Freshwater

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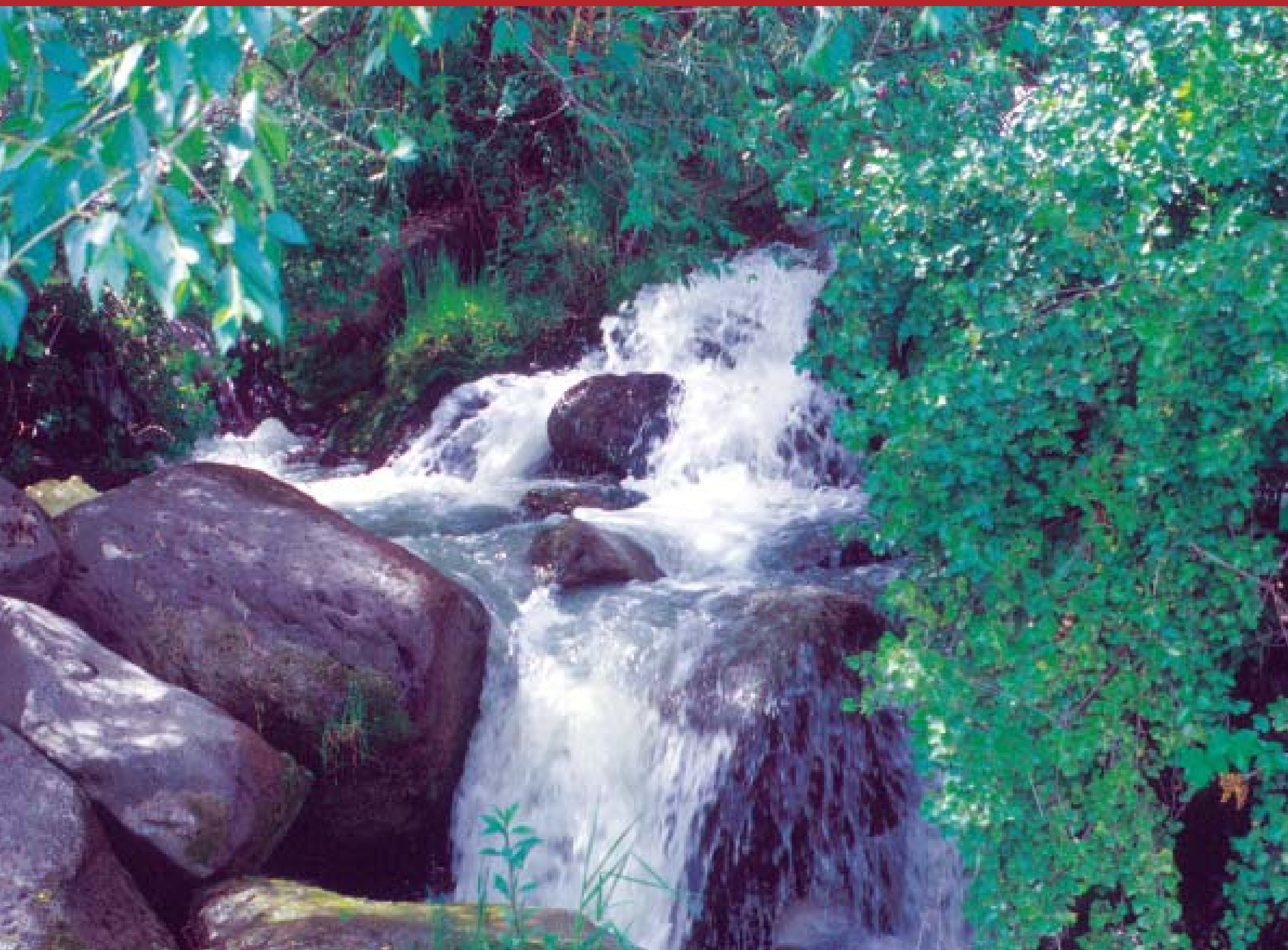


Freshwater

North America has abundant water resources and holds about 13 percent of the world's renewable freshwater (excluding glaciers and ice caps). Canada has about 10 times the per capita water resources and about half a million km^3 more water in total than the United States. Freshwater is not evenly distributed, of course: for example, the Great Lakes, the world's largest system of fresh, surface water lies in the east, 60 percent of Canada's water flows north, and water supplies in the United States are far more abundant in the eastern states than those in the west, particularly the dry southwest (EC 1998a; De Villiers 2000; CEC 2002). Some regions, such as California, suffer from acute water deficits, and the frequency of extreme events like droughts and floods is expected to increase in areas such as the Great Plains.

Extensive water control projects, including dams and canals, have been built to compensate for water deficiencies, generate hydroelectric power, control floods, and improve navigation. Today, water in less than half of the region's rivers still flows in a course unaltered by humans, resulting in changed hydrologic flows, landscapes, and wildlife habitat. Canada has more water diversions than any other country, particularly in the province of Quebec (CEC 2002). As in other parts of the world, environmental and aboriginal groups have opposed large dams because of their ecological and social impacts (see Box 25).

With an abundant supply of fresh water, a growing population, extensive irrigated agriculture, and growing municipal and industrial demands, North Americans use more water per person per year than any other people (De Villiers 2000). At the end of the 1990s, they used 1,693 cubic meters of water per capita per year (Gleick 1998). In the United States, recent conservation measures have led to declines in both per capita and total water consumption (De Villiers 2000). Between 1980 and 1995, total water withdrawals declined by nearly 10 percent while the population increased by 16 percent (Solley, Pierce, and Perlman

1998). In Canada, on the other hand, water withdrawal rose by 50 percent between 1972 and 1991 while the population grew by only 5 percent (EC 2001a). Water pricing in Canada does not reflect the costs of water provision, with the result that water is overused, industrial water recirculation rates have been low, and until recently, there has been little reinvestment in municipal water systems (EC 1998a). There is also an overall paucity of data and knowledge about water in Canada, which hampers reporting efforts.

Agriculture accounts for the largest proportion of total water consumed in North America. The United States has over 75 percent of the continent's irrigated cropland, which consumes its largest amount of water by far. In Canada, by contrast, agriculture is the fourth largest user of water. As discussed below, one of North America's priority concerns is the quantity and quality of the region's groundwater resources, which provide most irrigation supplies and drinking water to rural communities (CEC 2002).

Box 25: James Bay Hydroelectric Development

The province of Quebec nationalized hydroelectric development in the 1960s and began to harness the power of the northern rivers of the James Bay territory in the 1970s to provide the province with clean energy, jobs, and economic growth. The first phase of the project on La Grande River, about 1,000 km north of Montreal, diverted five rivers and created a reservoir of 4,275 km^2. The second phase diverted another five rivers. Together, these projects vastly changed the watersheds of 10,000 km^2 of territory that was home to some 10,000 First Nations Cree. Having failed to stop the project through the courts, the Cree signed a historic comprehensive land claim agreement in 1975 that was meant to compensate them for the loss of traditional lands and livelihoods.

The next phase, the damming of the Great Whale River north of the La Grande complex, announced in 1989, would divert two more rivers and flood 3,400 km^2 for four reservoirs. In 1985, La Grande was producing large electricity surpluses, some of which were sold to the eastern United States. Environmental groups in the northeastern United States and the Cree in Quebec mounted a strong campaign against the Great Whale Project. Part of their campaign focused on the advantages of energy efficiency over new hydroelectric development. They initiated and won a court case that provoked a comprehensive environmental and social assessment of the project's impacts. The project was eventually delayed indefinitely in September 1991 in reaction to new energy efficiency practices in New York state, a drop in its projected energy demand, and the cancellation of its energy import contract with Hydro-Quebec, combined with the need for a full and lengthy impact assessment (Barr 1992).

In a recent and much more modest development project, the Quebec government entered into partnership with the Cree in February 2002 to allow hydro installations along the Eastmain and Rupert rivers, subject to environmental approval, closing a deal deemed favorable by the majority of the Cree community. It includes financial compensation, increased control of their own community and economy, more power over logging, and more hydro-related employment opportunities (Canadian Press 2002).

Gross-point source water pollution has been successfully reduced in North America since the 1970s thanks to effective anti-pollution laws and regulations and clean-up programs. The US Clean Water Act of 1970 and subsequent amendments were instrumental in declines in industrial wastewater emissions and untreated sewage dumping. Non-point sources, however, such as agricultural runoff and urban storm drainage have increased, causing serious pollution problems. By the end of the 1990s, an overwhelming majority of US citizens—some 218 million—lived within 16 km of a polluted lake, river, stream, or coastal area (EPA 2000a).

Thirty years ago, one of the gravest issues facing North America's freshwater resources was the precarious state of the Great Lakes Basin, which contains the world's largest freshwater system and North America's biggest urban-industrial complex. The story of how the region tackled its complex and serious water problems is a striking example of cooperation among nations and local users.

Box 26: Some Health Risks From Groundwater Pollution

Groundwater contains naturally occurring chemicals that sometimes exceed drinking water standards or render it unfit for consumption. It may be that as much as half the groundwater within 496 m of the surface is too saline for use as drinking water (Moody 1996). Human activities are further reducing the quality of groundwater resources through the large and growing number of toxic compounds used in industry and agriculture. Once it was thought the soil acted as an effective filter, preventing all contaminants from reaching the water table, but there is now evidence that pesticides and other contaminants reach groundwater resources that can slowly spread the contaminants over large areas. Polluted groundwater is extremely expensive and difficult, if not impossible, to clean up. In many cases contamination may only be recognized after users have been exposed to potential health risks (Waldron 1992; Moody 1996; EPA 1998; EC 1999a).

About 20 to 40 percent of all rural well water in Canada may be affected by contaminants, mostly in the form of coliform bacteria from livestock and septic systems and nitrates from fertilizer (EC 1996). The incidence of bacteria in well water in Ontario has almost doubled in the past 45 years (Fairchild, Barry, and others 2000).

A number of recent reports of localized well contamination have alerted the public to the health risks associated with polluted groundwater (EC 1999a). In May 2000, for example, seven Canadians in Walkerton, Ontario, died and more than 2,000 became sick from *E.coli* contamination in the town's water supply. The source of contamination was livestock manure that had been spread, according to proper practices, on a farm near the town. Provincial budget reductions had led to shortcomings in the approvals and inspections programs of the Ontario Ministry of the Environment and years of improper practices at the public water utility. The tragedy alerted the Canadian provinces to the need to correct serious drinking water problems related to animal waste encroachment into groundwater supplies and, in the case of Ontario, to the roles played by budget cuts, staff reductions, and greater reliance on municipalities for regulating environmental services (Gallon 2000; O'Connor 2002).

Groundwater

Most of the continent's (unfrozen) freshwater resources lie in groundwater, which fills the spaces below the soil surface. It is stored in, and moves through, water-saturated zones called aquifers. In response to dwindling supplies of unpolluted surface water in the decades leading up to the 1970s, municipalities in the United States turned to groundwater. Similarly, between the 1960s and 1980s, the proportion of Canadians drinking groundwater more than doubled (OECD 1995b). By the mid 1990s, about 51 percent of all drinking water for the total US population and 99 percent of drinking water for the rural population came from groundwater, while in Canada, groundwater supplied 30 percent of the population, or about 8 million people, and 90 percent of rural dwellers (EPA 1998; Statistics Canada 2000). In the mid-1990s, a total of 23.4 percent of all US freshwater withdrawals for all uses came from groundwater, while in Canada, groundwater supplied only 2.3 percent of total water withdrawals (OECD 1995a).

Groundwater is critical not only as a direct supply of water for human uses, but also as a crucial part of the hydrological cycle, and its gradual discharge to rivers helps to maintain stream flow in dry periods. It is important to wildlife and their habitats as well, which are also affected by contamination and depletion (GF 1996).

The large and growing number of hazardous compounds used in industry and agriculture are threatening groundwater quality. It is now known that contaminants from non-point sources are present in many shallow wells throughout large regions of North America (Moody 1996) and present risks to human health (see Box 26). Table 3 shows the presence of selected chemicals in US groundwater.

Agriculture is the dominant factor in groundwater quality impairment (EC 1996), primarily through the

Table 3: Groundwater Contamination in the United States, Selected Chemicals, 1990s

	Share of Groundwater Percent		
Chemical Group	Containing at least one chemical in group	Containing two or more chemicals in group	Above drinking water guidelines for a single chemical
Nitrates	71	Not applicable[1]	15
Pesticides	50	25	Not significant
Volatile Organic Compounds[2]	47[3]	29	6

[1] However, nitrates are typically found in aquifers where pesticides are detected.
[2] A small share of these VOCs are used as pesticides.
[3] Samples from urban areas only.

Source: Sampat 2000b, 26

widespread use of commercial fertilizer, the main non-point source of nitrogen and phosphorous contamination. Artificial fertilizer use rose from 13.6 to 20.4 million tons a year over the past 30 years (IIFA 2001), peaking in 1981 in the United States then rising again after 1995. This increase reflects the rise in maize acreage, which uses 40 to 45 percent of all fertilizers (CEQ 1997) (see Figure 27). The nitrogen content of commercial fertilizer applied on farmland also increased, growing in Canada by 451 percent between 1970 and 1995 (Statistics Canada 2000). Some consider nitrates to be the most widespread groundwater contaminant (EPA 1998). Consumed in high concentrations, this chemical can cause infant methemoglobinemia, or blue-baby syndrome (Sampat 2000a).

In the mid 1970s, elevated nitrate levels resulting from fertilizer infiltration in rural groundwater supplies began to be detected (Gurganus and Engel 1989). Excessive nitrogen—that not taken up by crops—can leach into groundwater. This is increasingly the case in regions with concentrated industrial hog and other livestock operations using manure as a fertilizer (see Box 23 in the coastal and marine section). For example, between 1971 and 1991, the risk of nitrate contamination of aquifer waters in British Columbia is estimated to have doubled due to the concentration of animal production and some shifts to land uses with low nitrogen needs (MacLeod, Sanderson, and Campbell 2000).

Total Fertilizer Consumption, 1972-1999

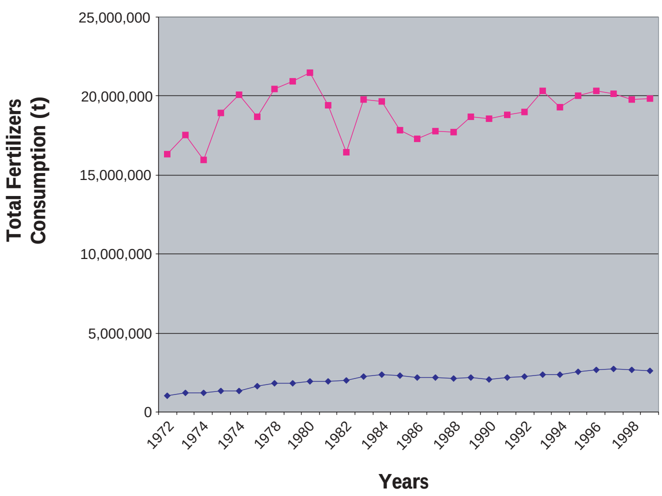


Figure 27
Total fertilizer consumption, 1972-1999.

Source: FAO 1990-1998

Although nitrogen contamination rarely exceeds levels of potential health risk, some groundwater wells in Canada's Atlantic provinces, where about 90 percent of the rural population relies on groundwater, have elevated nitrate concentration (Statistics Canada 2000). And in Ontario alone, a study found that 37 percent of 1,300 farm wells surveyed contained bacteria or nitrate levels exceeding provincial water quality objectives (AAFC 1997). Nitrate-nitrogen concentrations greater than the Canadian drinking water quality guideline of 10 mg per litre occurred in anywhere from 1.5 percent to over 60 percent of the wells visited in a recent regional survey, and levels are continuing to rise (AAFC 1997; EC 2001b).

In the United States in the mid-1990s, nitrates polluted groundwater to some extent in 49 states, although nitrate contamination at levels of potential health risk affects fewer than 2 percent of wells (OECD 1996). Concentrations of nitrate that exceed the US EPA drinking water standard of 10 mg per liter (as nitrogen) were found in 15 percent of samples collected in shallow groundwater beneath agricultural and urban land, which may be of concern in those rural areas that rely on shallow aquifers for drinking water (USGS 1999). Concentrations that exceed the recommended level are found mostly in aquifers that are subject to high nitrogen inputs and are most vulnerable to leaching (Revenga, Brunner, and others 2000). The US Department of Agriculture and most Canadian provinces have initiated strategies to help farmers develop nutrient management plans (EPA 1998; EC 2001c).

Pesticides also enter groundwater, and several incidents of contamination from field applications of pesticides were confirmed in the 1980s in the United States (Gurganus and Engel 1989). In the 1993–95 and the 1999 National Water Quality Assessments (NWQA), about half of the wells sampled contained one or more pesticides, with the highest detection frequencies in shallow groundwater beneath agricultural and urban areas. The overall frequency of pesticide detection in these studies is considerably higher than those reported by previous large-scale studies of pesticide occurrence in groundwater across the United States. Herbicides account for about 70 percent of total US use of pesticides. Water-quality standards and guidelines have been established for only about one-half of the pesticides measured in the study's water samples. Although concentrations of individual pesticides rarely exceed the current drinking water standards, some scientists suggest that the overall health and environmental risks of their combined effects are not adequately assessed (Kolpin, Barbash, and Gilliom 1998; USGS 1999).

In Canada, pesticide concentrations in groundwater are also mostly well below guidelines for drinking water. New application restrictions

for atrazine, the herbicide most often detected in groundwater, are expected to help reduce the concentrations found in the past due to long-term monoculture production in Ontario and Quebec (AAFC 2000).

Underground storage tanks (UST) containing, for example, petroleum products, acids, chemicals, and industrial solvents, and other types of waste, are leading sources of groundwater contamination by known or suspected carcinogens (Sampat 2000b). The tanks are often inappropriate containers for these substances or have been improperly installed. Prior to 1980, they were made of steel and many were not adequately protected against corrosion. Up to half of them leak by the time they are over 15 years old (EC1999a). In 1996, about 20 percent of US steel tanks were over 16 years old and some 25 to 30 percent were leaking petro-

Sectoral Share of Groundwater Withdrawals, 1987

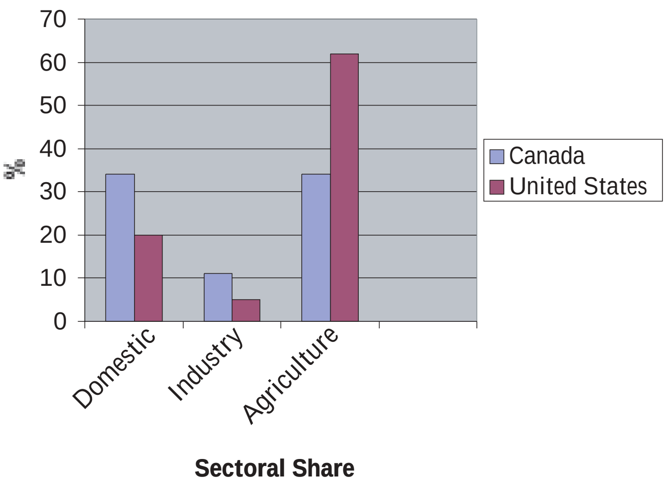


Figure 28
Sectoral share of groundwater withdrawals, 1987.

Source: UNEP, World Bank and WRI 2000, updated by White 2001.

leum products (Moody 1996). In 1998, over 100,000 petroleum USTs in the United States were found to be leaking. Environment Canada estimates that more than 20 percent of the 10,000 tank systems (underground and above ground) at federally owned or leased facilities in Ontario are currently leaking (EC n.d.). Tanks are leading sources of benzene, toluene, and xylene contaminants. Many contaminants are known or suspected carcinogens (Sampat 2000b). When MTBE, a chemical added to gasoline to reduce carbon monoxide pollution, leaks from storage tanks, it causes widespread groundwater pollution and is shown in animal studies to cause cancer (Tenenbaum 2000). As of 1998, State Underground Tank Remediation Funds have helped to clean up many US sites (EPA 1998).

Septic tank systems, the largest source by volume of waste discharged to the land, contain many organic contaminants and are suspected to be one of the key sources of rural well contamination by nutrients and microbes. Septic systems have a normal 10-to-15 year design life, and many of those built during the 1970s may be failing and causing groundwater contamination. Between one-third and one-half of US septic systems may have been operating inadequately in 1996 due to their age and other design and management shortcomings (Moody 1996). Another high-priority source of groundwater contamination is landfills that operated prior to the establishment of legislation requiring them to adhere to strict standards (EPA 1998).

The long-term availability of groundwater in arid agricultural regions is another key concern. In general, use of stored groundwater declined since the 1980s, but still accounted for about 10 percent of all freshwater withdrawal in the United States in the mid-1990s (OECD 1996). Agriculture is the largest user of groundwater resources, supplying 62 percent of US irrigated farmland in 1985 (OECD 1996; Sampat 2000b) (see Figure

28). Groundwater withdrawals in 1995 were generally highest in the western states to supply a growing population and to sustain agricultural production (EPA 1998). The Ogallala Aquifer under the High Plains is being depleted, with withdrawals exceeding the rate of renewal despite recent conservation measures (see Box 27).

Widespread recognition of the need to protect groundwater has

Box 27: The Ogallala Aquifer

The Ogallala Aquifer, which contains about the same amount of water as Lake Erie, underlies about 580,000 square kilometers of the Great Plains in eight states, most of which are the portion called the High Plains (see Figure 29). Although semi-arid and subject to frequent droughts, the Ogallala states make up one of the world's major agricultural regions, producing almost half of US beef and a significant proportion of its grain exports (Dugan and Sharpe 1996; De Villiers 2000). Nearly 30 percent of all the groundwater used for irrigation in the nation comes from the aquifer, and in 1990, about 95 percent of the water withdrawn from it was devoted to agriculture (McGuire, Stanton, and Fischer 1999).

The Ogalla Aquifer

Figure 29 *Source: HPDW 2002*

The number of irrigated areas expanded after 1940 and extensive groundwater irrigation development resulted in large water-level declines in many areas of the High Plains region (Blazs 2000). A trend of rapid aquifer decline rates of as much as 1.5 m a year in places slowed after the mid-1970s (Abramovitz 1996). Between 1980 and 1997, the decline was half the rate it had been between 1950 and 1980 (McGuire, Stanton, and Fischer 2000). A number of factors contributed to the declines: low well yields; improved water conservation irrigation equipment and management practices; conversion to crops requiring less irrigation; local regulation of groundwater withdrawals for irrigation; the geographic shift in irrigation away from areas of large potential rates of aquifer depletion; the withdrawal of some marginal lands from irrigated agriculture; rising energy costs; low farm prices; and above-normal precipitation (Dugan and Sharpe 1996; HPWD 1997/98). These are encouraging signs even though depletion continues (Abramovitz 1996).

Box 28: Water Use in the Las Vegas Valley

Las Vegas, Nevada's population began to grow with the opening of hotels and casinos during the boom in the gaming industry in the 1940s. Growth continued, fueled by tourism and migration toward the Sun Belt. By the 1980s and '90s, Las Vegas had become a major convention center. Over the past 20 years, the population in the Las Vegas Valley has increased dramatically (see Figure 30). Today, Las Vegas is the fastest-growing metropolitan area in the United States; its population is predicted to double by 2015.

The temperature in the Las Vegas Valley typically rises to 32.2 °C or more on over 125 days of the year and less than 1000 mm of rain fall annually to the valley floor. As the city grew (see figure 30a), so demand for water for residential, hotel, recreation, and industrial uses increased, and groundwater was withdrawn faster than it recharged, causing the land to subside in places. Water has been imported from the Colorado River, and during the last decade, the main aquifer has been artificially recharged with water from nearby Lake Mead. Although water levels have risen as a result, growing demand for water and limits on imports have led to withdrawals often exceeding recharge by factors of two to three.

Las Vegas Population Growth, 1982-99

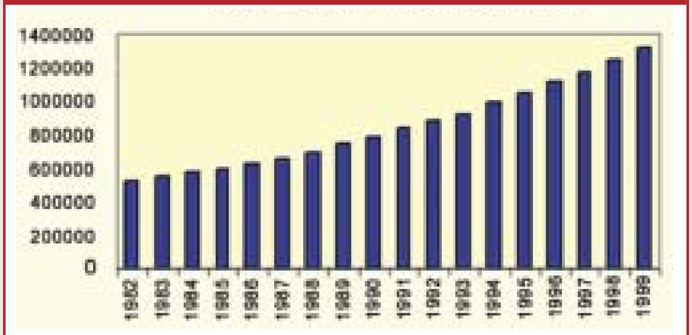


Figure 30 *Source: LVWCC n.d.*

With some 6,000 newcomers a month relocating to the valley, huge hotels that feature water-related attractions, over 50 irrigated golf courses in the area, and watering of inappropriate landscaping features, Las Vegas water uses are straining supplies. The Southern Nevada Water Authority (SNWA) is implementing strategies to expand the future supply of water to southern Nevada and the Las Vegas Valley. Since 1989, water conservation awareness campaigns have helped to reduce per capita water consumption by 12 percent (Acevado, Gaydos, and others 1997; Bennet 1998, Pavelko, Wood, and Laczniak 1999).

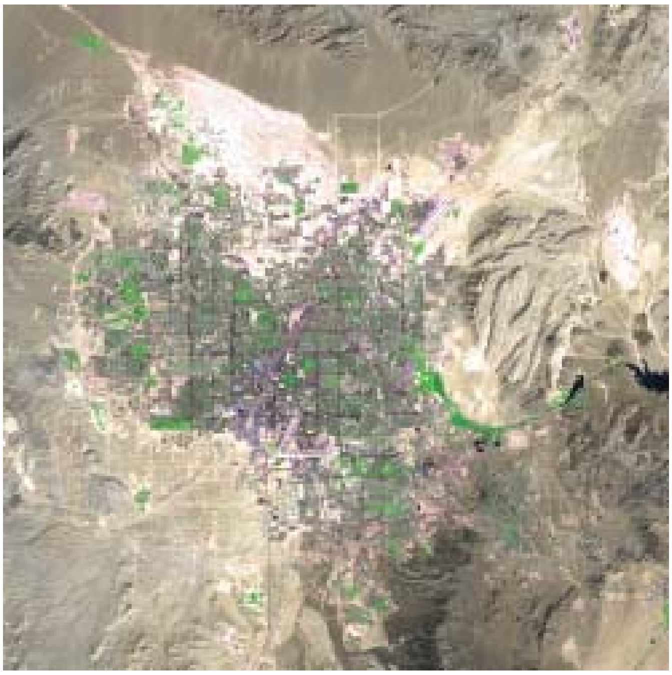
only recently arisen. Given the greater reliance on this resource in the United States, that country has taken a more active role in protecting it than the Canadian government (TFGRR 1993). The individual states and provinces have the primary responsibility for groundwater and groundwater jurisdiction in North America is divided and often fragmented among federal, state/provincial, and local governments (Cosgrove and Rijsberman 2000). Although there are some 20 EPA programs addressing groundwater, there is no single comprehensive, coherent federal legislation covering this resource. During the late 1980s and early 1990s, all US States enacted groundwater legislation

(TFGRR 1993; Gobert 1997). As shown in the Ogallala example in Box 27, an increase in dry farming practices and improved and more efficient irrigation techniques contributed to declines in groundwater withdrawals in the United States between 1980 and 1995 (EPA 1998).

Canada's 1987 Federal Water Policy, currently under revision, calls for the sustainable use of freshwater and recently, the Canadian federal government initiated new national legislation on the environment, trade, and groundwater issues (EC 1998a; EC 1999a). The US Geological Survey and the Canadian Geological Survey also undertook the task of examaning and reporting on issues affecting groundwater (DOI and USGS 1998; EC 1998a). Rights to groundwater are more complex than those for surface water because it is a transboundary resource and is used by a common pool of users (Rogers 1996). Recent dramatic population growth in the dry US interior (see Box 28), for example, has increased city-farm competition for groundwater as demands by an affluent and growing population increase (Rogers 1996, CEC 2000). At the international level, boundary water agreements lack specific guidelines regarding transboundary aquifers, complicating jurisdiction of shared groundwater resources.

Traditionally, groundwater management has focused on surface and groundwater separately (USGS 1999). Yet interactions between them have direct effects on regional water quality and availability, as well as on the health of wetlands, riparian ecology, and aquatic ecosystems in general (Cosgrove and Rijsberman 2000).

1972



2000

Figure 30a
These satellite images show the population growth that occurred in Las Vegas, Nevada USA from 1972 to 2000.

Source: NASA, Landsat

To evaluate the quantity and quality of water resources, coordination between surface and groundwater programs is essential (EPA 1998). To address this need, and to better detect the sources of non-point pollution, the US EPA introduced a river basin approach through its Index of Watershed Indicators (IWI), using 18 indicators of the health of the nation's water resources in 2,111 watersheds. The IWI shows that 15 percent of watersheds have relatively good water quality; 36 percent have moderate problems; 22 percent of the watersheds have more serious water quality problems; and 27 percent do not have enough information to be characterized. One in 15 watersheds are also highly vulnerable to further degradation (IWI 1999). Canada, too, adopted an ecosystem approach for watershed management and together with other levels of government and stakeholders is developing basin-wide action plans to restore numerous polluted aquatic ecosystems (EC 1998a).

Great Lakes Water Quality

The Great Lakes Basin is one of the Earth's largest freshwater systems, containing 18 percent of the world's fresh surface water (see Box 29). Less than 1.0 percent of the water is renewed annually by precipitation, surface water runoff, and groundwater inflow (EC 2000a).

As the region's economy shifted from a rural-agrarian one to North America's largest urban-industrial complex, the lakes became subject to a polluting mix of effluents resulting from inadequate sewage treatment and fertilizer and wastewater effluent. By the early 1970s, beaches were smothered with algae and the water was unfit for drinking unless extensively purified. Lake Erie suffered from excess phosphorus, algal blooms, and serious declines in some fish populations. Aboriginal communities, which relied heavily on the lakes' resources for their subsistence, were most affected. Newspaper headlines in 1970 declared that 'Lake Erie is Dead' (EC n.d.; EC 1999b).

Box 29: The Great Lakes

The Great Lakes lie within eight US states and the Canadian province of Ontario and span over 1,200 km from east to west, covering an area of 750,000 km^2 (EC 2000a). They form a transportation route from the Atlantic Ocean to the middle of the continent and part of the boundary between Canada and the United States. Half of the trade between the two countries crosses the region and they share the lakes' bountiful resources and services, which include diverse and abundant fish; water for shipping, municipal, industrial, and agricultural uses; hydroelectric power supplies; recreational playgrounds; and water for 27 percent of Canadians and 11 percent of US citizens. The region's waters also play a major role in North America's ecology and climate and the Basin supports extensive forests, huge mineral reserves, fertile agricultural areas, and an abundant and diverse wildlife (EC n.d; EC 1999b; EC 2000a).

Other clues pointed to more insidious problems. In the early 1970s, eggshells of the Double-crested Cormorant, a bird that is high on the aquatic food chain and subject to the effects of bioaccumulation, were some 30 percent thinner than normal (EC 1999b). Some species of bird populations crashed.

In 1970, the International Joint Commission (IJC), an independent organization of Canadian and US representatives that has existed since 1909 (see Box 30) released a report on the pollution problem in the lower Great Lakes.

The IJC report led to the 1972 signing of the Great Lakes Water Quality Agreement (GLWQA) (see Box 31) and the beginning of concerted efforts on the part of both countries to restore the Basin's water quality.

Public consultation and involvement were critical to the enactment of the GLWQA and to regional action plans, bringing together various interest groups to achieve consensus on issues and actions (EC 1999b; EC n.d). The numbers of NGOs dedicated to improving the Great Lakes environment grew substantially in the 1980s, and they took on roles in educating the public, lobbying governments, and serving as 'watchdog' to governmental progress. In 1982, Great Lakes United was formed and became the region's foremost and most influential basin-wide NGO (EC 1999b).

The call to action led to one of the notable success stories in the history of pollution reduction in the Basin. The 1970s IJC's report showed the link between increasing phosphorus concentrations and the

Box 30: Binational Cooperation, the IJC

Established under the Boundary Waters Treaty of 1909, the IJC has been in charge of preventing and resolving disputes over, and assessing and reporting on, water quantity and quality along the boundary between Canada and the United States. The IJC is an independent organization consisting of six members, three appointed by each head of government. Today, there are more than 20 boards made up of experts from both governments that carry out its work (IJC 2000a).

Box 31: Binational Cooperation, the GLWQA

Canada and the United States signed the Great Lakes Water Quality Agreement (GLWQA) in 1972. This milestone event committed the two countries to controlling and cleaning up pollution in the Great Lakes from industrial and municipal wastewaters. The major issue was phosphorus over-enrichment. In 1978, the GLWQA was renewed and made more comprehensive with the introduction of the ecosystem approach, in which the interactions among water, air, land, biota, and humans are considered together. The agreement was also expanded to address persistent toxic chemical discharges to the ecosystem. The 1987 protocol to the GLWQA set out targets or strategies for phosphorus load reductions, airborne pollutants, pollution from land based activities, and the problems of contaminated sediment and groundwater. Amendments required the two countries to develop Remedial Action Plans (RAPs) to clean up 43 Areas of Concern (AOCs) (see Figure 31) (EC n.d.; IJC 1989).

appearance of nuisance algae and suggested that the loadings would need to decline from about 28,000 tons a year to about 11,000 tons. Strict control of phosphates in detergents, sewage treatment plant upgrades and other pollution controls led to a 50 percent reduction in phosphorus levels in Lake Erie by the mid-1980s. Since then, it has continued to oscillate around the recommended level of 9,979 tons annually (AAFC 2000). Municipal phosphorus loadings to Lakes Erie and Ontario have been reduced by almost 80 percent since the 1970s, slowing algal growth and decreasing the extent of oxygen depletion in bottom waters. Once thought 'dead', Lake Erie now boasts the world's largest walleye fishery (EC n.d.; EC 1999b).

Another success story in reversing Great Lakes pollution is the reduction in production and use of a number of persistent toxic chemicals through legislated controls. For example, large quantities of wastewater from the pulp and paper mills located on the Lakes' shores were being discharged directly into the Basin's waters. These effluents carry dioxins and furans from bleaching agents, among other polluting constituents (EC 1999c). Since the late 1980s, government regulations have achieved an 82 percent reduction in chlorinated toxic substances

Figure 31
Areas of Concern (AOCs) in the Great Lakes

Source: EC 2000b

Areas of Concern (AOCs) in the Great Lakes

discharged from pulp and paper mills and reduced the dioxins and furans in effluents, resulting in their virtual elimination from the mills' wastewater. Since 1972, there has been an overall cutback of 71 percent in the use, generation, and release of seven priority toxic chemicals and a significant reduction in the number and magnitude of chemical spills (EC n.d.; EC 1999b).

DDT and PCB residues, once exceptionally high in cormorant eggs in the Great Lakes Basin, decreased by as much as 91 percent and 78 percent respectively between the early 1970s and 1998 (EC 2001b). Cormorant populations are breeding successfully again (see Figure 32) and other bird populations, such as the Osprey and Bald Eagle, are growing (EC 1998b; EC 1999b).

As government legislation and public participation addressed these problems, rapid urban and industrial development continued to cause environmental damage to the watershed during the 1990s. By 1990, the population in the Great Lakes Basin had reached 33.4 million, an 8 percent increase since 1970 (EC n.d.). During the 1990s, scientific studies pointed to new issues of concern.

By the mid-1990s, sediment contamination was identified as a key environmental problem in all Areas of Concern and the IJC named it a priority issue for the 1995–1997 biennial cycle (IJC 1997). Sediment accumulates in harbors and river mouths, which also receive

Double-crested Cormorant Population in the Great Lakes, 1971-1993

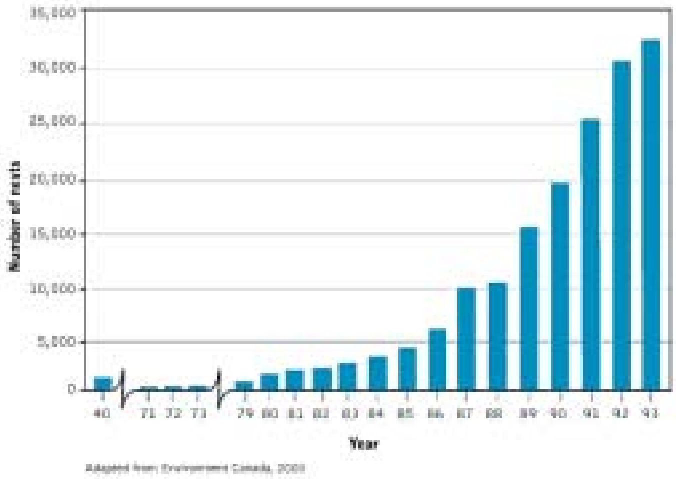


Figure 32
Double-crested Cormorant population in the Great Lakes, 1971-1993.

Source: AAFC 2000

urban and agricultural effluent. Animals and humans can be affected by the contaminants through contact with sediment or the consumption of fish from contaminated areas. The viability of commercial ports is threatened by contaminated sediment because of restrictions on vessel traffic and delays and costs related to dredging navigation channels and disposing of the dredged sediments. It is also costly to treat water taken from contaminated areas (IJC 1997).

Persistent toxic chemicals were also a concern. During the 1980s, the IJC noted a leveling out of the downward trend in contaminant concentrations (Bandemehr and Hoff 1998). As a result of the continued cycling of these substances in the ecosystem and the release from sediments, persistent toxic substances remained in the Basin even though many of them had been banned in North America. But during the 1990s, evidence revealed that pollutants carried in the air drift down onto the lakes, contributing significantly to water pollution (EPA 1997). One study reported

that up to 96 percent of PCBs in the Great Lakes came from the atmosphere (Bandemehr and Hoff 1998). In 1990, the two countries developed an integrated network to address the problem of atmospheric deposition (see Box 32).

Box 32: Binational Cooperation, Toxics and Atmospheric Deposition

Canada and the United States developed the Integrated Atmospheric Deposition Network (IADN) in 1990 through which they cooperate to assess the importance of atmospheric deposition relative to other inputs; identify the trends, sources, and distribution of deposition; and make the information available (Bandemehr and Hoff 1998). Then in 1997, they signed the Great Lakes Binational Toxics Strategy, in which they agreed to targets for eliminating persistent, bioaccumulative toxic substances and committed to continue assessing atmospheric deposition to the Basin (EC 2000a). The ultimate goal is for virtual elimination, to be achieved through a variety of actions focused primarily on pollution prevention from 1997 to 2005 (BNS 1999).

Although exposure to persistent toxic contaminants has decreased significantly over the past 20 years, some studies show that children of mothers who ate large quantities of Great Lakes fish were slightly smaller, somewhat less able to deal with stressful situations, and displayed slightly delayed neuromuscular development during infancy (Health Canada 1997). A 2001 study found that even the health of mature adults could be affected by exposure to contaminated fish. Adults who ate large amounts of fish from Lake Michigan and who had the highest levels of PCBs in their blood were found to suffer from memory and learning impairment (Schantz, Gasior, and others 2001). Those relying most heavily on food from the lakes and less likely to be reached by fish advisories are the most vulnerable to the threat of adverse health risks from toxic pollution in the Basin (IJC 2000b). Today, there is increasing concern about, and research into, the potential for exposure to persistent toxic substances from the Great Lakes to cause reproductive and hormonal disruption and learning disabilities (EPA 1996).

Despite the progress that has been made in a number of pollution issues in the Great Lakes, more remains to be done. The IJC’s 2000 report on Great Lakes Water Quality urged both governments to take further action to meet the GLWQA's goals, stating that neither one had committed adequate funding or taken the necessary decisive steps to ensure that the Lakes' waters are safe for drinking, swimming, and fishing. The report detailed the need to address the impacts of urbanization in the Basin, such as the nutrients, pathogens, chemicals, pesticides, and sediment introduced to waterways by runoff from cities, towns, and suburbs. It also expressed concern over the rate of progress in cleaning up sediments containing persistent toxic substances. The IJC further warned that existing regulations and guidelines for ballast exchange are inadequate to protect the lakes from exotic invasive species (see the biodiversity section) and urged the development of appropriate standards (IJC 2000b).

Other problems that remain in the Basin relate to the impact of urban development on sensitive tributary and near-shore habitats and acid rain in areas on the Canadian Shield (EC 1999b; EC 2000a). In addition, previous contamination continues to affect fish consumption due to persistent pollutants (EPA 1998)

The Great Lakes will face still other environmental challenges in the future. Over the past several decades, the Basin has experienced changes in hydrological conditions that are consistent with those projected by climate change models and global warming enhanced by human activity. Global climate change could lower lake levels by a meter or more by the middle of this century, causing severe economic, environmental, and social impacts. Water shortages throughout North America may also increase pressure to divert and / or remove water in bulk from the lakes, threatening the sustainable use of the Basin's surface and groundwater (IJC 2000c).

In the future the effects of climate change on North America's freshwater resources may include lower water levels in inland lakes and streams as well as increased demand for water for irrigation (EC 1998a). Both countries are undertaking studies to examine the potential effects of warming and adaptation strategies to changing water conditions. They are also aware that more needs to be done to understand the links between surface and ground water and to fully account for the total cost of water use and pollution.

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