Massive water diversion schemes in North America: a solution to water scarcity?

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Abstract

Massive water diversion projects have been proposed by engineers or public officials in the United States since 1951, but so far, only regional water transfers have been built, often at great cost and questionable economic benefit. Public opinions and governments are still worried in Canada and in the Great Lakes area that these projects could somehow be carried on. However, these massive undertakings prove to be poorly profitable compared to other means of water management, and are not necessary since water withdrawals are stabilizing in the United States, and other demand management techniques are emerging.
Keywords: water supply, water diversion, aqueduct, water transfer, irrigation, water conflict, Canada, United States.

1 Massive water transfer projects were once considered

Large-scale diversions of Great Lakes and Canada's waters have been discussed for several decades. Various proposals for transferring Canadian or Great Lakes water have emerged since the 1950s, beginning with the United Western Investigation in 1951, an extensive study conducted by the Bureau of Reclamation. The proposals have often been made by engineering corporations because of the obvious possibility to profit from large construction projects. Proposals to import water were also meant to satisfy rapidly growing urban areas like Phoenix and Las Vegas. According to the U.S. Census Bureau, the top five fastest-growing cities in the U.S. from 2000 to 2002 were all in Arizona and Nevada. With this great influx of people to an area with no substantial supply of freshwater, the temptation to look at the large water reserves in northern United States and in Canada was strong.

Table 1: Main water diversions in Canada.

Transfer	River (basin) to river (basin)	Transferred volume Mm^3/yr	Transfer distance (km)	% of river flow transferred
Long Lake	Kenogami -> Long Lake -> Lake Superior	1 340	0,4	na
Ogoki	Ogoki (Albany) -> Nipigon L. (Lake Superior)	3 571	8,5	na
Saint Joseph Lake	St-Joseph (Albany) -> Root (Nelson)	2 712	7	na
James Bay Complex	Caniapiscau (Koksoak) -> La Grande R.	25 071	250	40%
James Bay Complex	Eastmain and Opinaca -> La Grande	26 333	150	90% Eastmain 87% Opinaca
Churchill Falls (Labrador)	Naskaupi -> Churchill	6 307	~20	na
Churchill Falls (Labrador)	Kanairktok -> Churchill	4 100	~25	na
Churchill (Manitoba)	Churchill -> Nelson	24 440	~40	~70%
Kemano	Nechako (Fraser) -> Kemano	3 627	~18	60%

Water is a key ingredient in the fabric of Western American society, as well studied by Donald Worster [1]. The West is not that water-scarce, for several mighty rivers flow in the region; but it definitely is semi-arid, compelling any society living there to adapt. The twentieth century American society, empowered by the industrial age, decided to harness rivers and aquifers. The Southwestern United States has been looking for new water resources to use for farmland and for municipalities. The Los Angeles Aqueduct, diverting the Owens Valley River and Owens Lake, or the All-American Canal designed to boost agricultural production in the Imperial Valley, were among the first large endeavors to transfer water to the benefit of communities, sometimes at the expense of others, like Mexico or the Owens Valley farmers. The fast growth experienced by cities as well as by agriculture in this area put heavy pressure on water management organizations, and they found a positive echo with the federal government financing large dams and canals so as to « tame » wild rivers and put water to « useful use ». The need for irrigation water has led to the overuse of limited resources in the Western United States.

Massive water diversion projects began to bloom after World War II in the United States and in Canada. There already had been water transfer schemes implemented in the United States, such as the Los Angeles Aqueduct (1913), the Colorado River Aqueduct (1937), and the All-American Canal (1940). Major transfers were also built after 1937 in Canada, but the reasons and the scope were quite different: massive transfers in Canada were designed for large volumes over short distances, for hydroelectric purposes; in the United States, diversions involved rather smaller volumes, but over far longer distances, and for irrigation and urban water use.

Table 2: Main water diversions in the United States.

Transfer	River (basin) to river (basin)	Transferred volume Mm^3/yr	Transfer distance (km)	% of river flow transferred
Colorado River Aqueduct	Colorado -> Metropolitan Water District	1 494	387	8,1
All American Canal	Colorado -> Southern California	3 827	325	20,7
Central Arizona Project	Colorado -> Arizona (Tucson)	1 852	528	20
Los Angeles Aqueduct	Owens R. -> Los Angeles	443	541	~70%
Central Valley Project	Trinity, American, San Joaquin, Sacramento -> Central California	8 638	~600	na
California State Water Project	Sacramento -> Southern California	6 200	710	na

The Bureau of Reclamation, in the economic boom that followed the end of the war, began a major study to analyze the potential for expanding irrigation through the diversion of North American rivers; after 1951, the United Western Investigation was never to become more than a topic for electoral campaigns and speeches in the West. A major impetus for diversion projects came from the 1963 Supreme Court decision to force California to surrender to Arizona excess water it was withdrawing from the Colorado, above the share it had agreed to in the 1922 Colorado Compact. If California had to give up water, the only possible way to solve a potential water crisis was to import water from far away. Northwestern States (Oregon, Washington) refused the projected Columbia diversion; Canada thus seemed the obvious reservoir for Western water.

Engineering firms started to design huge transfer projects from Canada. Let us mention a few of them:

Table 3: Water Export Projects from Canada.

Project	Year	Annual transfer volume (km^3)	Cost of construction (billion current $)
North American Water & Power Alliance (NAWAPA)	1952	310	100
Great Lakes Transfer Project	1963	142	n.a.
Magnum Plan	1965	31	n.a.
Kuiper Plan	1967	185	50
Central North American Water Project	1967	185	30 to 50
Western State Water Augmentation	1968	49	90
NAWAPA-MUSCHEC (Mexican United States Commission for Hydroelectricity)	1968	354	n.a.
North American Waters	1968	1 850	n.a.
GRAND Canal	1983	347	100

Source : Marc Reisner, *Cadillac Desert*, Viking, New York, 1993, p.489; J.C. Day and Frank Quinn, *Water Diversion and Export : Learning from the Canadian Experience*, Geography Department, University of Waterloo nº36, Waterloo (Ontario), 1992, pp.36-37.

2 They were never close to being implemented

2.1 Continental water transfer schemes are gigantic

Ralph M. Parsons Limited, an engineering firm in Pasadena, California, first introduced the North American Water and Power Alliance (NAWAPA) proposal in 1964. The NAWAPA plan proposed to divert 310 000 million m^3 per year of Canadian and Alaskan waters through Canada to the United States and to the northern states of Mexico. The Yukon, Skeena, Fraser, Peace and Columbia rivers would have been dammed, and the Rocky Mountain Trench, where are located the Canadian cities of Banff and Jasper, would have been drowned so as to form a huge reservoir. The whole the plan involved 240 dams and reservoirs, 112 water diversions and 17 aqueducts and canals. The scheme, projected to take 40 years to complete, was supposed to be privately funded and executed. The cost was projected at approximately $300 billion in 1964 dollars.

Although the plan lay dormant for over 15 years, economic problems in the 1970s (Reisner [2]) followed by the droughts in the 1980s (Linton [3]) alarmed Western US politicians, who feared severe economic depression if enough water was not available for agriculture, and led to the reintroduction of the proposal in the US in the late 1980s (de Silva [4]).

The Great Replenishment and Northern Development Canal (GRAND Canal) plan, actively promoted by the late Quebec premier, Robert Bourassa, in 1985, was proposed by Tom Kierans, a Newfoundland engineer, in 1959. The plan proposes to dam the mouth of James Bay. Sluice gates in the dike enclosure would open at low tide and close at high tide, allowing salt water to flow into Hudson Bay while retaining fresh water from local rivers in James Bay. Within a few years, James Bay would become a fresh water lake (Kierans [5]). Twenty percent of the fresh water from James Bay would be pumped down to the Great Lakes. Each second, 1 125 m^3 of water from Lake Superior would then be transferred to the dry regions of Canada and the US through a canal system crossing the Canadian Shield through the Ottawa River and the French River to the Georgian Bay of Lake Huron, and then from Lake Superior or Lake Michigan to dry regions in Western Canada and United States.

Although the proposal failed the Environmental Impact Assessment, some believe that it is still on a "long term" agenda (Holm [6]). This would be unlikely given the present budgetary constraints, for in 1994 the capital costs for the Grand Canal were estimated to be $100 billion. Operation costs are projected to be $1 billion a year, mainly because of the huge energy costs that are implied by the lifting of the water over the crest of the Canadian Shield, and the maintenance of the James Bay dyke.

2.2 Massive water transfers are costly projects

The main reason why such giant schemes never came to reality is that demand was not really present in the United States for Canadian water. Vocal militants have well underlined the potential for such a possibility, but the economics of the projects have so far worked against them and will do so for several more years. Water transported by aqueducts over long distances is costly, because it is expensive to operate these infrastructures, in terms of maintenance and energy to activate the pumps, but above all because the capital requirement is huge (Table 4).

The cost estimates of water imported from Canada or the Great Lakes to the Western United States vary from 81 ¢ to 2.43 $ per cubic meter, depending on the volume, the origin of the derivation and its length. Promoters of such projects, up to now, find it difficult to attach credible cost evaluations; this variability undermines the reliability of the investment requirements, a situation that cools the enthusiasm of governments and private firms, given the capital amount required.

Jean Coutu, an entrepreneur from Quebec, gave up a large water export project by tanker from Sept-Îles, in 1998, because he failed to set up an export business plan that would prove profitable. “ It's got to be cost-competitive with the next best alternative, which, in most cases where the water would be shipped, is desalination”, says Sandra Postel, from the World Water Project. “Those costs, while still very high compared to traditional water costs, have been coming down. Despite all of the information I've seen on the ideas for shipping water by tanker and all the phone calls I've gotten from various companies interested in doing this, I've yet to see some serious cost numbers. What does it cost to take water from some part of Canada and ship it to China or the Middle East?" (Postel [7]).

Table 4: Estimates of direct operation cost of water transported by different means, 2002.

	Production Cost ($US/m^3)	Level of technology control	Advantages	Shortcomings
Transfer Canal (500 km)	0,8 to 3	High	Capacity to deliver large volumes	- Huge investment required - Major ecological and social impacts
Plastic Bags	0,55 (Cyprus) to 1,35 (Greek Islands)	Average	Supplies isolated islands or coastal cities	- Technology to be improved - Small volumes
Water-carrying ships	1,25 to 1,5	High	Simple technology	- Small volumes - Relatively high costs
Iceberg transportation	0,5 to 0,85	Very low	Immense resource to be tapped	Technology to be perfected for a regular supply
Desalination from sea water	0,75 for 40 000 m^3/d (Abu Dhabi) 0,85 for 40 000 m^3/d (Cyprus) 0,66 for 100 000 m^3/d (Tampa Bay)	High	- Immense resource - Acceptable cost for urban markets - Fast decreasing operating costs	Large initial investment Environmental impacts of salt residue
Water recycling	0,07 to 1,80	Average to high	Increases the resource without developing new sources	- Investments and operating costs are higher if the water is very polluted - Rarely acceptable for drinking water

Source: Lasserre, Frédéric and Descroix, Luc. *Eaux et territoires: tensions, coopérations et géopolitique de l'eau.* Presses de l'Université du Québec, Québec, 2003.

3 Is diverted water really needed?

3.1 Costs are too high for the main market, agriculture.

In Florida, or in the Western part of the United States, water conflicts that emerged because of the large share (about 80%) of available water that agriculture consumes, are evolving towards water being transferred from agriculture to cities, without it being necessary to develop new resources. Water pricing; competition from other countries; cost incentives that lure American producers to Mexico, are among the factors that explain why water use in agriculture remained roughly stable between 1990 and 2000 throughout the country. If the federal government does agree, during the Doha Round of trade negotiations, to reduce agricultural subsidies, water prices for farmers could increase markedly, thus giving financial incentives to consume less, or water demand for irrigation could decrease because of several farmers getting out of business.

In Utah, water from the Central Utah Project will cost at 24,3 ¢ per m³; the farmers will be billed only 0,65 ¢ per m³ (Anderson [8]). Most water delivered to the irrigation sector in the West is billed far under its production cost, thanks to large governmental subsidies. The poor value of agricultural products, compared to industrial and urban uses, undermines the legitimacy of the present sharing of the resource, but sheds light on a possible alternative to massive water transfers. In California, the cost of urban water in the Los Angeles area lays between 24 and 32 ¢ per m³; farmers in the nearby Imperial Valley only pay 1,2 ¢/m³ for water carried through the Colorado River Aqueduct. This surprising situation may not last, since the purchasing power and the political will of large urban areas in the Western United States enable them to purchase water rights from farmers. In a context of progressive increases in irrigation water costs, more and more farmers are tempted to transfer their rights while making huge profit rates that they cannot dream of in agriculture (Hayes [9]).

Hydrologists estimate that water supply issues in New Mexico would be solved – with enough margin to absorb a doubling of the population – if only 10% of water used by farms was transferred to cities (Linthicum [10]). In California, if the Imperial Irrigation District (IID) managed to save between 6,3 et 9,5% of its total use for 2002, the saved volumes would satisfy needs of Los Angeles and San Diego (Hayes [11]). In 2003, 33.2% of irrigated surfaces in the IID were growing alfalfa, 24.9% hay, and 11% wheat, low-value crops (IID [12]). The agricultural sector in the West is increasingly feeling the effects of tough competition. Despite transportation costs and a 376% tariff, Chinese garlic is cheaper. The price of several crops is decreasing, because of the competition from developing countries. In 2001, sales of cotton, prunes and pistachios dropped by 33%; sales of broccoli and plums were down by 24%; of tomatoes and lettuce by 22%: « California farmers may soon find that there is more money in selling their water rights than in using them to raise crops » (*The Economist* [13]), a trend observed throughout the West (Linthicum [14]).

Besides, the Secretary of State, Bruce Babbitt, decided in 1999 to force California to respect the 1963 Supreme Court verdict, compelling the State to reduce its withdrawals from the Colorado River from 6,4 billion m³ to 5,4. Given the low use of Arizona farmers of their share of the river, California would be interested in buying back part of this billion m³ for its urban sector (Anderson [15]).

The adaptation of American agriculture to finite water volumes is quite possible, as testified by the evolution of the sector in the Midwest

(Soussan [16]). The Ogallala aquifer, despite alarmist forecasts, is still not exhausted – although it is still overpumped. Between 1974 and 1990, underground water pumping was reduced by 43% because of the shrinking of irrigated surfaces and the introduction of more efficient watering systems. Farmers used 16% less water per hectare between 1979 and 1989 than between 1964 and 1974. Annual overdraft was reduced from 2 billion m^3 in 1969 to 241 million m^3 in 1991: poorly profitable producers went out of business; the others adapted and implemented more effective irrigation systems (Mayrand [17]).

The 1999 decision to compel California to respect the Supreme Court decision was enforced in January 2004: California found itself forced to make do with a billion m^3 less. However, no panic occurred, nor did massive diversion projects from Canada or the Great Lakes become reactivated. The California government decided to accelerate its transfer programs from the irrigation sector to the industrial and urban sectors, develop its incentives towards recycling and water savings, and build more desalting plants (*The Economist* [18]). Cities can thus take advantage of the fast decreasing costs of desalting techniques, inverse osmosis in particular. In Florida, in March 2003, the new Tampa Bay plant was inaugurated : it is able to produce 95 M liters per day, about 10% of the city use, for 65,5 ¢ per m^3, distribution included (as against a cost of 1,62 $ in 1990). In 2007, a new major desalting plant should be put into operation in San Diego, with a capacity of 190 millions liters per jour, for a cost of 270 M$ (Jehl [19]). The water it will produce will cost 72,6 ¢ per m^3. In 1993, San Diego had refused desalting as too expensive at the time. Water demand is expected to grow by 33% to 2020, according to the San Diego Water Authority; but the Authority also forecasts a reduced dependence on imported water from the Colorado, thanks to the development of desalting (with its share going from 0 in 2003 to 14% of distributed water), water savings (10%), recycling (from 1 to 6%) and the transfer of water from farmers (from 0 to 22%) (Jehl [20]).

3.2 A stabilizing demand in the United States

As a whole, water withdrawals in the US increase more slowly now than population, and could even begin a downward trend should competition from foreign fruits and vegetables producers increase against local farmers.

Besides, although there still is room for improvement, water use per person is showing signs of stabilization, probably thanks to the dual tariff and education policies. Urban consumers begin to value water conservation. Californian cities are also benefiting from this general trend towards stabilizing or diminishing per capita urban demand. Since 1990, global water demand in southern California, very urbanized, shrank by 16%, whereas the population increased by 15%. In Seattle, total water demand has remained the same since 1975, despite a population increase of 30%. In Boston, the demand has fallen by 30% since 1989 (Gleick [21]). Recycling, conservation, transfer from farmers, occasional regional water derivation are the solutions considered when planning long-term water resources; no mention is presently made of long-distance water derivation, whether from Canada or the Great Lakes (Soussan [22]).

Table 5: Evolution of water use in the United States, 1970-2000.

	1970	1975	1980	1985	1990	1995	2000
Population, in million	205.9	216.4	229.6	242.4	252.3	267.1	285.3
Variation, %	6.2	5.1	6.1	5.6	4.1	5.9	7
Withdrawals, billion m^3/d	1.4	1.6	1.67	1.52	1.55	1.53	1.55
Variation, %	19.4	13.5	4.8	-9.3	2.3	-1.5	1.5
Of which :							
Thermoelectric	0.65	0.76	0.80	0.71	0.74	0.72	0.74
Industrial	0.18	0.17	0.17	0.12	0.11	0.11	0.08
Irrigation	0.49	0.53	0.57	0.52	0.52	0.51	0.52
Public supply	0.1	0.11	0.13	0.139	0.146	0.15	0.165

Source : adapted from USGS, *Water Use in the United States*, 1998, 2004

Although water is still used at an unsustainable rate in part of the Western United States, importing water from Canada or the Great Lakes is not as urgent as it appeared to be to some politicians a few years ago, nor does it appear to be an economically interesting option.

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