast water on ships, or for emergency short-term uses, such as firefighting, are not considered diversions. This is also the section where Chicago's current diversion is excluded from the rules of the compact. Illinois refused to sign the Compact until this clause was added. Lastly, Section 4 creates a standard for a cumulative assessment of all consumptive uses and

[50] Hall
[51] Ostrom
[52] Great Lakes Basin—St. Lawrence River Basin Water Resources Compact 4.12.1
[53] Dempsey

diversions to be created at a minimum every five years, including consideration of climate change and implementation of the precautionary principle, meaning only strong suspicion and supportive evidence of possible harm is needed, not scientific proof, in order to implement a policy on the issue. As stated before, the Compact calls for these reports, but it does not address the action that will need to be taken if the level of diversions is found to be too great for the Great Lakes environment.

Articles 5 and 6 give rights to the involvement of federally recognized tribes and the public respectively on giving input and consideration on applications for diversions and Basin management. All Council minutes and documents must also be made public.

Article 7 addresses enforcement and disagreements, including the right of any person or state to use this compact in state or federal court if they feel it is being misused or neglected by any state or the council. Therefore many of the specifics of the Compact enforcement may be set by precedent in court. This precedent may underestimate climate change in future disagreements. Article 8 limits the Compact's jurisdiction by stating it does not overrule any existing law or treaty, and allows for amendments of the Compact. The allowance for amendments addresses Schllager and Heikkila's concern that interstate compacts are too rigid to address future challenges. If the situation changes in the Great Lakes, the Council can vote to alter the Compact to solve the problems. Article 9 simply reveals what conditions were needed to enact this Compact, considering it as a whole and impending approval by all eight Great Lake States and the Federal Government. All such conditions have been met, and the Compact became official in 2008.

In order for the Compact to have been signed into law and for any action to be taken, all of the states must agree on what the correct action to take will be. Each state has different stakes in the issues, therefore many compromises had to be made in the forming of the compact and may have to be made in any further ruling. This need for agreement may lead to "lowest common denominator" policies that are less effective than more flexible policies.[54] On the other hand, because unanimous agreement is necessary scholars Leach and Sabatier argue that policies and decisions will be higher quality because they will be well thought out.[55] Considering the Great Lakes—St. Lawrence River Basin Water Resources Compact took over seven years of

[54] Kennedy, 2000 (qtd in Schlagager and Heikkila)
[55] Leach and Sabatier 2006 (qtd in Schlager and Heikkila)

compromising to write and pass it is evident that much thought went into its writing. The limit of 90 days on deliberations for diversion requests written into the Compact may prevent actions taken in the name of the Compact from being as well thought out, but it also prevents them from being unaddressed indefinitely because of disagreements.

As previously mentioned, the Compact upholds Ostrom's theory of common-pool resources. Ostrom argues that stakeholders of common-pool resources such as the Great Lakes can effectively cooperatively regulated and use the resource sustainably without outside force. Unfortunately, the Compact does not meet *all* of the eight "design principles" for successful common-pool resource management.[56] The Compact clearly outlines the boundaries for Great Lakes Water use, meeting design principle number one. Only communities within the basin and limited surrounding communities have access to the water. The second principle is the establishment of enforceable resource use rules with proper consideration for appropriation and local conditions. The Compact meets this by requiring comprehensive reports on the water levels, inflows, and consumptive use of water from the Great Lakes. It also includes consideration for regional activities and conditions, such as precipitation levels and pollution risks for the lakes. Accurate measurement of inflow is vital to the success of the Compact in maintaining Great Lake water levels. Every state has the power to enforce the Compact, and a consensus of the governors allows for amendments therefore fulfilling the third principle of "collective choice arrangements." The fourth principle is that stakeholders have the ability to monitor each other which is fulfilled in that any state, organization, or individual can bring a violator of the Compact to court. The Compact falls short, however, in upholding the fifth principle of "graduated sanctions." If a state breaks the Compact they can be brought to court, but that takes funds, which are not guaranteed and will not necessarily punish the violator in a timely or effective matter. The sixth principle calls for "conflict-resolution mechanisms." The Compact meets this by establishing the ruling Great Lakes Council and allowing for amendments to the Compact if needed, including possible clarifications of the rules. However, this does not guarantee that all states or localities will interpret or enforce the Compact the same. The seventh principle is simply that the institution has a recognized right to organize, which has a federally approved interstate compact, the Great Lakes Compact clearly achieves. Finally the Great Lakes

[56] Ostrom, pg 90

Compact is supported with a vast network of local governmental, state, and regional organizations, which help uphold the eighth priority of having nested enterprises.[57]

Another weakness of the Great Lakes Compact is that its regulations of diversions could be overridden by federal government mandates or Supreme Court rulings. As stated earlier, the Supreme Court ruling on the Illinois River Diversion was excluded from the Compact rules. In 1940 the large Long Lac and Ogoki diversions into the Great Lakes bypassed regional legislation by a special international agreement between Canada and the United States.[58] If placed under stress to use Great Lakes water the federal governments of Canada and the United States may choose to dissolve or approve an exception to the Great Lakes Compact.

Diversions Requested Under the Compact:

The city of New Berlin, Wisconsin, is the first community to apply for and be granted a diversion under the Great Lakes—St. Lawrence River Basin Water Resources Compact. New Berlin falls into the "straddling community" category. The diversion is for an average of 2.38 million gallons of water per day, most of which is returned to Lake Michigan through the Milwaukee Metropolitan Sewerage District.[59] The Lake Michigan water will be used to replace groundwater sources contaminated with Radium.[60] The consumptive use allowance is 10-15% by Wisconsin standards.[61] Neither the diversion nor consumptive use levels were large enough to warrant regional review, therefore Wisconsin allowed the diversion after concluding it met all standards set by the Compact, including an ambitious conservation plan.[62]

The City of Waukesha and the Waukesha Water Utility have made their intentions to ask for Lake Michigan water in the near future very clear. Waukesha is located very near New Berlin, but it qualifies as a "straddling county" and thus is subject to stricter diversion requirements. On June 3, 2009, the Waukesha Water Utility released a fifty-page document

[57] Ostrom, 2000 pg 90-102
[58] Heinmiller, 664
[59] Wisconsin DNR, "New Berlin Approval"
[60] Wisconsin DNR, "Findings"
[61] Great Lakes Commission 2006
[62] Wisconsin DNR, "Findings"

titled "Responses to Questions Regarding Waukesha's Potential Application For Great Lakes Water."[63]

Waukesha is currently using water contaminated with radium from deep aquifers.[64] The diminishing quality of water is the prime reason Waukesha is searching for a new water source. Options for new sources include groundwater from other parts of the county, the development of shallow sandstone wells, and water from Lake Michigan. Waukesha's initial cost-benefit analysis and environmental impact analysis led them to decide that using Lake Michigan for their new water source would be the most sustainable and cost-effective choice.[65]

The request would be for an allowance of 18.5 million gallons per day, but average use would be much less according to Waukesha officials. Peak water use in Waukesha currently reaches 26.9 MGD, but Waukesha claims its new conservation programs will not allow water use to reach those high levels. The 18.5 MGD request may limit growth in the area since the city has already demonstrated the capability of using more than that amount of water. In order to attach Waukesha to the Milwaukee Sewer District--and thus Lake Michigan--it would cost the city up to $70,000,000 in addition to all the money spent on research already. Operating costs would be about five million dollars annually.

Waukesha is also hoping to submit its diversion application with a unique return-flow plan. They would pipe the treated wastewater, originally their share of the diverted water, into a nearby creek, which flows into a river, and back into Lake Michigan. The "Exception Standard" in Article 4 of the Compact states that water can be returned to the Basin through an existing wastewater treatment facility, but it does not say if it has to be directly returned into the lake by pipe or not.[66] This could lead to some disagreement among the states on whether or not the Waukesha plan meets the criteria for return-flow by using the natural creek. If this return flow plan does not get passed, it may not be cost-effective for Waukesha to get water from Lake Michigan as their new source.

[63] Waukesha Water Utility
[64] Waukesha Water Utility, 39-40
[65] Waukesha Water Utility, 7-8
[66] Compact 4.9

Methods

In order to predict whether or not lake levels will remain stable with current and future water use under the Great Lakes-St. Lawrence River Basin Water Resources Compact, I adopted the water balance formula from USGS for the Great Lakes in combination with aspects from the "Optimal Compact" formula developed by Lynne Bennett, Charles Howe, and James Shope.[67]

$$\mathbf{W \geq E + O + [D_1 (1\text{-}p) + C_1] + \ldots [D_{10} (1\text{-}p) + C_{10}]}$$

Where,

W	= amount of inflow into the Great Lakes
E	= evaporation
O	= natural channel outflow (St. Lawrence River)
D_1 to D_{10}	= Amount of water diverted from the Basin in each state or province
p	= proportion of diverted water returned to basin
C_1 to C_{10}	= amount of water consumed in each state or province.

Consumptive use and diversions were calculated using the published "Annual Reports of the Great Lakes Regional Water Use Database Repository" from 1998 to 2006.[68] These reports give detailed consumption and diversion amounts reported from each Basin state in gallons per day in annual averages. The amount of water diverted thru the Illinois River was added to diversions and consumptive use amounts since it was not included in any of the original reports. Data from the Illinois River diversion was collected and reported by the U.S. Army Corps of Engineers.[69] Published data is only available through 2005; therefore I used the same numbers in 2006 as it is unlikely there was a large change in the amount diverted. Illinois River levels were converted to billions of gallons per day, matching the Great Lakes Commission reports, as

[67] Bennett
[68] Great Lakes Commission 2006
[69] Army Corp of Engineers

opposed to originally being reported in cubic feet per second. Inflow and natural outflow data were derived from the United States Geological Survey report on Great Lakes water balance in 2005.

After calculating current Great Lake's water use, future water use was calculated using additional probable diversions under the Great Lakes-St. Lawrence River Basin Water Resources Compact, including New Berlin in 2009, Waukesha by 2012, Lowell in Indiana, the Waterloo Pipeline in Ontario in 2035, and probable diversions around the Toledo area in Ohio. Increases in consumptive use were also estimated and calculated into future water use. Finally, the amount of bottled water exported from the Great Lakes Basin and the max allowable diversion from the Illinois River were added to future basin water usage up to 2050.

The current and calculated water usage levels in the Great Lakes Basin were then compared to the component net basin supply (NBS) of the Great Lakes by the USGS.[70] The component NBS is amount of water entering the Great Lakes through groundwater seepage, precipitation, inflowing channels, and runoff –minus evaporation and diversions. The USGS reported levels individually per lake, but this paper added all numbers into one for the entire Great Lakes system. As there is some uncertainty in NBS calculations, the average estimated and maximum variation from all states was calculated for this report. The average amount of flow leaving the basin through the St. Lawrence River, 244000 cfs, was converted to billions of gallons per day and subtracted from the NBS, calculated the available amount of inflow for diversions and consumptive use before it should effect long-term lake levels.[71] The outflow through the St. Lawrence River acts as "O" in the water balance formula, and was subtracted from W, making "W=NBS-O", thus calculating the amount of available inflow for diversions and consumptive use before negatively affecting water-balance. Thus the final equation for stable water levels in the Great Lakes used for future predictions in this paper is:

$$\mathbf{NBS\text{-}O \geq D+C}$$

Where,

[70] Neff and Killian
[71] Schweiger

NBS = precipitation + natural channel inflow + groundwater seepage – evaporation

O = outflow through the St. Lawrence River

D = total diversion amounts in the Basin

C = total consumptive use levels in the Basin, including consumptive use percentages of diverted water.

Results

Since 1998, reported withdraw and consumptive levels throughout the Great Lakes Basin have reduced, as seen in Figures 2 and 3.

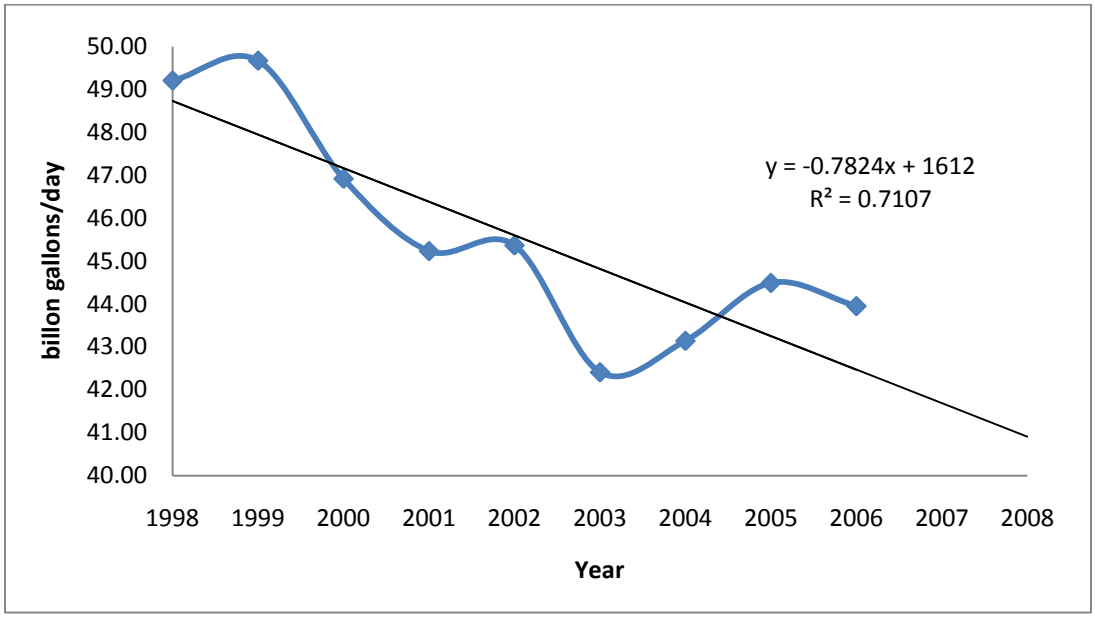

Figure 2: Diversions from the Great Lakes

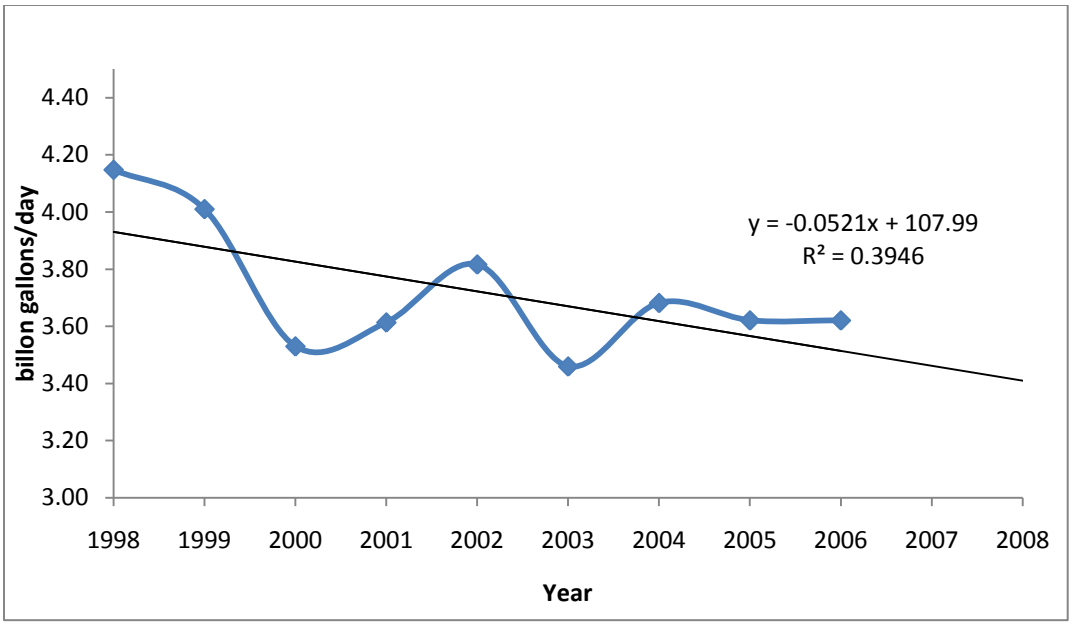

Figure 3: Consumptive Use of Great Lakes Water

Both diversions amounts and consumptive use levels have fluctuated in the last ten years, reasons for which are discussed later in this paper. From 2004 to 2006 levels consumptive use were relatively stable.

Currently, consumptive use levels are not above the average available inflow to the Great Lakes. The amount of water diverted from the lakes is higher than the average available inflow, but not higher than the maximum estimate available inflow, as seen in Figure 4.

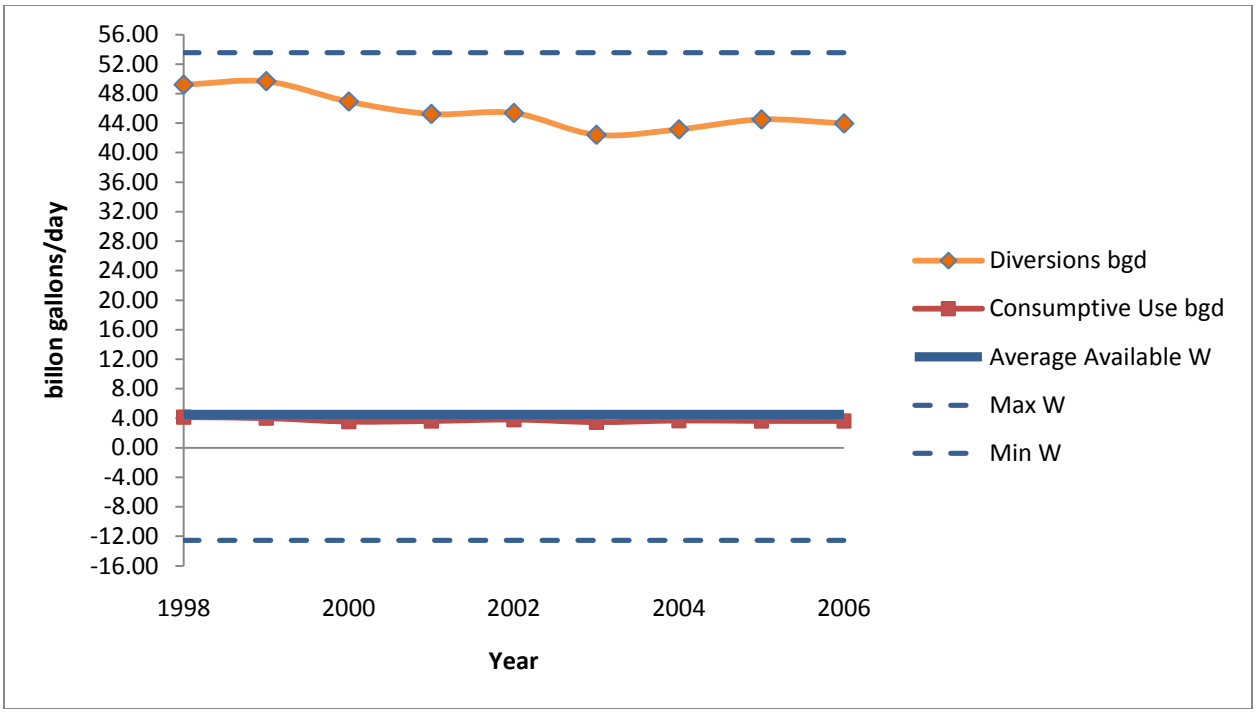

Figure 4: Current Great Lakes Diversions and Consumptive Use

The average available inflow is 4.50 bgd while the highest level of consumptive use, 1998, is only 4.15bgd. Consumptive uses in 2005 and 2006 were the least amounts reported in the past eight years, taking up 80.4% of the available average inflow. Diversion amounts in 2006 are at 43.95 bgd, 82.04% of the maximum estimated available inflow, and 49.07 bgd the average available inflow.

Figure 5 uses the same available inflow levels as is seen in Figure 4, but adjusts diversions and consumptive levels to portray probable diversion changes under the Great Lakes—St. Lawrence River Basin Water Resources Compact and changes of water use within the basin for the next forty years, including increases in bottled water production, smaller allowed diversions by states, and the larger proposed diversions such as Waukesha and Lowell. It also accounts for max diversion amounts from the Chicago Illinois River Diversion.

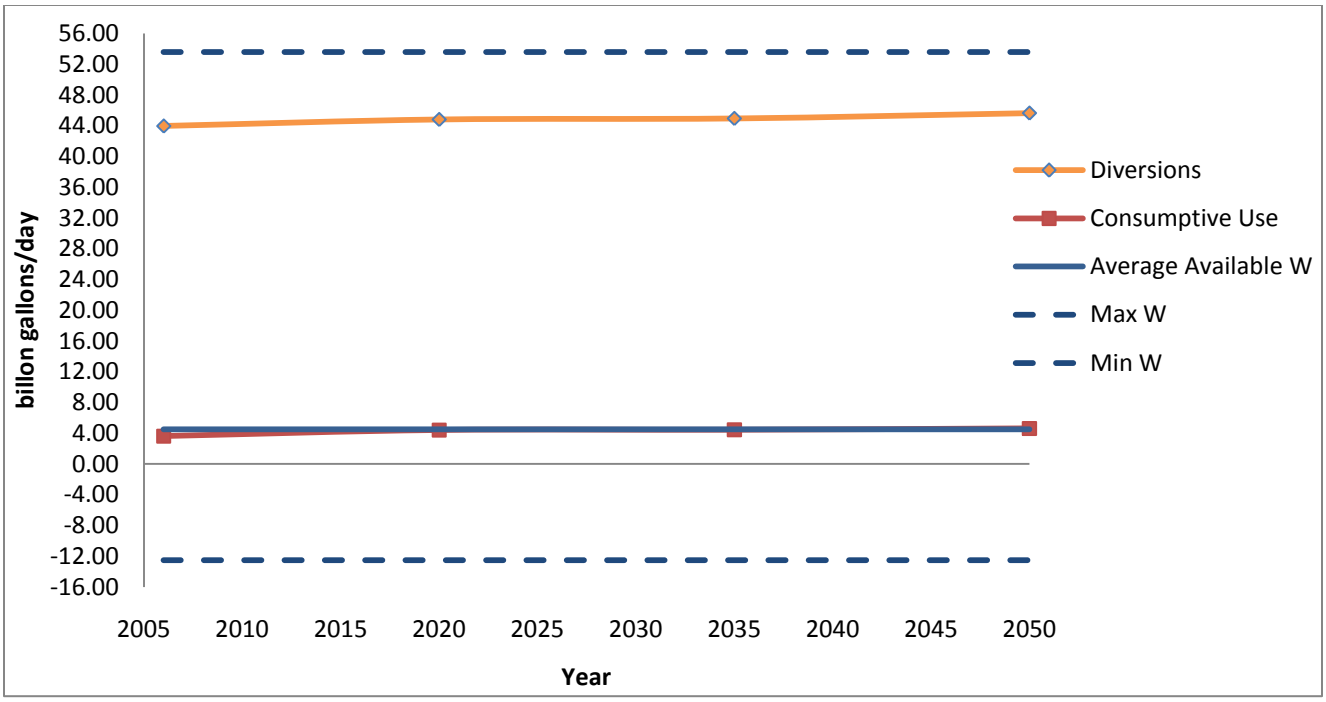

Figure 5: Future Diversions and Consumptive Use

Using probable increases in diversions and consumptive use under the Compact, consumptive uses will be greater than the average available inflow by 2050. Consumptive use is estimated at 4.62 bgd versus the average available inflow level of 4.50 bgd. Figure 6 shows the changes in recorded consumptive use from 1998 to 2050, which shows its relation to average inflow.

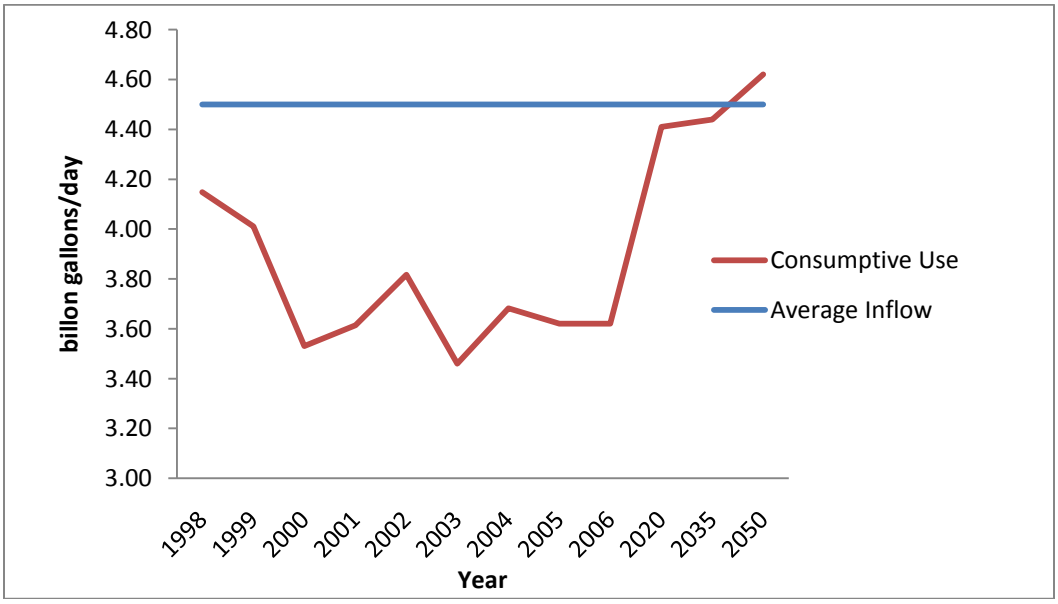

Figure 6: Reported Consumptive Use Compared to Average Inflow

The amount of diverted water only increased by 4.4%, and still is not higher than the estimated maximum amount of available inflow, as seen in Figure 5. However, consumptive use increased by 10.2% from 1998, still far from the estimated maximum amount of available inflow, but slightly over the average estimated maximum amount of available inflow.

Discussion

My hypothesis that the Great Lakes-St. Lawrence River Basin Water Resources Compact would not effectively achieve its purpose of limiting diversions and consumptive water use to levels not detrimental to the Great Lakes ecosystem was supported. By 2050, consumptive usage of Great Lakes water may be greater than the average available inflow to the Great Lakes, as seen in Figures 5 and 6. Although *all* the increases accounted for in calculations for future consumptive use are unlikely to be approved and carried out, it *is* a possible scenario under the Great Lakes Compact. In 2050 consumptive use by these calculations will be greater than average available inflow by 0.12bgd, which will accumulate, possibly lowering water levels and St. Lawrence River flow permanently.

Figures 2 and 3 show the Great Lakes States dedication to reducing consumptive use and diversion amounts even before the Great Lakes Compact was official. There is a general trend of reduction of both diversions and consumption amounts throughout the basin. As seen in the figures, there have been some fluctuations in these levels over the recent years. Trends could be more accurately predicted if annual water use reports were available for years earlier than 1998.

Consumptive use coefficients stayed relatively the same as did the methods for calculating diversions per state from 1998 to 2006. Data collection, however, was neither thorough nor were methods consistent across the basin states as stated in the Annual Water Use

Reports by the Great Lakes Commission.[72] The Compact calls for comprehensive water resources reports by 2013, which should fill in the gaps in water use data.[73]

Figure 4 shows that recent historic consumptive use levels are below the average available inflow. Data supports that the Great Lakes—St. Lawrence River Basin Compact was a preventative piece of legislation, and not a reactive one to an already existing problem in the area. This makes the compact unique in water resource compacts as it attempts to curb a possible dilemma in the future rather than treat an existing problem.

Available inflow levels were calculated by using NBS reports from each lake basin by the USGS minus average flow of the St. Lawrence River as reported by the Army Corp of Engineers.[74] The range of available inflow levels, indicated by the maximum and minimum estimates, may be greater in the model seen here because they were calculated by averaging uncertainty in inflow for each individual lake basin. The uncertainty of NBS in individual lake basins may be higher than the Great Lakes Basin as a whole because of fluctuations in natural intrabasin flows between the lakes.

Figure 4 shows diversion levels are above the average available inflow level, but as diversions are currently set-up to steadily return flow into the Great Lakes, this should not negatively affect the lakes. The Compact itself, however, does not specifically require flow to be steadily and quickly returned to the lakes. Precedent would assure most future diversions would follow historic trends of water returning to the lakes through treated wastewater flows, thus in a steady, non-intrusive flow.[75] Care should be taken in future diversions to track temperatures and nutrient levels of return-flow to insure they match current lake water composition as not to disturb the ecosystem.

As the estimated minimum available inflow is negative, I did not compare consumptive use levels to it. If the minimum levels are correct overtime, a decrease in flow out of the St. Lawrence River will occur naturally, bringing the level of available inflow to higher levels. Decreases in the St. Lawrence River flow will be one of the first and most telling indicators if

[72] Great Lakes Commission1998-2006
[73] Great Lakes Compact
[74] Neff and Nicholas, Schweiger
[75] Waukesha Water Utility

consumptive use of water in the basin becomes higher than available inflow, as is predicted and seen in Figure 5.

Although the trends for consumptive use and diversions were declining, my models for future water use levels estimated an increase on both accounts, as seen in Figure 5. This may be because my model does not account for reductions of current consumptive uses or changes in the types of water uses in the basin, such as a possible decrease in irrigation which has high levels of consumptive use. Also, consumption levels of water in the future may be reduced by water conservation efforts by the states, thus decreasing the consumption coefficient for new public-supply diversions.

The fact the consumptive use of Great Lakes water is higher than the average available inflow by 2050 in the model, even by such a small amount, should cause concern. The Great Lakes-St. Lawrence River Basin Water Resources Compact does not prevent bottled water industries from exporting water from the basin, which accounts for vast amounts of consumptive use and which has the possibility of continuing to increase in the future. Nor does the Compact require states to decrease their consumptive use and increase conservation. The Compact requires states to develop conservation plans, but not to implement them.[76] Finally, the Compact does not require regional review and approval for diversions smaller than 100,000 gallons per day which in aggregate have the ability to negatively affect the lakes as much as a few large diversions.

The predictions of the model in this paper will be altered in actuality by outside factors. Each state takes individual action to decrease and monitor water usage, even in areas not under the Compact's jurisdiction. Minnesota, for example, had stricter water use policies than the Compact even before the document was signed.[77] Minnesota also had already begun monitoring Lake Superior water levels in 2000, showing that the region was already headed in a similar direction before the Compact obligated them to do so.[78] Similarly, in 2006 Michigan began to monitor large water withdraws and came up with a water withdraw assessment tool which could

[76] Great Lakes Compact
[77] Minnesota Department of Natural Resources
[78] Minnesota Environmental Quality Board

be useful to the region as a whole.[79] In 1992, New York released a 25 year plan for their Great Lakes water resources, including goals of sustainable water use and cooperative intergovernmental policies.[80] States such as Pennsylvania immediately drew up reports on Great Lakes water consumption after signing the Compact into law.[81] Additional regulations by the states appear to go beyond Compact regulations as a general trend, therefore predicted water consumption in the model are most likely high—a positive diagnosis for Great Lakes sustainability.

Climate change may also create a change in the models, affecting the natural levels of inflow and outflow. A study in 2008 revealed that the Great Lakes region has long been susceptible to climate change. Most major historical changes in lake levels have been credited to changes in surrounding glacier mass, however, it is now known that some major fluctuations were due to climate change. For example, about eight thousand years ago dry climate conditions dropped lake levels an average of twenty meters for a period of four-hundred years.[82] A U.S. Geological Society report in 2010 ranked the Great Lakes region as moderately vulnerable to coastal variation due to changes in lake level.[83]

Current climate change has already begun to affect the Great Lakes region. Lakes, especially Lake Michigan, Lake Superior and Lake Huron, have much less ice cover recently, increasing over all temperature and evaporation levels.[84] That increase in evaporation, as well as a loss in precipitation levels, have helped to lower Lake Huron and Lake Michigan's water levels nine inches below the nearly century long average.[85] Lake Erie has not been as effective, because the majority of its inflow comes from Lake Huron, not run-off.[86] However, if Lake Huron's levels continue to drop it is sure to have a devastating effect on Lake Erie as well.

The IJC's Great Lakes Water Quality Board predicts that climate change will lead to a decrease in lake levels. Although more precipitation in the region overall is predicted, the

[79] Michigan Department of Natural Resources and Environment
[80] New York Department of Environmental Conservation
[81] Pennsylvania Department of Environmental Protection
[82] "Great Lakes Water Level Sensitive to Climate Change."
[83] Pendleton
[84] "Lake losing superiority."
[85] Mittelstaedt
[86] Mittelstaedt

precipitation will come in more extreme events, not a general increase in precipitation year round. Less ice coverage will lead to an increase in temperature and evaporation. Decreases in regional run-off and groundwater recharge will lead to less inflow into the lakes. If inflow to the lakes is lower, the amount of water the region can sustainable use will be lowered even if demand for that water remains the same.[87]

For future studies, incorporating action trends by the individual states and provinces into models may give a more accurate prediction of future diversion and consumption levels in the Great Lakes Basin. Concrete data on state water diversion and consumptive use levels under state law should be available for this application within five years.

For future studies it may also be beneficial to account for possible changes in inflow to the Basin caused by climate change and groundwater availability. Calculating water balance and water usage in the Great Lakes Basin will also become more accurate after 2013, as comprehensive reports will become available as required by the Compact.

Conclusion

The Great Lakes—St. Lawrence River Basin Water Resources Compact is an example of a region working cooperatively together to protect their natural resources from outside use. The Compact successfully prevents the majority of diversions outside the Great Lakes Basin in order to prevent disasters in the Basin similar to the destruction of the Aral Sea. The Compact, however, does not effectively reduce consumptive use within and smaller diversions around the basin. Because of this, it is predicted that consumptive use of Great Lakes water will begin to be greater than the average available inflow by 2050, thus leaving long-term negative effects in the Great Lakes ecosystem.

Consumptive use, however, has the possibility of being lower than predictive levels if states individually increase conservation and reduce consumptive use, as supported by recent trends. Climate change may alter the other side of the equation—the amount of available

[87] Great Lakes Water Quality Board

inflow—thus the amount of consumptive use that will negatively affect water levels and the Great Lakes ecosystem may be less than currently predicted.

The Great Lakes-St. Lawrence River Basin Water Resources was a major step in protecting the waters of the Great Lakes, but individual state and province actions will still be the determining factor in the long-term health of the Great Lakes ecosystem.

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