THE OPPORTUNITY COST OF AN ABUNDANT RESOURCE: THE CASE OF WATER DIVERTED FROM THE GREAT LAKES TO THE OGALLALA AQUIFER REGION

*James R. Gale and Thomas E. Merz**

Introduction

The increasing demand for water in the United States coupled with a declining supply of water in many sections of the arid states (those west of the 100th meridian) has led to renewed interest in additional diversion of water from the Great Lakes system. Recent political response is evidenced by a conference of governors from each of the eight Great Lakes states along with premiers representing the Canadian provinces of Ontario and Quebec [3, 4]. We believe the major theme of the conference can be accurately summarized by the following: ". . . jobs should be located where adequate supplies of fresh water exist, rather than attempting to move water to other regions." [3, p. 5]. This line of thought has become more popular among public officials as water abundant areas continue to face record levels of structural unemployment. Public officials sometimes argue that water can be an important locational factor for economic activity. However, to relate the level of economic activity in a region to the physical measure of the availability of one factor of production (water) is an over simplification. While water is a necessary input for many production processes, it can be conserved, substituted for in production processes (see Babin et al., [1]), rationed through a pricing mechanism, recycled and transported so as not to play a major role in the location of economic activity. Furthermore, available evidence does not support the contention that water has played a role in industrial locational decisions between regions. In a 1968 study, Howe [9] found no evidence that natural water abundance results in higher regional growth rates or that limitations of water constrain regional economic growth. He did find, however, that intra-regional growth patterns were influenced by water availability. In a later study, Garrison and Paulson [6] found that water availability did have a positive effect upon employment at the microlocational level.

Rather than water influencing capital flows between regions, it is more likely to be the case that water will flow between regions to meet the demands in water deficient areas. This has certainly been the case in the southwestern part of the United States.

To date no proposal has been seriously considered for diverting additional quantities of water from the Great Lakes basin. Much of the current dialogue, however, focuses on the plight of users of water drawn from the Ogallala Aquifer due to the fact that water is currently being pumped from large parts of

* Michigan Technological University

the aquifer at rates well in excess of recharge rates. This paper examines one aspect of a possible diversion of water from the Great Lakes Basin to the Ogallala Aquifer Region — the opportunity cost of the diverted water. It does not address environmental or legal questions that arise from water diversion. (On these topics see, for example, Hartman and Seastone [7], Hirshleifer, et al., [8] and Howe and Easter [10].)

The Great Lakes System

The Great Lakes water system consists of the five Great Lakes (Superior, Michigan, Huron, Erie, Ontario), the St. Lawrence River, the Welland Canal and numerous surface and groundwater sources within the drainage basin.[1] Except for the diversion of Lake Michigan at Chicago and consumptive uses, the water in the Great Lakes is used within the region and ultimately flows from Lake Ontario into the St. Lawrence River.[2]

The flow of water through the system is either regulated, as is the Lake Superior discharge into Lake Huron, or uncontrolled, as is the discharge from Lake Huron into Lake Erie through the St. Clair River, Lake St. Clair and the Detroit River. Because both the United States and Canada border the Great Lakes, international commissions have been formed to regulate various interlake flows and manmade diversions to and from the Great Lakes. The regulatory activities are designed to maintain lake levels and channel depths for shipping and other activities.

Currently, the main sources of water for the Great Lakes are basin runoff from land, precipitation on the lakes and the Long Lac and Ogoki diversions of water from Canada into Lake Superior. Water losses from the system stem from a diversion at Chicago into the Illinois River, consumptive uses, evaporation and the outflow into the St. Lawrence Seaway. Table 1 presents data on water sources and losses for the period 1950-1960.[3] Current diversions accounts for a small part of the total water flows in the system and have been factored into decisions of agencies regulating interlake water flows.

Most of the water in the system that is withdrawn by households, businesses and governments (mostly municipalities) is eventually returned by direct discharge into lakes and streams or by infiltration into the groundwater table. Consumptive use, that portion of withdrawn water not returned to the

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[1] The material in this section is taken from "Great Lakes Diversions and Consumptive Uses: Report to the International Joint Commission," by the International Great Lakes Diversions and Consumptive Uses Study Board [11].

[2] A diversion refers to the transfer of water into the Great Lakes watershed from some other watershed or vice versa. Consumptive uses of water refer to that portion of water which is withdrawn or withheld from the Great Lakes and not returned.

[3] A minor diversion from Lake Ontario to the New York Barge system is not explicitly shown in Table 1. This diversion has little net effect upon water flows and is not expected to change significantly.

Table 1. Average Annual Great Lakes Water Flows[a] (1950-1960)

Sources		Losses[b]	
Precipitation	228,000	Evaporation	178,000
Runoff	119,000	St. Lawrence Outflow	238,000
Canadian Diversion (Long Lac/Ogoki)	5,000	Chicago Diversion	3,200
		Consumptive Use	4,900

[a] Flows are in units of cubic feet per second (cfs).

[b] The Welland Canal Diversion averaged 7,000 cfs. from 1950-1960. In transferring water from Lake Erie to Lake Ontario, the canal increases the outlet capacity of Lake Erie.

Source: Report to the International Joint Commission [11].

system, includes water assimilated by plants and animals, used in products or lost from the system because of evaporation and leakage during use.

Levels of withdrawals and consumptive use of water from the Great Lakes Basin for seven sectors in 1975 are presented in Table 2. The sector with the highest consumption rate was manufacturing at 2,500 cfs. While, in total, a large amount of water is withdrawn (75,600 cfs), only 6.5 percent of it is lost from the Great Lakes system.[4]

Table 2. Great Lakes Withdrawal and Consumptive Levels[a] (1975)

Sector	Withdrawal		Consumptive	
Municipal	7,000	(9)[b]	830	(17)
Rural-Domestic[c]	560	(1)	330	(7)
Manufacturing	26,000	(34)	2,500	(51)
Mining	1,200	(2)	240	(5)
Rural-Stock[d]	210	(0)	210	(4)
Irrigation	480	(1)	350	(7)
Power Generation[e]	40,100	(53)	480	(10)
Total[f]	75,600		4,900	

[a] Levels (cfs) include United States plus Canada.

[b] Number in parentheses represents percentage of the total withdrawal or consumptive use.

[c] Rural non-communal private use mostly from groundwater sources.

[d] Water for the feeding and sanitation of livestock.

[e] Thermal-electric power generation.

[f] Rounded to the nearest hundred.

Source: Report to the International Joint Commission [11].

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[4] Consumptive uses as a percentage of withdrawals for the Great Lakes averaged seven percent in 1975. The 1975 ranking, from highest to lowest, of withdrawal and consumptive use for the Great Lakes is: 1. Erie 2. Michigan 3. Ontario 4. Huron 5. Superior.

Based on such parameters as trends in population, employment, gross national product, per capita consumption, economic growth, energy use and governmental policies, the International Great Lakes Diversions and Consumptive Uses Study Board (hereafter noted ISB [11]) developed future projections of withdrawals and consumptive uses. The most likely projection (MLP) for each of the seven water use sectors in the years 2000 and 2035 is presented in Table 3.[5] It should be noted that these projections were based upon rather optimistic expectations pertaining to the growth in manufacturing and power generation.

If the most likely projections scenario were to materialize, consumptive use of water in 2035 would be at the rate of 25,400 cfs (Table 3).[6] This figure represents 10.7 percent of the total outflow (238,000 cfs) of water from Lake Ontario into the St. Lawrence Seaway.[7] In contrast to the projected consumptive uses of water, the actual 1975 use was 4,900 cfs which represents 2.1 percent of the total outflow of the Great Lakes system into the St. Lawrence Seaway. Noting that the consumptive uses MLP is a small percentage of the total flow through the lakes system, the ISB concluded that "the possibility of general shortages in the basin is remote" [11, p. 6-54].

[5] The Study Board prepared projections for each sector in five year increments to the year 2035 with 1975 as the base year. Only the results for the selected years 2000 and 2035 are presented here. The MLP projection is the one judged by the Study Board to have the highest probability of occurring relative to other projections considered. The Study Board also developed high and low projections by varying a number of the assumptions used in calculating values.

[6] In both the United States and Canada, power generation is, and is projected to continue to be, the largest withdrawal use followed in each country by manufacturing. For the United States, the power sector is projected to have the highest compound annual growth rate of consumptive use at 5.5 percent. It is projected that power will replace manufacturing as the largest consumptive use. In 1975, the United States power sector consumed about 10 percent of the total amount of water consumed in the basin by that country. This consumption is projected to increase to 50 percent of the total amount consumed. Most of this increase is attributed to meeting standards set by the Clean Water Act. For Canada, the power sector ranked the fifth largest consumer of water in 1975 (manufacturing topped the list). Consumptive use annual growth rates of 5.6 and 2.2 percent are projected for the Canadian power and manufacturing sectors, respectively. As is the case with the United States, it is projected that by 2035 the power sector will head the list as the largest Canadian consumer of water in the Great Lakes Basin.

[7] Such an increase would reduce the mean level of the unregulated Lakes Michigan-Huron and Erie by .73 and .76 feet, respectively.

Table 3. Great Lakes Water Uses Forecasts[a] (2000, 2035)

	Withdrawal		Consumption	
Sector	**2000**	**2035**	**2000**	**2035**
Municipal	9400	13200 (1.1)[b]	1100	1600 (1.1)
Rural-Domestic	650	730 (0.4)	390	450 (0.5)
Manufacturing	38000	77000 (1.8)	4600	9500 (2.2)
Mining	2000	3600 (1.8)	340	500 (1.2)
Rural-Stock	250	360 (0.9)	250	360 (0.9)
Irrigation	800	1300 (1.8)	630	1000 (1.9)
Power	89500	291900 (3.4)	2600	12000 (5.6)
Total[c]	140500	388100 (2.8)	9900	25400 (2.8)

[a] Levels (cfs) are most likely projections for the United States and Canada.

[b] Figures in parentheses are compounded annual growth rates (percentage) from 1975 to 2035.

[c] Total may be off due to rounding.

Source: Report to the International Joint Commission [11].

The Opportunity Costs of the Consumptive Uses MLP

While the quantity of water may be abundant enough to meet the consumptive uses of MLP, the opportunity cost of rising consumptive use of Great Lakes water is clearly not zero. Increased consumptive use is similar to an increased diversion of water out of the Great Lakes. Either action results in lower lake levels. Costs associated with commercial navigation, power generation and recreational activities and the effects of erosion and flooding on shoreline property are known to be very sensitive to lake levels.

The ISB hydrologically and economically evaluated the impact of ten diversion scenarios. The results provide an indication of the economic impact of the consumptive uses MLP. In particular, the ISB noted that lowering of the mean levels of Lake Superior and Michigan-Huron by the consumptive uses MLP would produce an average annual benefit to shoreline property interests of substantially more than 6 million dollars by the year 2035. *Exceeding* these benefits however are substantial losses to hydropower facilities and commercial navigation interest. ISB estimates that a reduction in water supply due to the MLP could result in annual losses to commercial navigation of greater than $13.8 million and hydro-power facilities on the Niagara and St. Lawrence Rivers of $205 million by the year 2035.

The above points are illustrated graphically in Figure 1. Q1 represents the 1975 consumptive use rate. Q2 indicates the consumptive uses MLP. As indicated earlier, since Q2 represents a small percentage (10.7) of the mean outflow through the St. Lawrence Seaway a general water shortage in the region is not likely. (Actually, 154,000 cfs and 350,000 cfs represent the recorded minimum and maximum outflows through the St. Lawrence Seaway, respectively.) Given the difference between Q2 and Q1 it seems unlikely that available supplies will need to be rationed. Within the Great Lakes Region, water charges will probably continue to reflect pumping and distribution costs rather than a market clearing price. Such costs, however, should not be confused with the opportunity cost of increases in consumptive use or diversion. As noted above, such increases will impose costs on various uses of Great Lakes water by altering lake levels. (Curve CC in Figure 1 is drawn to reflect such costs.) Thus, while it is common to characterize the Great Lakes Region as one with an "abundant" supply of fresh water, one should be careful not to give the false impression that the opportunity cost of using the resource is zero or insignificant.

An External Demand for Great Lakes Water

The Ogallala Aquifer is a large, fresh groundwater source underlying approximately 220,000 square miles in the states of Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas. The aquifer serves a number of sectors in the region including residential, municipal, industrial and agricultural (for irrigation). Unfortunately, the geologic characteristics of the aquifer and the semiarid climate of the region limit the amount of natural recharge into the southern part of the aquifer. Since the natural recharge is insufficient to make up for withdrawals from the system, the level of the aquifer in some areas is dropping.[8]

The largest water use in the Ogallala Aquifer Region, by far, is for irrigation. This sector accounts for 90 percent of freshwater use in the High Plains area and 94 percent of irrigation water is withdrawn from the Ogallala Aquifer. It is the expanded use of irrigated water in the past and the expected growth of irrigation in the future which will severely reduce water availability from the Ogallala Aquifer.

A recent study by Banks, Keller and Feeley (hereafter noted BKF [2]) examines five water management strategies for dealing with the Ogallala Aquifer problem. Each strategy is viewed as an alternative to current water use trends (the "baseline") and is compared to this projected baseline using 1977 as the base year. Two management strategies are directed to changing the demand for water over time while three are aimed at increasing water supplies to the region. The five strategies are summarized by Williams and Banks [13]. Only strategies one and five need to be mentioned here.

The first strategy is designed to voluntarily reduce the demand for water through incentives provided from technological change and improved water and agricultural management practices at the farm level. While some improved efficiencies in water use are assumed in the baseline, Strategy 1 incorporates even greater efficiencies. Under Strategy 1, some currently irrigated farmland will be idled or used in less productive dryland farming as water sources are depleted.

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[8] The concern of federal, state and regional interests over the consequences of reduced water supplies in the region led to a study [2] of the problem conducted by a consortium of private and public agencies. This study constitutes the basis for the discussion in this section.

Strategy 5 is of concern because its implementation would represent the demand for water located outside of the region. Under Strategy 5, it is assumed that enough water would be imported to restore irrigation capacity on lands previously irrigated which were projected to exhaust water supplies during the study period under Strategy 1. In essence, Strategy 5 would prevent the loss of agricultural products from lands taken out of production as the water in the Ogallala Aquifer is depleted. In the BKF study, the primary sources of diverted water are assumed to be the Missouri, Arkansas and White River. No determination was made as to whether or not "surplus water" exists from these sources.

The annual amount of water required to maintain agriculture production in the year 2020 was estimated by BKF to be 4.1 million acre-feet. With this amount of imported water, the region could maintain 23.6 million acres in agricultural production (in 2020) which represents 24 percent more land in production than Strategy 1 where no water is imported into the region.

BKF assumed the transporting cost of the imported water would be borne by the public-at-large and suggested that if irrigators were charged at the estimated "ability-to-pay" for imported water, total returns to land management and water under Strategy 5 would be less than for the Baseline case.[9]

Let us assume that the 4.1 million acre-feet of water needed to maintain the current level of irrigated acreage in the High Plains region are obtained from the Great Lakes. Among the alternative routes which have been suggested, the Chicago diversion is considered here.[10] Under this plan, the outflow of water from Lake Michigan into the Illinois River and eventually to the Mississippi River would be increased from the current 3,200 cfs to 8,870 cfs.[11] A cascading effect would thus be created where water withdrawn from the Mississippi River and transported to the Great Plains area would be replaced by water from the Great Lakes.

A diversion of an additional 5,670 cfs from Lake Michigan will reduce lake levels throughout the Great Lakes and cause economic benefits and costs similar to those discussed previously. One approximation of these possible costs is provided in a 1981 study by the U.S. Army Corps of Engineers [12]. They examined the net costs associated with increased diversion rates from Lake Michigan of 6,600 cfs and 10,000 cfs. Taking account of the benefits

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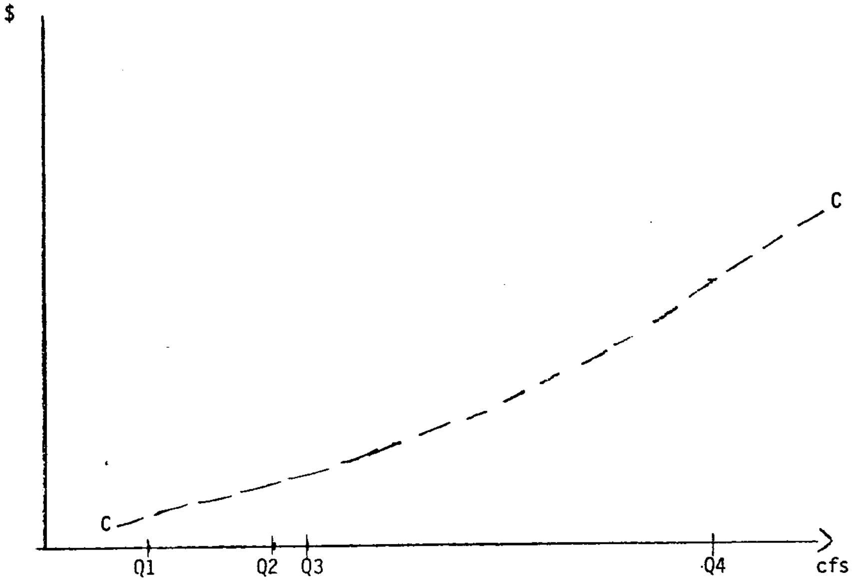
[9] The unit costs per acre-foot of water delivered to terminal storage was estimated by BFK to be in the range of $291-$569. The maximum ability-to-pay for imported water by users for much of the region is $120 per acre-foot where ability-to-pay is defined by BFK as the difference in per acre return between irrigated and dryland farming plus groundwater pumping costs.

[10] Other diversion routes which have been considered are from Lake Superior to the Missouri River and from Lake Erie to the Ohio River (see DeCooke et al., [5]).

[11] 4.1 million acre-feet per year is equivalent to 5,670 cfs.

from reduced shoreline damage, increased navigation costs and power loss evaluations, the annual estimated net costs are $22.6 million and $42.6 million for each respective rate. In the previously cited International Study Board (ISB) Report [11], the net additional annual costs of increasing the Chicago diversion from 3,200 cfs to 8,700 cfs were estimated to be $20.6 million. De Cooke, et al., [5] examine three possible locations for diverting water to the Ogallala Aquifer Region. In particular, the authors consider the cases of diverting water from Lakes Superior, Erie or increasing the diversion rate from Lake Michigan at Chicago by 6,800 cfs. Their estimate of the annual net costs for the Chicago diversion is $74 million. Clearly, all the above studies point to significant opportunity costs for various entities in the Great Lakes Region if the increased diversion of 5,670 cfs were to occur. Such a diversion is represented by Q3 in Figure 1.

FIGURE 1



Q1 = 4,900 cfs (1975 Consumptive Use Rate)

Q2 = 25,400 cfs (Consumptive Uses MLP in 2035)

Q3 = Q2 + 5,670 cfs diverted to Ogallala Aquifer Region

Q4 = 238,000 cfs (Mean outflow through St. Lawrence Seaway)

CC = Opportunity Cost (in dollars)

An important difference between Q3 and Q2 in Figure 1 is that the economic value associated with Q2 will be captured by entities within the Great Lakes. The economic benefit associated with Q3-Q2 will accrue directly to the agricultural sector in the High Plains Region. The only benefits to individuals in the Great Lakes Region will be secondary in the form of possible lower agricultural commodity prices.

Summary and Implications

If one combines the potential growth in net water usage within the Great Lakes with a possible demand for water from the High Plains Region, the opportunity costs to current users within the Great Lakes is significantly increased. Even though the mean outflow through the St. Lawrence Seaway far exceeds current and projected water uses, lower lake levels increase navigation and hydroelectric costs. These costs are large relative to the benefits associated with reduced erosion on shorelines and increased recreational activities. Thus, it appears that governmental officials representing Great Lakes interests are justified in opposing any increased diversion of water unless adequate compensation were to occur.

REFERENCES

1. Babin, Frederick G., Cleve E. Willis and P. Geoffrey Allen. "Estimation of Substitution Possibilities Between Water and Other Production Inputs," *American Journal of Agricultural Economics,* (1982), 148-151.

2. Banks, Harvey O., C. W. Keller and Frank G. Feeley. "Six-State High Plains Ogallala Aquifer Regional Resources Study: Summary," High Plains Associates, Austin, 1982.

3. Council of Upper Great Lakes Governors. "Great Lakes Water Resources Conference Preliminary Proceedings," Mackinac Island, Michigan: Michigan Department of Commerce, 1982.

4. _______. "Water: Untapped Hope for the Future," Mackinac Island, Michigan: Michigan Department of Commerce, 1982.

5. DeCooke, Benjamin G., Jonathan W. Bulkley and Steven J. Wright. "Great Lake Diversions: Preliminary Assessment of Economic Impacts," paper prepared for Canadian Water Resources Association, 36th Annual Conference, Saskatoon, Saskatchewan, June 21-23, 1983.

6. Garrison, Charles B. and Albert S. Paulson. "Entropy as the Measure of the Areal Concentration of Water-Oriented Industry," *Water Resources Research,* 9 (1973), 263-269.

7. Hartman, L. M. and Don Seastone. "Water Transfers: Economic Efficiency and Alternative Institutions," The Johns Hopkins Press, Washington, D.C., 1970.

8. Hirshleifer, Jack, James DeHaven and Jerome Milliman. "Water Supply: Economics, Technology and Policy," The University of Chicago Press, Chicago, 1960.

9. Howe, Charles. "Water Resources and Regional Economic Growth in the United States, 1950-1960," *Southern Economic Journal,* 34 (1968), 477-489.

10. _______ and K. William Easter. "Interbasin Transfers of Water: Economic Issues and Impacts,"The Johns Hopkins Press, Washington, D.C., 1971.

11. International Great Lakes Diversions and Consumptive Uses Study Board. "Great Lakes Diversions and Consumptive Uses," Report to the International Joint Commission, Ottawa, Ontario and Washington, D.C., 1981.

12. United States Department of the Army. Corp of Engineers, Chicago District. "Increased Lake Michigan Diversion at Chicago Demonstration and Study Program." Chicago, April, 1981.

13. Williams, Jean O. and Harvey O. Banks. 1982. "Groundwater Depletion and Regional Agriculture Alternative Projections," *Texas Business Review,* (1982), 276-280.