Conflicts, costs and environmental degradation – impacts of antiquated ground water allocation policies in the Great Lakes Basin

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Abstract

Ground water is a source of drinking water for many people and is the primary source for irrigation and livestock watering in the Great Lakes region. The use of ground water in the Great Lakes Basin has substantially increased in the past few decades due to population growth, technological innovation, agricultural development and inefficient water use. Despite the increase in demand, there have been no significant changes in the ground water allocation policies in either Canada or the United States since the nineteenth century. Six of the ten jurisdictions of the Great Lakes Basin still rely on archaic common law principles to determine the allocation of ground water, while Ontario’s water taking permit program has shown that centralized government regulation can be equally ineffective. Therefore, the courts and governments of the Great Lakes Basin are effectively encouraging unrestricted withdrawals of ground water, and as a result, water tables are declining, well interference incidents are increasing and ground water divides are shifting. These physical effects are giving rise to economic costs, social conflicts and environmental degradation. To mitigate the impacts of antiquated ground water allocation policies in the Great Lakes Basin, the authors suggest institutional change and a range of legal tools to better protect this critically important resource.

Keywords: Allocation policies; Common law; Environmental degradation; Great Lakes Basin; Ground water; International legal regime; Social conflicts

1. Introduction

The Great Lakes Basin consists of the five Great Lakes (Lakes Superior, Michigan, Huron, Erie, and Ontario), their connecting channels, and the international section of the St. Lawrence River, together


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with their tributaries (IJC, 2000). These lakes constitute about one fifth of the world’s total fresh surface water supply, nearly 23,000 km$^3$ of water (Grannemann et al., 2000). In addition to the Great Lakes, there are over 80,000 smaller lakes and thousands of rivers and streams which flow into them (Colborn et al., 1990). Underlying all this surface water is a vast ground water system, the volume of which is roughly the size of Lake Michigan (more than 4,100 km$^3$ of water) (Grannemann et al., 2000). The use of this ground water system has substantially increased in the past few decades due to several factors including population growth, technological innovation, agricultural development and inefficient water use.

Population growth in the Great Lakes Basin over the last century has been rapid (USEPA/Government of Canada, 1995). Currently, over 40 million people (including one third of Canada’s population) live in and around the basin (GLU, 2003). The basin has become one of the world’s foremost commercial and industrial areas with the development of metropolitan areas like Toronto, which grew by 9.8% between 1996 and 2001 (Statistics Canada) and Chicago, which grew by 11% between 1990 and 2000 (Perry & Mackun, 2001). Many smaller cities have also experienced considerable population growth including six of Canada’s fastest growing municipalities (Statistics Canada, 2002). In terms of ground water dependence, cities located away from the shorelines of the Great Lakes are often heavily reliant on ground water for their municipal and industrial supply. As these cities have grown, so has the intensity of their withdrawals from their underlying aquifers. Surprisingly, even cities located on the shores of the Great Lakes, such as Chicago, Detroit, and Milwaukee in the United States withdraw large quantities of ground water. Table 1 shows the intensity of ground water use in the Great Lakes Basin. It should be noted that ground water studies are being conducted throughout Ontario, but withdrawal data is currently only available for a limited number of cities in the Canadian portion of the basin.

Technological innovation accompanied the start of significant growth in the basin and this innovation allowed for the withdrawal of large quantities of ground water from aquifers. Prior to the invention of the centrifugal pump and the internal combustion engine, ground water users relied on hand pumps and windmills. These innovations, which occurred in the early twentieth century, paved the way for the large-scale removal of ground water.

As a result of population growth and technological innovation, approximately 21 percent of the residents of the basin now depend on ground water for their drinking supply and ground water is the primary source of water for all self-supplied residential, industrial and commercial uses (Farid et al., 1997). Furthermore, as the population in the basin has grown, so has the need to increase agricultural output. Water use for agriculture in the basin has been increasing at a staggering rate, with irrigated land increasing 25 fold in the period from 1949–1997 (Glynn, 2002) and projections suggest significant increases in agricultural development by 2020, particularly in the Canadian portion of the basin (IJC, 1999). It is estimated that more than half of the fresh water utilized for irrigation and watering livestock in the basin comes from ground water (Glynn, 2002). Although some of the water used for irrigation can be expected to return to the ground water system through infiltration, current irrigation practices in the basin allow for much of the water (about 80%) to be lost to the system through evapotranspiration (IJC, 1999). Therefore, significant increases in irrigated land could have serious consequences for ground water levels.

In general, the water users in the Great Lakes Basin are some of the most wasteful in the world. At a national level, Canadians and Americans use more water per capita than any other nation (Boyd, 2001; OECD, 2004). Further, studies in the U.S. have shown that the Great Lakes states are withdrawing water at a greater rate than the majority of other states in the country (Hutson et al., 2004). Water use trends in
the United States portion of the basin also indicate that the amount of ground water being withdrawn in the basin has significantly increased. Matching a general trend in the U.S., between 1990 and 1995, the total amount of surface water withdrawals in the basin decreased by 380 million litres per day (a decrease of less than 1%) while ground water withdrawals increased by nearly 1140 million litres per day (an increase of nearly 25%) (Solley et al., 1993, 1998). Patterns of water use for the Canadian side of the basin are not readily available at present (Kreutzwiser et al., 2004; Rutherford, 2004; de Loe, 2005), although a number of provincial and federal initiatives are attempting to improve this situation (Environment Canada, 2004; Great Lakes Commission, 2004; MNR, 2004; MOE, 2004). While it is not possible to accurately state whether ground water use is increasing in the Canadian portion of the basin, the growth in conflicts over ground water withdrawals would suggest that, at least in some areas of Ontario, greater pressure is now being exerted on ground water resources than in the past. Examples of this pressure include conflicts between communities and water bottling operations (Hoffmann & Mitchell, 1995), residents and golf courses (ECO, 2001), farmers and suburban users (ECO, 2000a), and citizen groups and dewatering operations (Gorrie, 2004; Swainson, 2004).

Despite rapid growth and the considerable pressure now exerted on ground water resources, courts and governments continue to allow, and even encourage, unrestricted ground water withdrawals. As a result, intensive ground water withdrawals are causing negative consequences which are often hidden from view but which give rise to social conflicts and environmental degradation. This paper highlights

Table 1. Intensive groundwater withdrawals by metropolitan areas and cities in the Great Lakes Basin.

<table>
<thead>
<tr>
<th>Cities</th>
<th>Ground water withdrawals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m³/day</td>
</tr>
<tr>
<td>Chicago (IL)*</td>
<td>757,080</td>
</tr>
<tr>
<td>Milwaukee (WI)*</td>
<td>352,042</td>
</tr>
<tr>
<td>Lansing (MI)*</td>
<td>340,686</td>
</tr>
<tr>
<td>Battle Creek/Jackson (MI)*</td>
<td>310,402</td>
</tr>
<tr>
<td>Detroit (MI)*</td>
<td>295,261</td>
</tr>
<tr>
<td>Kalamazoo (MI)*</td>
<td>295,261</td>
</tr>
<tr>
<td>South Bend/Mishawaka (IN)*</td>
<td>238,480</td>
</tr>
<tr>
<td>Elkhart/Goshen (IN)*</td>
<td>147,630</td>
</tr>
<tr>
<td>Cleveland/Akron (OH)*</td>
<td>136,274</td>
</tr>
<tr>
<td>Grand Rapids (MI)</td>
<td>124,918</td>
</tr>
<tr>
<td>Portage/Michigan City (IN)*</td>
<td>113,562</td>
</tr>
<tr>
<td>Green Bay (WI)</td>
<td>102,205</td>
</tr>
<tr>
<td>Toledo (OH)*</td>
<td>102,205</td>
</tr>
<tr>
<td>Syracuse (NY)*</td>
<td>56,781</td>
</tr>
<tr>
<td>Rochester (NY)*</td>
<td>45,424</td>
</tr>
<tr>
<td>Fort Wayne (IN)*</td>
<td>41,639</td>
</tr>
<tr>
<td>Barrie (ON)*</td>
<td>41,240</td>
</tr>
<tr>
<td>Erie (PA)*</td>
<td>37,854</td>
</tr>
<tr>
<td>Buffalo (NY)*</td>
<td>26,497</td>
</tr>
<tr>
<td>Sault Ste. Marie (ON)*</td>
<td>17,384</td>
</tr>
<tr>
<td>Sudbury (ON)*</td>
<td>14,948</td>
</tr>
</tbody>
</table>

* Data for U.S. metropolitan areas came from Grannemann et al. (2000).
† Data for ground water withdrawals in Canadian cities were only available for a limited number of cities and were obtained directly from the municipalities.
those consequences and suggests ways in which institutional change and legal reform can minimize those consequences.

2. The allocation of ground water rights in the Great Lakes Basin

2.1. Constitutional foundation for ground water allocation

Under the Canadian Constitution, both the federal and provincial governments have powers relating to water management, but the provincial governments have the primary role in managing water resources (Constitution Act, 1982 being Schedule B to the Canada Act 1982 (U.K.) 1982, c. 11). Significant federal powers relate to international agreements (Section 132) and sea coast and inland fisheries (Section 91(12)).

The powers of the United States Congress with respect to water management are much broader than the Canadian parliament. This is largely because of a provision in the United States constitution known as the “commerce clause”, which allows Congress to regulate commerce with foreign nations and among the states (U.S. Const. Art. I, §8 cl. 3). In relation to the Great Lakes Basin, the powers of Congress to legislate extend not only to the Great Lakes themselves, but also to the surface flow of the tributaries and to tributary ground water (Saunders, 2000). In an international watershed such as the Great Lakes Basin, important federal powers include the power of Congress to enter into treaties, the power to approve interstate compacts, and the property power of Congress, which grants water rights to Indian reservations. Another important federal law in the basin is the Water Resources Development Act (WRDA) of 1986, which prohibits any new or increased diversion of water from any US portion of the Great lakes or their tributary for use outside the basin unless the governors of all Great Lakes States approve the diversion. However, the issue of whether or not WRDA applies to ground water is somewhat unclear (Galloway & Pentland, 2003). Consequently, allocation of ground water within the Great Lakes Basin has largely been left to the courts and legislatures of individual states. In the event of a conflict between state and federal law, laws passed by Congress would take precedence because the U.S. constitution provides that federal powers are superior to state law (U.S. Const. Art. VI, cl. 2). Despite the wide powers available to Congress, it has rarely exercised its full authority with respect to ground water quantity management (Tarlock, 1988).

2.2. Common law rules

2.2.1. Historical basis of allocation rules. The rights to withdraw ground water from the Great Lakes Basin are currently allocated by a complex and disjointed legal and institutional system. Apart from Québec, which has a civil law system, all the jurisdictions within the Great Lakes Basin have their ground water laws founded in English common law. The earliest leading authority is the English case, Acton v. Blundell (1843) 152 E.R. 1223 (Ex. Ch.). In this case, the court drew a distinction between surface water and ground water because of the difficulty in determining the quantity of ground water which had been transmitted from adjoining lands. The court held that percolating ground water should be treated as part of the soil, and in accordance with the property law maxim that every man has the right to
the natural advantages of his soil, it was determined that the water could be utilized by the property owner without giving rise to a legal claim (Lucas, 1990).

Consequently, due to a lack of scientific understanding, an artificial legal distinction (which has been pervasive in the law ever since) was drawn between surface water and ground water (Tarlock, 1988; Lucas, 1990). While rights to use surface water were restricted so that riparians (those who own land adjacent to a river or stream) could not alter the natural flow of the stream, the rights to use ground water were essentially limitless, and this became known as the absolute ownership rule (or the “rule of capture”). The mid-nineteenth century American and Canadian courts welcomed the absolute ownership rule because uninhibited ground water consumption helped stimulate agricultural and urban development (Tarlock, 1988).

2.2.2. American common law developments. In the United States, the twentieth century introduction of high capacity pumps resulted in greater pressure on ground water resources. The ensuing conflicts, which were predominantly between cities and farmers, provided the impetus for a modification to the absolute ownership rule. In the majority of eastern American states, the modification took the form of the reasonable use rule which places three constraints on absolute ownership. First, the use has to be reasonable. This means the landowner cannot cause injury to other common users by maliciously diverting ground water or allowing it to be wasted during pumping. Second, the use has to be for a beneficial purpose on overlying land, and third, the extraction of percolating water for use on non-overlying land is presumed unreasonable (Tarlock, 1988). This third constraint places a prima facie prohibition on the diversion of water away from the land overlying the aquifer (off-tract), but the presumption can be rebutted if it is shown that no injury will be caused to other overlying landowners.

Although it is an improvement on the absolute ownership rule, the reasonable use rule for ground water is still less restrictive than the reasonable use rule applicable to surface water. Unlike the surface water rule, the ground water rule does not require the proportional sharing of water by common users and contains no preference for domestic use. The reason for this is that the reasonable use rule was essentially designed to resolve disputes between farmers and burgeoning cities raiding rural lands for water. The rule’s major flaw is that it fails to address competition between neighbouring property owners who do not transport the water off-tract (Getches, 1990). In other words, as long as the use of ground water takes place on their own land, the reasonable use rule permits property owners to abstract as much water as they want. This is the case even if such pumping may exhaust the aquifer or lower the water level to a point where other landowners cannot make use of it. In the twentieth century, this reasonable use rule became the predominant ground water law throughout the United States and has been particularly prevalent in eastern states. In the Great Lakes Basin, the reasonable use rule was adopted by Michigan (Schenk v. City of Ann Arbor, 196 Mich. 75, 163 N.W. 109, L.R.A. 1917F 23, Ann. Cas. 1918E 267 (1917)) and is still used in New York (Forbell v. City of New York, 61 N.Y.S. 1005 N.Y.A.D. 2 Dept. 1900), Pennsylvania (Rauthrauff v. Sinking Spring Water Co., 359 Pa. 129, 133, 14 A.2d 87 (1940)) and through statute in Illinois (Illinois Water Use Act (1983) 525 ILCS 45). In an attempt to deal with the inherent limitations of the reasonable use rule, the American Law Institute modified the rule in the Restatement (Second) Torts § 858 (1979). Section 858 extends the ambit of the reasonable use rule to protect small pumpers from well interference caused by another overlying user. The rule also considers prior use as a factor in determining whether pumping is reasonable or not. The effect of the modification is most clearly evident in the comments portion of Section 858 which states: “... the salient factor is not the place of withdrawal but the withdrawal of water in unprecedented quantities for purposes not
common to the locality”. In the Great Lakes states, the Restatement (Second) Torts § 858 has been adopted by courts in Michigan (Maerz v. United States Steel Corp., 474 N.E.2d 339 (Wis. 1974)), Ohio (Cline v. American Aggregates Corp., 15 Ohio St. 3d 384, 474 N.E.2d 324 (1984)) and Wisconsin (State v. Michels Pipeline Constr., Inc., 63 Wis. 2d 278, 292, 217 N. W.2d 339 (1974)). However, this rule is not a substantial limitation on pumping and does not encourage ground water users to consider the effects of their pumping on hydrologically connected surface water bodies (Tarlock, 2000).

Two states, Minnesota and Indiana, did not adopt the reasonable use rule. Indiana is the only state that still applies the absolute ownership rule; whereas Minnesota adopted a rule known as ‘correlative rights’ (Erickson v. Crookston Water Works Power & Light Co., 105 Minn. 182, 117 N.W. 435, (1908)). This rule is essentially the application of the law pertaining to surface water rights and it gives all overlying owners correlative rights to an equitable share of a common aquifer (Tarlock, 1988). When the common supply is sufficient, each overlying landowner may take all he/she needs for use on his own or for use off-tract. However, where there is insufficient water in the aquifer to supply the full needs of all, each landowner may only extract a reasonable share relative to the other overlying owners. Reasonable share excludes any use that occurs off-tract. As Minnesota also has a permit system, this rule is less significant than it once was.

2.2.3. Ontario’s common law. Like Minnesota, the use of a permit system in Ontario renders the common law less relevant than in those American states which have yet to enact legislated rights. However, it is conceivable that a legal dispute could occur between ground water users who are not required to obtain a permit (these users are outlined below). In this case, the common law would be applied to resolve the conflict. The Ontario courts followed the absolute ownership rule up until 1977, but there is uncertainty as to whether it applies today. The rule appeared to be overruled by the Ontario Court of Appeal in Pugliese v. National Capital Commission et al. (1977) 79 D.L.R. 3d 592, which held that it could not construe the defendants’ right to abstract ground water as an unlimited right. In this case, the court held that this would be out of keeping with the principles of the law of tort, and stated that both negligence and nuisance principles could restrict the absolute right to ground water use. However, the case was then appealed to the Supreme Court of Canada, which based its decision on statutory law and appeared reluctant to affirm the common law analysis of the Ontario Court of Appeal. Therefore, it is still unclear whether pumping that does not exceed the amount established in the statute can give rise to a claim in negligence or nuisance in Ontario (CELRF, 1986). If the common law analysis of the Court of Appeal is still applicable, Ontario’s common law rules would closely resemble developments in American ground water law.

2.2.4. The limitations of common law allocation. Even if judicial decision-making develops sensitivity to the complex problems of excessive ground water withdrawals, the common law will always be ill equipped to prevent ground water resources from being over-exploited. First, common law systems are reactive by design and are incapable of initiating long-term management plans to prevent the excessive exploitation of ground water resources (Charles & VanderZwaag, 1998). Second, due to the complexity of the science and the need for expert witnesses, litigation involving ground water is a particularly expensive and time-consuming process which requires motivated and financially secure litigants to bring it forward (Charles & VanderZwaag, 1998). Third, common law allocation is based on property ownership, and other parties with legitimate interests, such as environmental and community organizations are effectively excluded from the legal process (Bowman, 1991; Eckersley, 2004). As a
result, broader social and environmental concerns over excessive ground water withdrawals are generally ignored. Fourth, many cases do not come to trial because the defendants (who often have deeper pockets) agree to a settlement with the plaintiff, and either pay to deepen the plaintiff’s well or pay financial compensation (WDNR, 1997). Last, if a case does come to trial, the advantage generally lies with the defendant because the plaintiff has the burden of proving damage, a difficult proposition in most ground water disputes.

3. Legislated rules for allocation

Table 2 provides a breakdown of legislation relating to ground water use in the basin. It is important to note the difference between registration and regulation in terms of government measures. While these two measures are frequently grouped together as evidence of state action, they are in fact fundamentally different. Registration systems merely seek to monitor the use of a resource by requiring users to report their intended use prior to pumping. Regulatory systems actually control the use of a resource by requiring some or all users to apply for and obtain permits from the relevant government department. These permits grant the users the legal right to use ground water subject to whatever conditions accompany the permit. Typically, to affirm their legal authority to implement a permit system and to clarify the superiority of regulation over common law rules, governments will declare public ownership of the resource (although this has not been done in Ontario, Percy, 1988; Nowlan, 2005). Some landowners in the U.S. have asserted that ground water regulations are an unconstitutional appropriation of property. However, these “takings” claims have been rejected whenever they have been raised (Tarlock, 1988).

Currently, only four of the ten jurisdictions (Ontario, Québec, Minnesota and Wisconsin) are allocating ground water through regulatory permit systems. The remaining six still rely on common law rules. Two jurisdictions (Illinois and Indiana) allow for ground water use to be regulated in emergency situations and Wisconsin has created specialized ground water management areas to address the depletion of their deep sandstone aquifer. Even where regulatory systems are in place, without a true commitment to the protection of water resources, these systems can prove to be as ineffective as the common law.

3.1. Ontario’s permit system: an example of ineffective ground water regulation

Until recent amendments took effect, Ontario’s permit program was a good example of an ineffective regulatory system. Under the Ontario Water Resources Act (1990) R.S.O. c.O40, any ground water user who wishes to withdraw more than 50,000 litres (13,000 gallons) per day for purposes other than domestic, livestock watering (as long as water is not taken into storage) and fire fighting, must obtain a permit. Also exempted are those who use water through works established prior to 1961. The permits are distributed according to Ontario’s Permit to Take Water Program, which was established under the OWRA. There have been numerous scathing reports highlighting deficiencies of this program including insufficient data on water use and water supply, unclear objectives and water use priorities, failure to protect the environmental uses of ground water, ignorance of the cumulative effects of pumping, lack of coordination with local municipalities and conservation authorities, limited public participation, and,
Table 2. Legislative measures in Great Lakes jurisdictions applicable to ground water withdrawals.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Legislation</th>
<th>Registration/Regulation</th>
<th>Registration trigger level litres per day (gallons per day)</th>
<th>Regulation trigger level litres per day (gallons per day)</th>
<th>Special regulated groundwater areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan</td>
<td>Michigan Code §324.32705</td>
<td>Registration</td>
<td>379,000 (100,000)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Illinois Water Use Act (1983) 525 ILCS 45</td>
<td>Registration</td>
<td>379,000 (100,000)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Ohio Revised Code §1521.16</td>
<td>Registration</td>
<td>379,000 (100,000)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Indiana Code Ann. §14-25-7 Water Resource Planning Act, Act 220 (2002)</td>
<td>Registration</td>
<td>379,000 (100,000)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Pennsylvania</td>
<td>Water Resource Planning Act, Act 220 (2002)</td>
<td>Registration</td>
<td>379,000 (100,000)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>New York Great Lakes Water Conservation and Management Act (1989)</td>
<td>Registration</td>
<td>11 million (3 million) during 30-day period</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>Groundwater Protection Act, Wisconsin Act 310 (2003)</td>
<td>Regulation</td>
<td>379,000 (100,000)</td>
<td>379,000 (100,000)</td>
<td>Ground water management areas (southeastern Wisconsin and Lower Fox Valley)</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Minn. Stat. 103G.271</td>
<td>Regulation</td>
<td>38,000 (10,000) or 3.8 million (1 million) per year</td>
<td>38,000 (10,000) or 3.8 million (1 million) per year</td>
<td>N/A</td>
</tr>
<tr>
<td>Ontario</td>
<td>Ontario Water Resources Act, Section 34 (1990)</td>
<td>Regulation</td>
<td>50,000 (13,000)</td>
<td>50,000 (13,000)</td>
<td>N/A</td>
</tr>
<tr>
<td>Québec</td>
<td>Groundwater Catchment Regulation (2002)</td>
<td>Regulation</td>
<td>75,000 (19,500)</td>
<td>75,000 (19,500)</td>
<td>N/A</td>
</tr>
</tbody>
</table>
poor enforcement due to inadequate funding (Kreutzwiser et al., 1999, 2004; Leadley & Kreutzwiser, 1999; McCulloch & Muldoon, 1999; ECO, 2000b, 2001; AMO, 2002; O’Connor, 2002). As a result of these inadequacies, permits for ground water use in Ontario have rarely been denied and have essentially been “free for the asking” (McCulloch & Muldoon, 1999). In the Credit Valley watershed, the Conservation Authority found that if all the permits for water takings in their watershed were fully utilized, there would not be adequate supplies of water to meet the demand (Vicki, 1999).

Whether these criticisms will continue to apply depends on the effectiveness of recent amendments to the permit system (Water Taking and Transfer Regulation, January 1, 2005, O.R. 387/04). These amendments are designed to clarify the objectives and priorities of the system, make the issuance of permits more ecologically sensitive and ensure that water takings are restricted in areas of already high water use. They also require notification of withdrawals to be provided to local authorities and the annual reporting of water use. On paper, these amendments appear to significantly strengthen the existing permit system. However, their success will depend largely on whether the government commits sufficient additional resources and staff to implement and enforce the program.

3.2. Quebec ground water regulation

As the only civil law jurisdiction in the basin, Quebec’s ground water laws are derived from the Quebec Civil Code, which provides for the unencumbered use of ground water under one’s property, providing there is no legislation or regulation prohibiting that use (Quebec Civil Code S.Q., 1991, c. 64.). In 2002, the Groundwater Catchment Regulation was introduced and this sets out rules which relate to the withdrawal of ground water and the use of ground water (Groundwater Catchment Regulation (2002) c. Q-2, r.1.3). The regulation provides that operations capable of withdrawing over 75 m$^3$ of ground water per day (75,000 litres or 19,500 gallons) must first obtain authorization from the Ministry of the Environment. Operations which withdraw less than 75 m$^3$ per day but which are intended for human consumption by more than 20 persons must also obtain an authorization, as must operations which intend to withdraw water from a ground water catchment area for the purpose of selling spring or mineral water.

3.3. Annex 2001: a push for regional reform?

Annex 2001 is a supplement to the Great Lakes Charter (1985), a regional agreement primarily drafted in response to the fear of bulk water exports to foreign countries and diversions to the southern United States. While the Great Lakes Charter is a good-faith non-binding agreement, the implementing agreements of Annex 2001 (signed December 13, 2005) are intended to have binding effect (although they still do not constitute binding international law). To get around the fact that only the federal governments have the constitutional competence to sign internationally binding agreements, the implementing agreements include one good-faith agreement between all the jurisdictions of the basin (the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, 2005) and an interstate compact that, once approved by the states’ and the United States’ Congresses, will bind only the states (the Great Lakes-St. Lawrence River Basin Water Resources Compact, 2005). To have legal significance in the Canadian portion of the basin, it is intended that Quebec and Ontario will incorporate
the provisions of the good-faith agreement into their own domestic provincial law. While the provisions applicable to out-of-basin diversions are relatively strong, the provisions applicable to in-basin ground water withdrawals are relatively weak. One positive aspect of the agreements is that all jurisdictions are required to establish regulatory permit systems for large-scale surface and ground water withdrawals. Therefore, the six jurisdictions which currently have no permit systems for ground water would now be required to enact legislation which would regulate large-scale ground water users. Unfortunately, this requirement will still fall short of having a significant impact on ground water withdrawals within the basin. Due to considerable pressure from agricultural and industrial lobbies (CGLI, 2005), the trigger levels for regulation are discretionary with a default threshold of 379,000 litres per day (or 100,000 gallons per day) over a 90-day period (Article 206). Three of the four jurisdictions currently regulating ground water in the basin (Ontario, Québec and Minnesota) have considerably lower permit levels (Table 2). Also, there are vague and limited directions for the design of permit programs (Article 203). This means jurisdictions will effectively have complete discretion over the formulation of allocation rules. Importantly, without including a requirement for stakeholder collaboration in permit regulation, governments will likely favour ‘command-and-control’ approaches. These approaches might look good on paper but are difficult to implement without public cooperation and allow under-enforcement due to a lack of accountability to affected communities.

4. The international legal regime

Following a number of disputes over transboundary waters (Beck, 1991), the United States and Canada signed and ratified the Boundary Waters Treaty in 1909. The Treaty is the primary statement of international law concerning the surface water resources shared by Canada and the United States. However, the Treaty does not refer to ground water. This omission is problematic because it creates uncertainty over the international law rules which would apply if there is an international dispute over ground water in the basin (Morris, 2006). Moreover, while agreements under the Treaty have given the International Joint Commission (a bi-national body created by the Treaty) power to assist the two federal governments in addressing water quality issues, including ground water quality (the Great Lakes Water Quality Agreement, 1978), there are no agreements which address ground water quantity. This is despite the fact that water quantity and quality are intimately related elements of the basin’s ecological integrity.

5. The consequences of intensive ground water pumping

The ineffectiveness of domestic, regional, and international laws to place reasonable limits on ground water pumping in the basin has contributed to significant physical effects on hydrological processes, which have given rise to economic costs, social conflicts and environmental degradation. A United States Geological Survey case study in southeastern Wisconsin is an excellent illustration of the effects of ground water pumping in the basin (USGS, 2005). The area consists of four counties bordering Lake Michigan, and contains two major urban centres, the City of Milwaukee and the City of Waukesha. These centres are separated by the subcontinental divide, which marks the edge of the basin. Any water which collects east of this surface water divide flows towards the Great Lakes and any water which
collects west flows toward the Mississippi basin. Between 1985 and 1995, the use of ground water, in the region, increased by 29% while the use of surface water decreased by almost 12% (SEWRPC, 2002). Ground water serves over 68% of municipal systems in the region, as well as all of the 244 privately owned community systems, and it is the only source available to domestic users outside the municipal service areas. The region’s agricultural sector is also extremely reliant on ground water (SEWRPC, 2002).

The effects of pumping from local ground water flow systems have been most obvious in Ozaukee County (north of Milwaukee County) where developers have favoured extraction from the dolomite aquifer, rather than the deeper sandstone aquifer. Ground water pumping in this county has lowered the water table and intercepted water which would otherwise have fed wetlands or rivers and streams which eventually flow into Lake Michigan (USGS, 2005). Overall, it is estimated that between 1964 and 2000, the cumulative effects of pumping from shallow aquifers in the four counties which border Lake Michigan (Ozaukee, Milwaukee, Racine, and Kenosha) has reduced direct ground water flow from these counties into Lake Michigan by 11.4% and reduced indirect discharge into Lake Michigan by 8.5% (USGS, 2005). In some places, the flow of ground water has actually reversed so that water is flowing from Lake Michigan into the local ground water system as recharge. Although the reduction in flow to Lake Michigan is relatively small, the study is clear evidence that ground water pumping in shallow aquifers affects local surface water bodies such as streams, lakes and wetlands, and if extensive across the basin, could potentially lower water levels in the Great Lakes.

The shallow local flow system is divided from a deeper sandstone aquifer by the Maquoketa Shale Aquitard. Large-scale cumulative pumping from this deep aquifer has had significant effects on regional ground water flow. Initially, the highest concentration of wells in this region was in the Milwaukee metropolitan area. At its natural level, the water level in this confined aquifer was measured at 186 feet above the surface of Lake Michigan. By 1980, the level had declined by 375 feet (Grannemann et al., 2000). More recently, Waukesha County has taken over as the biggest pump in the region, and since 1979 has increased its pumping by 25% (Gaumnitz et al., 2004). The vast majority of the water used in the county is extracted from the deep sandstone aquifer, and as a consequence, water levels in Waukesha County have dropped some 500 feet since pumping began (USGS, 2005). Waukesha County is intersected by the subcontinental surface water divide which marks the western edge of the basin and the City of Waukesha lies west of the subcontinental divide. As a result of large-scale pumping in the City of Waukesha, the centre of the large cone of depression which previously sat under the City of Milwaukee has moved west so that it now underlies the City of Waukesha. The regional ground water divide has shifted with the cone of depression and has moved nearly ten miles west of its pre-development position and now lies some 27 miles west of the subcontinental divide (Figure 1). Consequently, ground water which would once have flowed into Lake Michigan or the tributaries which feed Lake Michigan is being intercepted by wells lying west of the subcontinental divide (USGS, 2005). Following use, this ground water, which was previously part of the basin, is now discharged as wastewater into rivers and streams in the Mississippi basin. It is an unfortunate irony that legal rules prohibit the extraction of Lake Michigan water by Waukesha County to prevent the diversion of water from the basin, while hydrologic reality shows that extraction of ground water by wells in Waukesha is having the same effect.

The physical effects of intensive ground water pumping in the Great Lakes Basin have given rise to numerous detrimental impacts including economic costs, social conflicts and environmental degradation. Many of these impacts are taking place at a local scale, but regional scale impacts have also given rise to conflicts among states, and may even lead to international disputes.
5.1. Economic costs

Intensive ground water pumping can cause significant economic costs. The greater the drawdown, the deeper the well needed to access the ground water and the larger the pump required to abstract it. Moreover, larger pumps require more electricity to operate. Further, the depletion of an aquifer at a rate which will eventually exhaust that resource will compel municipalities to change or supplement their water supply by using a more expensive source. In the Waterloo region of Ontario, the Regional Municipality’s Long Term Water Strategy anticipates that by 2035, large scale pumping will have depleted the underlying aquifer to such a level that the construction of a 120-kilometre pipeline to either Lake Huron or Lake Erie will be required. Depending on the lake from which the water is extracted, this project will cost an estimated $432 million or $478 million (Regional Municipality of Waterloo, 2000). The need for alternative water supplies may also arise if ground water pumping disturbs naturally occurring contaminants in aquifers, such as radium or arsenic (Gaumnitz et al., 2004), or causes saltwater intrusion (Alley et al., 1999). As well, ground water pumping can induce chemicals, pesticides and heavy metals from surface water bodies into the ground water system. As a result, communities will need to install expensive water treatment processes in order to avoid serious health consequences, such as those which occurred in Walkerton, Ontario in May 2000.

5.2. Social conflicts

Ground water pumping can lead to conflicts between different users. Often, it is rural homeowners who are the first to feel the effects of ground water pumping. For example, in Saginaw, Michigan, ground water pumping of the glaciofluvial and sandstone aquifers by farmers has resulted in drawdown and...
caused shallow domestic residential wells to dry up (Hoard & Westjohn, 2001). In Monroe County, Michigan, the amount of water withdrawn by quarry dewatering has doubled since 1991 and now makes up 75% of the total ground water withdrawn in the county. It is suspected that quarry dewatering has had similar impacts on domestic wells as extraction for irrigation in Saginaw (Nicholas et al., 2001). Conflicts have also arisen between companies running water bottling operations and local communities in Ontario (Hoffman & Mitchell, 1995) and Michigan (Michigan Citizens et al. v. Nestle Waters, Mecosta County Cir. Ct. No. 01-14563-CE (2003)).

Conflicts between the agricultural and municipal sectors over the use of ground water resources have always been a problem. In fact, the “reasonable use rule” was originally invoked by courts to prevent these particular conflicts. However, this rule has generally been circumvented by legislation which permits municipalities to intrude into rural areas to install deep wells and high capacity pumps without giving rise to liability. Municipalities argue that they have little choice because of the rapid growth they are experiencing, but as demand continues to rise, more frequent conflicts between the two sectors seem inevitable (Grannemann et al., 2000).

5.3. Environmental degradation

In Mecosta County, Michigan, a high profile legal case highlighted the conflict between ground water pumping and the environment, and the enjoyment of that environment by local communities (Michigan Citizens et al. v. Nestle Waters, Mecosta County Cir. Ct. No. 01-14563-CE (2003)). In 2001, John Engler, then governor of Michigan, attracted Perrier (the bottled-water company) to Mecosta county with $10 million dollars worth of tax incentives. Now, part of Nestlé Waters North America Inc. (Nestlé), Perrier was granted access to the shallow unconfined aquifer in the Sanctuary Springs area of Mecosta County. A number of local residents were concerned that the operation’s extensive pumping would have a serious impact on the local environment. These residents formed an organization called the Michigan Citizens for Water Conservation (MCWC) and initiated a lawsuit seeking an injunction against the continuation of Nestlé’s operations.

The Honourable Lawrence C. Root decided in favour of MCWC and held that Nestlé’s pumping would have significant consequences for the local environment. At the rate of 400 gallons per minute (the pumping capacity of Nestlé’s wells), he found that the pumping would cause a 29% loss in base flow to local streams; the water levels in nearby wetlands would decrease by up to one and a half feet and lakes in the area would decline by up to six inches. As a result, the impacts flowing from these physical effects would be considerable. Regarding the streams, he noted that the reduced flow would raise temperatures and increase sedimentation, thereby narrowing channels and exposing areas which would normally be under water. This would have serious consequences for the aquatic species in the stream and impact its recreational and aesthetic values. Judge Root also accepted scientific evidence which showed pumping at less than the full capacity of Nestlé’s wells was already affecting the wetland’s hydroperiod as water levels in the wetlands were low during seasons when those levels should have been rising. The evidence showed that an overall drop in water level of a mere one to two inches would cause considerable harm to the wetlands, including the drying out of the predominant plant characteristic, sedge tussocks, and the unnatural exposure of the underlying soil and peat. This exposure would encourage invasive plant species to displace the native plant ecology and impact the rich animal life which was dependent on the wetlands. This case is currently being appealed to the Supreme Court in...
Michigan after the trial judge’s decision was overturned by the Court of Appeals. Until it reaches the Supreme Court, a legal order has restricted Nestlé’s pumping to 218 gallons per minute (MCWC, 2006).

5.4. Regional conflicts

Conflicts over ground water pumping have even occurred between states. Throughout the last century, Illinois was embroiled in a legal dispute with Wisconsin over the amount of water it was taking from Lake Michigan and diverting out of the basin into the Mississippi River via the Chicago Ship and Sanitary Canal. Wisconsin argued that the diversion could have serious impacts on lake levels, navigation, the operation of locks and ports, and hydroelectric power development. Consequently, a judicial decree was issued by the U. S. Supreme Court limiting the withdrawal of water from Lake Michigan by Illinois to 1,500 cubic feet per second (Wisconsin v. Illinois, 281 U.S. 696 (1930)). This was later increased to 3,200 cubic feet per second in 1967 to account for the growth in the Chicago metropolitan area (Wisconsin v. Illinois, 388 U.S. 426 (1967)). In addition to exploiting Lake Michigan water, Chicago has also been tapping into the Cambrian-Ordovician aquifer, the same sandstone aquifer which underlies much of Wisconsin. In 1864, when the first well was drilled into this deep confined aquifer, the water level was measured at 130 feet above the surface of Lake Michigan. By 1980, the water level had declined by 900 feet (Grannemann et al., 2000). The cone of depression produced by the massive pumping operations in the Chicago area extended 438 square miles into Wisconsin. As a result, ground water was draining from Wisconsin into Illinois at a rate of 35,200 m³ (9.3 million gallons) per day (Fetter, 1981). Fetter estimates that in 1973 this was costing Wisconsin over 1.4 million U.S. dollars per year in lost accessible water. This figure did not include additional costs for the construction of deeper wells, larger pumps and the increased electrical usage (Fetter, 1981). In 1980, the United States Supreme Court amended their 1967 decree to make it clear that in return for access to Lake Michigan water, Illinois was expected to reduce its ground water withdrawals (Wisconsin et al v. Illinois et al. (1980) 449 U.S. 48; 101 S. Ct. 557; 66 L. Ed. 2d 253). To a certain extent, Illinois has complied with the decree. By 1994, water withdrawals for public supply in Chicago had decreased and the ground water level had risen by as much as 250 feet in some parts of the metropolitan area. However, in other areas, particularly southwestern Chicago, levels continue to decline (Grannemann et al., 2000).

5.5. International disputes?

In the previous century, there were a number of international disputes which arose between Canada and the United States over shared water resources. These included the St. Mary-Milk River dispute, the Birch Lake-Lake of the Woods dispute, the Chicago Diversion dispute, and the Columbia River dispute (Beck, 1991). None of these water-related disputes were caused directly by excessive ground water pumping. However, as the demand for ground water increases, and the understanding of ground water flow in the basin improves, it may become apparent that excessive ground water extraction on one side of the border is depriving the other side of important ground water resources or causing a decline in the levels of the Great Lakes. In this situation, it is quite conceivable that a dispute over ground water,
such as the one which occurred between Illinois and Wisconsin, could occur between Canada and the United States.

6. Directions for reform

6.1. Institutional change

The first step towards better decision-making for sustainable ground water allocation in the Great Lakes Basin is for all governments to assert control over ground water resources and enable a transfer from private property rights to public ownership. This can be achieved through a comprehensive piece of legislation which explicitly acknowledges the public nature of ground water resources.

Placing control of allocation solely in the hands of a centralized bureaucracy, however, may result in little or no change to the manner in which ground water is allocated. Governments tend to be reactive, often responding to environmental problems only after they have reached a state of crisis. In addition, government efforts to allocate ground water usually rely on command-and-control approaches. As citizens are rarely involved in the formation of these measures, they generally lack understanding of their governments’ intentions and treat these approaches with suspicion (NRC, 1999; Kreutzwiser et al., 2004). In this situation, where public cooperation is limited, adequate staffing and effective enforcement mechanisms become particularly important. Unfortunately, environmental departments tend to be poorly staffed and enforcement provisions are rarely implemented. This is precisely the scenario which has undermined Ontario’s permit to take water program (McCulloch & Muldoon, 1999; ECO, 2001; Kreutzwiser et al., 2004).

An alternative approach to purely centralized government allocation is to vest planning authority in local watershed-based collaborative institutions. Comprised of the stakeholders affected by allocation decisions, these planning institutions lay the foundations on which sustainable allocation can be based. Experience with collaborative planning for ground water allocation in Canada and the United States is limited because allocation has traditionally been determined by judicial common law principles or through state or provincial permit programs. However, a growing body of literature discusses the theoretical and practical advantages of collaborative planning in the general management of natural resources (Wondolleck & Yaffee, 2000; Karkkainen, 2001; Day & Gunton, 2003), and in various aspects of watershed management other than ground water allocation (Born & Genskow, 2000; Cannon, 2000; Webler & Tuler, 2001). Useful international examples which could provide guidance for the development of these types of institutions exist in France and Australia (Burchi, 1999; Burchi & Nanni, 2001). Both of these countries utilize collaborative planning for ground water allocation. These planning processes, which are established according to watershed boundaries, share several common elements, including: access to good scientific knowledge, such as information on available supply and the role of the aquifer in the watershed; maintenance of an inventory of ground water withdrawals; performance of impact assessments to identify situations of well interference and the impacts of withdrawals on water quality, surface waters and dependent environments; assessments of future economic, social and environmental demands; and identification of policies and objectives based on consensus among stakeholders which are used to establish priorities for future use, restrictions on existing use, and tools for implementing the plan.
6.2. Legal tools for implementing ground water allocation plans

There are a number of best practices and innovations which can be considered useful tools for implementing the provisions of ground water allocation plans. These include:

6.2.1. Low permit thresholds. Depending on the size of the jurisdiction and the population reliant on ground water resources, it may be impractical to require all users to obtain permits. If this is the case, permit thresholds should be set at a level which does not exclude ground water withdrawals which interfere with other wells or result in detrimental impacts for the environment. The threshold should be no higher than in Ontario, which is 50,000 litres (13,000 gallons) per day. This threshold was intended to capture small to mid-sized farms. Minnesota’s threshold of 10,000 gallons per day is the best practice in the basin (See Table 2). In addition, the permit threshold should be based on potential pumping capacity rather than measured over a given period, as is frequently the case. This is the requirement under the Groundwater Catchment Regulation in Québec. As well, provisions which take the cumulative effects of ground water pumping into account should be made, so that permits can be required even for wells which are pumping less than the threshold.

6.2.2. Collaborative priorities which recognize ecosystem needs. The ecological integrity of the relevant watershed should be the first priority in ground water allocation. Once this has been accounted for, permits should be issued according to priorities designated in the local watershed allocation plan. Priorities should be designated in a collaborative plan (rather than through legislation) because the plans are more flexible to local needs. This is the situation in New South Wales, Australia, where collaborative water sharing plans give initial priority to the needs of the dependent ecosystem, and then prioritize for human need (Water Management Act, 2000 No. 92). The water sharing plans in New South Wales also take into consideration the potential impact of climate variability.

6.2.3. Well-spacing to prevent interference. Cumulative impacts of ground water pumping by closely spaced wells can be mitigated by attaching well-spacing requirements to the issuance of permits. Well-spacing requirements should be calculated and incorporated into permit systems to prevent well interference.

6.2.4. Buffer zones to protect sensitive ecosystems. Through the use of test wells, ground water allocation plans should identify surface water bodies which are sensitive to the effects of ground water pumping. The plans, or the government agency responsible for implementing the plans, should identify buffer zones next to designated sensitive surface water bodies, and no permits, or at least very limited permits for ground water pumping should be approved for these areas. For example, Wisconsin’s Groundwater Protection Act creates “ground water protection areas” which are areas within 1,200 feet of an outstanding water resource or any trout stream (Wisconsin Act 310, 2003). The Act requires the Department of Natural Resources to undertake an environmental review of any proposals for high capacity wells in these areas.

6.2.5. Special management for high ground water use areas. In areas where ground water use is especially high and where impacts on underlying aquifers are dramatic, it may be necessary to institute special ground water management regimes separate from the rules applicable to the rest of the state or...
province. These regimes may include a prohibition on new ground water permits and/or place restrictions on existing permits. Wisconsin is currently considering what regulatory measures to introduce for its designated groundwater management areas under the Groundwater Protection Act (Wisconsin Act 310 (2003)) and four counties in Illinois have special emergency restriction powers (Illinois Water Use Act (1983)).

6.2.6. Low water/drought planning to respond to climate variability. It is important that allocation decisions respond to conditions of drought or low water. For example, Ontario’s Low Water Response Plan (OLWRP) (MNR et al., 2003) defines three levels of low water conditions. The first level indicates a potential water supply problem and requires voluntary conservation measures. At the second level, limitations can be placed on new permit approvals and restrictions can be considered for existing permit holders. At the third level, collaborative teams comprised of stakeholders (known as Watershed Response Teams) establish priorities for water users through a consensus building process. The Ministry of the Environment can then restrict existing permit holders according to these priorities. At this level, water allocations are stringently enforced.

6.2.7. Conservation measures for demand management. Permitting programs can encourage the conservation of ground water resources by requiring applicants to demonstrate that they are using water efficiently before a permit is issued. This is a requirement which has been successfully incorporated into allocation decisions in the Southwest Florida Water Management District and has been a consideration in the issuance of some permits in Ontario (Brandes et al., 2005).

6.2.8. Permit charges for cost recovery, royalties for efficiency. Governments can recover some of the costs of permit programs by charging fees for permit applications. If the fees are assessed as a flat rate, they will likely only cover the administrative and enforcement costs of the permit programs. However, if the fees are based on volume, the government is essentially charging a royalty which may encourage agricultural and industrial users to try to limit their ground water use in order to reduce the royalty payable to the government (Renzetti & Dupont, 1999). In France, water use charges are levied according to volume, location and source, and groundwater abstractions are charged at 2 to 3.5 times higher than surface water withdrawals (Burchi, 1999).

6.3. Integration with other laws

As far as practicable, governments should ensure that allocation is coordinated with other ground water management tools including source protection, land use regulation and demand management. A more integrated, holistic approach will more effectively address the complexity of this hidden resource.

6.4. Reform at the regional/international level

To address regional and potential international impacts of ground water pumping in the Basin, the International Joint Commission (IJC) should be specifically assigned a mandate to address ground water
issues in the basin. This mandate could be exercised through a Great Lakes Watershed Board (GLWB), which would be responsible for preventing and resolving regional disputes over ground water use. Responsibilities could include: the maintenance of a basin wide inventory of ground water and a database of ground water withdrawals; designation of critical ground water areas, and formation of ground water management councils to manage these areas; monitoring ground water management efforts by basin jurisdictions; and recommendations to these jurisdictions on best practices (Morris et al., 2006).

7. Conclusion

The laws which allocate ground water in the Great Lakes Basin are outdated. They were established at a time when scientific understanding of ground water hydrology was extremely limited. Since that time, scientific understanding has substantially improved but the rules which govern the use of ground water are still rooted in the nineteenth century. In six of the ten jurisdictions of the basin, common law determines the allocation of ground water. In light of the problems arising from ground water pumping, these archaic rules are no longer tenable. Common law systems were designed to resolve disputes between property owners, but not to allocate limited resources. Water taking permit programs, as in the case of Ontario, do not guarantee the protection of ground water resources. In addition to domestic legal inadequacies, the lack of clear regional and international obligations for the responsible management of the basin’s ground water resources is detrimental to the long term economic and environmental interests of the residents of the basin.

Common law allocation and ‘command-and-control’ regulation must be replaced with laws and policies which engage communities in an ethical discourse concerning the legacy they want to leave for future generations. Governments must therefore consider alternative institutional approaches, such as collaborative planning, and a Great Lakes Watershed Board. A number of legal tools have been listed which can help protect this precious resource, but the quality and legitimacy of these legal tools will depend on the transfer of responsibilities, along with proper funding and support, to local and regional planning institutions.

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References


Statistics Canada [http://www.statcan.ca](http://www.statcan.ca)


