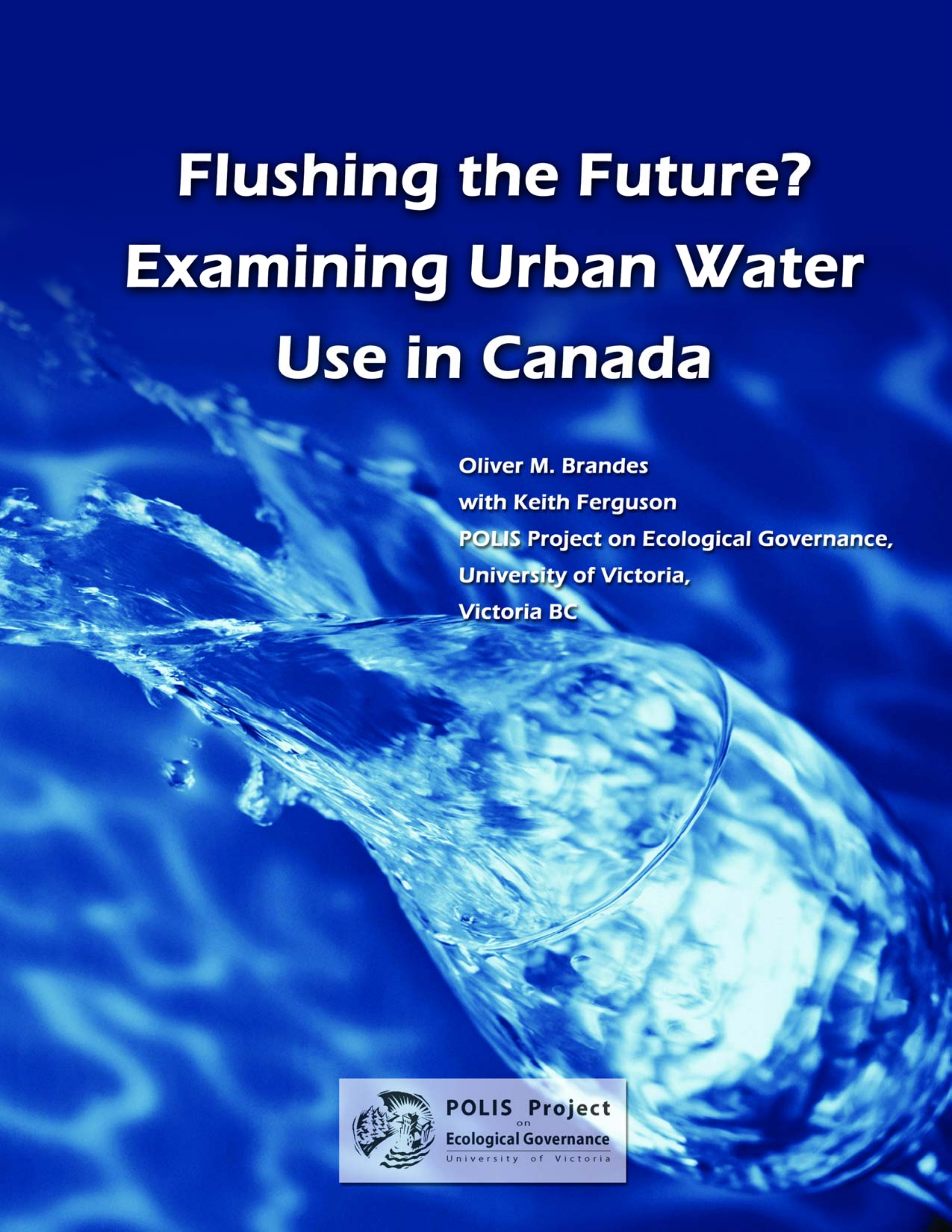

Flushing the Future? Examining Urban Water Use in Canada

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Urban Water Demand Management

Flushing the Future?
Examining Urban Water Use in Canada

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Urban Water Demand Management

Executive Summary

1. Introduction

Water problems are mounting worldwide, and water rich countries such as Canada are not exempt. Increasing global consumption, population growth, urbanization, pollution, and climate change all put increasing pressure on this finite resource, resulting in regional and global scarcities. Despite a widespread belief of an abundance in Canada, such scarcities, especially seasonal ones, are already a reality in many parts of the country. Indeed, in a 2001 report to the House of Commons, the Commissioner of the Environment and Sustainable Development stated: "the availability and management of fresh water is becoming one of the greatest environmental, social and political challenges of the 21st century" (CESD 2001:23).

This report examines urban water use in Canada in order to understand the current approach to its management, and to assess the potential for innovative alternatives. In contrast to the traditional supply side approach, which increases water supply in response to predicted increases in demand, the report provides a basis for serious consideration of a long-neglected policy approach focussed on demand-side management (DSM).

2. Context and Background: the problem of limited quantity

Despite an image of the earth being a water planet, only a fraction of this apparent water supply is accessible for global human use. More than one billion people lack access to clean drinking water, and half the world's population does not even receive the standard of water services once available to cities in ancient Greece and Rome. Even so, at present, the world's six billion people use 54 percent of all the accessible fresh water contained in rivers, lakes, and underground aquifers. Beyond this evident inequality, by 2025, based on population growth projections, it is estimated that this figure will jump to 70 percent.

In Canada, the per capita level of water use exceeds that of most other industrialized countries, and it is rising. Wastage and inefficient use result in over-extended regional water supplies and supporting infrastructure. The ecological implications of high volume water use are profound. Dams, dikes, levees and other diversions are primary destroyers of aquatic habitat and disruptors of ecological function, both up and downstream. Not all water withdrawn is returned to the source, and often the water that is returned is polluted or in a degraded state. Such factors have contributed significantly to aquatic ecosystems becoming some of the most threatened on Earth.

The era of endless, easily accessible water is over. All sectors of water use in Canada, from manufacturing and thermal power generation to agriculture and municipal services, must find new ways to address the challenge of scarcity and to reduce their ecological impacts.

3. Water Supply in Canadian Cities

The majority of Canadians live in large urban and regional centres, and municipal water use represents a significant portion (12 percent) of overall water withdrawals in Canada. Urban users in Canada use more than twice as much water as their European counterparts, with significant levels of wastage and inefficiency. Such high levels of urban water use have resulted in expensive supply and disposal infrastructure expansions, ecological impacts in developed areas where environmental stresses are already high, and increasing pressure on water treatment facilities to treat all water to drinking quality standards.

Urban Water Demand Management

4. Urban Water: a snap shot of twenty Canadian cities

A survey of twenty selected Canadian cities across the nation shows a significant variation in both domestic and total daily municipal water use per capita. In terms of per capita daily domestic use, Charlottetown (156 litres), Yellowknife (164 litres), and Iqaluit (167 litres) were the lowest users, while Hamilton (470 litres), Whitehorse (519 litres), and St. John's (659 litres) were the highest. This represents a fourfold difference between the highest and the lowest domestic users. In terms of total per capital daily use, Iqaluit (278 litres), Waterloo (359 litres), and Regina (395 litres) were the lowest users, while St. John's (878 litres), Hamilton (921 litres), and Montreal (1287 litres) were the highest. This again represents a fourfold difference.

Some variation is to be expected, given the multiplicity of factors affecting urban water use, such as: climate, availability of supply, prices and pricing structure, the relative mix of commercial, residential and industrial use of municipal water, governance and decision-making structures, and regional conservation initiatives. The survey found that individual metering and the use of volume-based pricing (where customers are charged according to the amount of water they use) generally corresponded with lower water use. However, given the wide variation in water use among the cities, further investigation is required to fully understand the policy implications of this diverse situation.

This study provides two important conclusions. First, the significant variance of water use suggests that the potential exists to reduce urban water use by adopting available best practices and programs, and that doing so will have little overall effect on the quality of life. Second, as a basis for moving to best practices, better data and uniform information are needed to allow for detailed studies, and to assist water managers to compare and assess water use in their region and across Canada.

5. Demand-Side Management: a proposed approach to urban water issues

Demand-side management (DSM) is an alternative (or, more accurately, complementary) approach to increasing supply infrastructure. It involves decreasing the demand for water through a mix of education, technology, pricing reform, regulation and recycling. In those North American cities where significant DSM measures have been implemented, it has often shown considerable success in reducing urban water use.

By reducing the amount of water withdrawn from the environment, DSM holds the potential to reduce pressures on freshwater ecosystems, to avoid scarcities from becoming more widespread, and to generate cost savings by delaying or eliminating the need for costly construction associated with increasing supply. DSM also addresses non-monetary social concerns for water conservation, such as uncertainties about future needs, preserving options for future development, and sustainable development of water resources.

6. Summary and Future Directions

In many regions, DSM can address existing water stresses and an appropriate DSM regime may also help to ensure a sustainable water management regime. In looking to the future, as part of a broader "soft path" approach to water management, it is timely to assess just what might be the full potential for DSM and what are the barriers to implementing it more widely.

Contents

Executive Summary……………………………………………………………………………………… 1

Contents…………………………………………………………………………………………………… 3

List of Figures…………………………………………………………………………………………… 5

Foreword…………………………………………………………………………………………………. 7

1 Introduction……………………………………………………………………………………….. 8

1.1 Purpose and organization of the report……………………………………………………… 9

2 Background: the problem of limited water quantity…………………………………………… 10

2.1 The global picture……………………………………………………………………………… 10

2.2 The national picture…………………………………………………………………………… 11

2.3 Canadian water consumption— an international comparison……………………………… 12

2.4 Canadian water use by sector………………………………………………………………… 13

2.4.1 Thermal power generation………………………………………………………………… 13

2.4.2 Manufacturing……………………………………………………………………………… 14

2.4.3 Municipal use……………………………………………………………………………… 14

2.4.4 Agriculture………………………………………………………………………………… 15

2.4.5 Mining……………………………………………………………………………………… 15

2.5 Factors contributing to increasing demand and decreasing supply………………………… 17

2.5.1 Population growth…………………………………………………………………………… 17

2.5.2 Urbanization………………………………………………………………………………… 17

2.5.3 Pollution……………………………………………………………………………………… 17

2.5.4 Climate change……………………………………………………………………………… 18

2.6 Ecological impacts of human water use……………………………………………………….. 18

Urban Water Demand Management

3 **Water Supply in Canadian cities**………… 20

3.1 Why look at cities?………… 20

3.1.1 Summary………… 23

3.2 Governance and municipal water management………… 23

3.2.1 Categories of municipal water use………… 23

3.2.2 Governance and service delivery………… 24

3.2.3 Pricing: flat vs. volume based rates………… 25

3.2.4 Water treatment………… 25

4 **Urban water: a snapshot of twenty Canadian cities**………… 26

4.1 Variations between cities………… 27

4.2 Trends………… 28

4.3 Regional differences………… 29

4.4 City size………… 30

4.5 Municipal water use by sector………… 31

4.6 Meters and pricing………… 32

4.7 The need for further study and better information………… 33

4.8 Summary………… 34

5 ***The potential for demand-side management*** **(DSM)**………… 36

5.1 What is demand-side management?………… 37

5.2 The water "soft path"………… 38

5.3 DSM measures………… 39

5.3.1 Socio-political strategies………… 39

5.3.2 Economic strategies………… 41

5.3.3 Structural and operational strategies………… 41

5.4 Summary………… 44

6. ***Summary and future directions***………… 46

Appendix A: Canadian city snapshots………… 47

References………… 58

List of Figures

Figure 2.1: Global fresh water availability………………………………………………………… 10

Figure 2.2: Canadian residential water use in comparison, 1996…………………………… 12

Figure 2.3: Water use by sector, 1996………………………………………………………………. 13

Figure 2.4: Regional water use by sector, 1996…………………………………………………… 14

Figure 2.5: Canadian municipal water use by sector (national averages)…………………. 15

Figure 2.6: Water use in Canada, 1996…………………………………………………………….. 16

Figure 3.1: Total municipal water flows (millions of cubic metres per day)…..……………… 21

Figure 3.2: Canadian residential municipal average daily water flow, (litres per capita).. 21

Figure 3.3: Surveying drinking water quality in Canada…………………………………………. 23

Figure 3.4: Changes needed to protect drinking water………………………………………… 24

Figure 4.1: The 20 chosen cities and populations served by municipal water systems, 1999……………………………………………………………………………………………….. 26

Figure 4.2: Domestic and total per capita daily water use and rankings for 20 selected cities, 1999..…………………………………………………………………………... 27

Figure 4.3: Trends in water use in the selected cities through the 1990's…..……………….. 28

Figure 4.4: Domestic and total per capita daily water use by territory and province, 1999……………………………………………………………………………………………….. 29

Figure 4.5: Total and domestic per capita daily water use by population served, 1999... 30

Figure 4.6: Municipal water use percentages by sector, 1999………………………………… 31

Figure 4.7: Residential use grouped by percentage metered………………………………… 32

Figure 4.8: Residential water consumption by pricing method by province, 1999……….. 33

Figure 5.1: Water Conservation……………………………………………………………………… 36

Figure 5.2: Benefits of water efficiency……………………………………………………………... 37

Figure 5.3: A parallel with energy…………………………………………………………………….. 38

Figure 5.4: DSM reduces water use………………………………………………………………….. 38

Figure 5.5: Waterloo, a Canadian water conservation example……………………………… 39

Urban Water Demand Management

Figure 5.6: The soft path……………………………………………………………………………… 39

Figure 5.7: Water demand management measures…………………………………………… 40

Figure 5.8: Canadians use more water and pay less for it…………………………………….. 41

Figure 5.9: Xeriscaping……………………………………………………………………………… 42

Figure 5.10: Closing the loop……………………………………………………………………… 42

Figure 5.11: Toronto Healthy House……………………………………………………………… 43

Figure 5.12: Water ethic…………………………………………………………………………….. 44

Urban Water Demand Management

Foreword

Imagine Canada 50 years from now. The full impacts of climate change are an everyday reality. The world, and Canada, have been getting hotter; and with that heat, river and lake levels have dropped dramatically. Seasonal summer flows have plunged as rivers and the landscape dry up. Drought and forest fires are common occurrences. A scary scenario? Certainly. But for much of rural Canada, it is a likely one.

Now, imagine Canada's cities 50 years now. Where will they get their water from? And how will they use it? This report begins to address these questions by looking at what Canadian cities do now and what they can do in the future. Throughout the country, public awareness about water is rising, sparked by the crises at Walkerton and North Battleford. But this awareness is largely focused on water *quality*, not water *quantity*. Water, after all, just comes out of the tap.

Flushing the Future? looks beyond the tap to address the use of water in Canada's cities today. There is, it finds, a huge disparity in how much urban dwellers use across the nation, and an almost complete lack of understanding (let alone policy, or innovative opportunities) concerning water use. For citizens, water quantity is virtually a non-issue and, for politicians, it is a topic fraught with peril. As the report demonstrates, this neglect is a mistake, one that will only become more costly with time. Today, the potential for innovation exists, a potential that makes economic as well as environmental sense. But we are not seizing it.

The first in a series of reports on urban water use, *Flushing the Future?* demonstrates the need for a future different from the past. As we address this need throughout the series, we hope to move Canadians toward a process that is, in any event, inevitable. We can start now to create a sustainable future for our cities, one that is more sensitive and sensible. Better to act in five years than 50, embracing new practices now will protect and enhance the quality of urban life and do it in a least cost way. And, given our present neglect, we will do so in ways that we have not yet begun to appreciate.

Michael M'Gonigle,
Eco-Research Professor,
Director, POLIS Project,
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Urban Water Demand Management

1 Introduction

Water problems are mounting worldwide, including in water-rich countries such as Canada. Increasing consumption, population growth, urbanization, pollution, and climate change act in concert to increase the pressure on this finite resource, resulting in regional and global scarcity, and considerable ecological consequences. A central challenge of global public policy is to reduce that pressure.

Canada, it would seem, is in an enviable position given its abundant share of the world's freshwater resource. Comprising one percent of the world's population, Canada possesses almost 20 percent of the global freshwater resource, suggesting perhaps that water supply is not a concern in Canada. However, most of Canada's fresh water is found in distant glaciers, ice caps and remote water bodies, and is therefore not easily accessible by a population concentrated in a relatively small number of urban areas. Therefore, to meet increasing supply needs entails rising economic and environmental costs. Referring to global water supply, the Commissioner of the Environment and Sustainable Development has stated, "the availability and management of fresh water are becoming one of the greatest environmental, social, and political challenges of the 21st century" (CESD 2001:23).

All sectors of water use in Canada, from manufacturing and thermal power generation to agriculture and residential use, must find new strategies to cope with existing pressures on local water resources, and the challenge of increasing regional and seasonal water scarcity. As a part of the national solution to the water situation, Canadian cities offer a compelling opportunity to change water use patterns. The majority of Canadians live in large urban and regional centres, and municipal water use represents a significant portion (12 percent) of overall water withdrawals in Canada. The scale and scope of urban water use, the capital-intensive nature of water provision in cities, and the existing state of wastage and inefficiency in the urban context, provide strong incentives and relatively easy opportunities to decrease water use without substantially altering lifestyles or Canadian quality of life standards.

In recent years, a number of water management experts[1] have pointed to demand-side management (DSM) as a key tool for changing water use patterns. Rather than trying to find new and often more distant sources, as is the norm in a supply-side approach, DSM seeks to influence demand and thereby reduce the need for increased supply. At the very least, DSM holds the potential to defer both capital costs associated with increasing infrastructure for water provision and wastewater treatment, and decrease the environmental degradation associated with high levels of water extraction from and wastewater return to the environment. In conjunction with a broader "soft path" approach (see s. 5.2), DSM has the potential to act as a catalyst to shift the present water management approach from a centralized supply orientation to one that focuses on the service that water provides such as by matching water supply quality with appropriate end use.

[1] Sandra Postel (1997), Donald Tate (1990), Bruce Mitchell (1997), Dan Shrubsole (2001), Marq de Villiers (2000), David Brooks (2003), Peter Gleick (2003) and Amory Lovins (1999).

1.1 Purpose and Organization of the Report

This report examines urban water use in Canada. A key question is whether there is a need or the potential to refocus the current supply-oriented approach to urban water management to one that is more "efficient". In this context, the report introduces the potential that DSM may have to redirect the urban water management regime in Canada from increasing supply to decreasing demand.

The report begins in Chapter 2 with a background examination of the issue of water resources from a global and national perspective, and explains some of the factors and trends that contribute to the rising demand and falling supply of water resources, as well as some of the associated ecological impacts. Chapter 3 discusses urban water use and water management in Canadian cities; Chapter 4 presents a survey of water use in 20 selected cities. Collectively, these chapters review the need for, and the potential of, water conservation initiatives in Canadian cities, and provide the foundations on which future policy initiatives will rest, including attempts to address systemic and institutional possibilities for future innovation in the urban water management context. Chapter 5 then discusses the opportunities for demand-side management in Canadian cities, and the potential for a 'soft path' for water. Finally, Chapter 6 presents some conclusions, and outlines future directions.

2 Background: the problem of limited water quantity

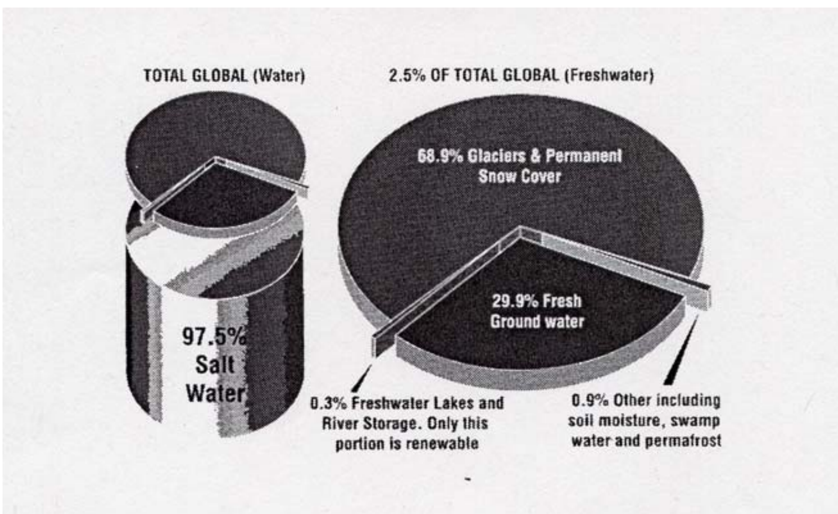
"The world's thirst for water is likely to become one of the most pressing resource issues of the 21st century"

World Resources, a publication of the United Nation's Environment Program, the World Bank and the World Resources Institute.

2.1 The global picture

Despite an image of the earth being a water planet, only a fraction of the globe's water is accessible for human use. Of the total volume of water on the planet (an estimated 1,386,000 cubic kilometres), only 2.5 percent is fresh water (see Figure 2.1), most of which is locked in glaciers, ice caps and permanent snow cover. Therefore, realistically, it has been estimated that only 0.77 percent of all water is held in forms accessible to humans (Shiklomanov, 1993: 13).

Figure 2.1: **Global fresh water availability**



Shiklomanov, I. 1993. In *Water in Crisis: A Guide to the World's Fresh Water Resources.* Edited by P. Gleick. Oxford University Press, p.14

In many parts of the world there is a growing scarcity of fresh water available to meet human demands. More than one billion people today lack access to clean drinking water (Gleick and Wolf 2002: 2). Half the world's population does not receive the standard of water service available to many cities in ancient Greece and Rome. Access to sanitation is so limited that preventable water-related diseases kill an estimated ten to twenty thousand children every day (World Health Organization 2000). Many experts, governments, and international organizations are predicting that water availability will be one of the major challenges facing human society in the 21st century and that a lack of water will be one of the key factors limiting development (World Meteorological Organization 1997).

At present, the world's six billion people use 54 percent of all the accessible fresh water contained in rivers, lakes, and underground aquifers (Cosgrove & Rijsberman 2000: 7). Included in this use is water withdrawn for human activities such as bathing and drinking, growing crops, sewerage, and many manufacturing and industrial processes. Half of this water is then returned to the environment, albeit often in a degraded state as a result of water's function as a vehicle for "pollution dilution". It has been estimated that by 2025, population growth will increase the proportion of water used by humans to 70 percent (Postel 2000: 941). Such a degree of human appropriation of fresh water will likely severely degrade aquatic ecosystem services, in turn decimating fish populations and even driving additional species to extinction. Postel (2000: 945) sums up the situation with an ominous prediction: "Given projected demographic trends and the already serious state of decline of many freshwater ecosystems, I maintain that society will need to approximately double water productivity over the next three decades"[2].

Globally, 70 percent of water withdrawn for human use is for agriculture, primarily irrigation. Industry accounts for 20 percent, and domestic use (household, drinking, sanitation) accounts for 10 percent (Cosgrove & Rijsberman 2000: 7). These global averages vary between regions. In Africa, for instance, agriculture comprises 88 percent of use, seven percent for domestic use, and only five percent for industry. In Europe, industry uses the most water (54 percent), followed by agriculture (33 percent) and domestic (13 percent). In North America, agriculture accounts for 49 percent, followed by industry (42 percent) and domestic (nine percent) (WWC 1998: 6).

2.2 The national picture

Canada has more fresh water than any other country. Comprising less than one percent of global population, Canadians possess 20 percent of the world's total freshwater resources and seven percent of its renewable supply of fresh water. As noted above, however, most of Canada's fresh water exists in generally inaccessible forms (Environment Canada 2003), and is not evenly distributed between regions. Canada's Atlantic and Pacific coastal areas receive abundant rainfall (averaging between 1100 and 1400 millimetres of precipitation per year) while the Prairies, which oscillate between flood conditions in the spring and near drought conditions in the summer, receive less than 500 millimetres of precipitation yearly (Environment Canada 2003). Parts of the Yukon and the Interior of British Columbia receive so little rainfall that they are *de facto* deserts.

Much of the renewable freshwater supply is concentrated in areas of lowest population density. Sixty percent of the freshwater in Canada drains north; however, 90 percent of the national population lives within a few hundred kilometres of the southern border. Thus, the population has access to, at most, 40 percent of Canada's renewable freshwater resources. Environment Canada reports that fresh water in southern Canada is "heavily used and often overly stressed" (Environment Canada 2003a). Looking at the Great Lakes basin more specifically, the Commissioner of the Environment and Sustainable Development (CESD 2001: 24) reports that: "At the current rates of use, the strain on the available supply of fresh water in the basin may contribute to decreased water levels, which could cause significant environmental damage and substantial social costs."

[2] By 'productivity', Postel means to get more services from the same amount of water used or even from less water used. This approach necessarily entails a shift in focus to the nature of demand, beyond just the usual concern with supply.

Water conservationists have argued that misconceptions about the availability and abundance of water have contributed significantly to Canada's high levels of water consumption. Reforming water resource management in Canada requires that this misconception be challenged. As Kreutzwiser (1995: 281), a leading Canadian water academic, argues:

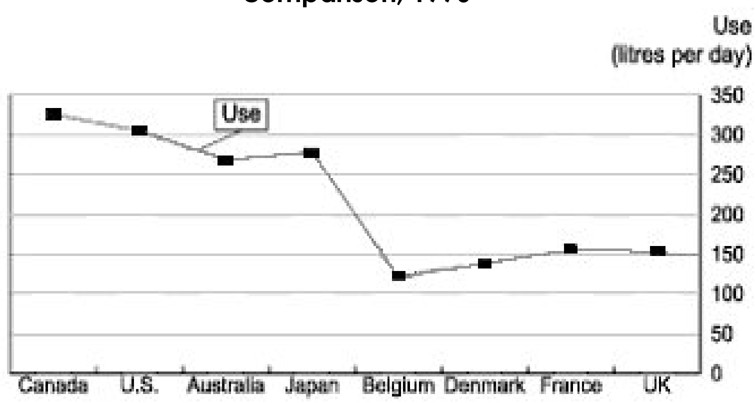
> *"…perceptions of the abundance of water resources must be tempered by a realization that these resources are finite. Fuller appreciation of the value of water resources is a prerequisite to more effective allocation that minimizes conflict among competing uses and enhances the sustainability of these uses."* [3]

2.3 Canadian water consumption – an international comparison

A study of environmental indicators conducted by the OECD (1999), reveals that the average Canadian uses a total of 4,400 litres water per day. This figure takes into account all uses of water: agriculture, manufacturing, mining, some power production[4], and municipal, which includes residential and commercial uses. These uses provide the foundation for the Canadian economy and underpin most economic activity. Despite comparable levels of wealth and standards of living, Canadians use more than four times the amount of water used by the average European (OECD 1999). According to Environment Canada, over the last 20 years water use in Canada has increased by 25 percent. This is in marked contrast to many other developed nations, such as Sweden, the Netherlands, Poland, Denmark and even the United States, which have all been able to decrease their overall water use since 1980 (Boyd 2001: 14).

In terms of residential water use, Canadians use at least twice as much water per person as citizens in many other industrialized countries, especially those in Europe (see Figure 2.2). The average Canadian served by a municipal water system used 326 litres per day in 1996 compared to 128 in Germany, 130 in the Netherlands, and 149 in the United Kingdom (OECD 1999). Similar to per capita total water use in Canada, domestic use has also risen since 1980. By 1999, it had increased to 343 litres per person per day, a five percent increase from the figure of just three years previous (Environment Canada 2001).

***Figure 2.2:* Canadian residential water use in comparison, 1996**



Source: OECD—All data is from 1994 to 1999 except data on U.S. use, which is from 1980 *(CESD 2001)*.

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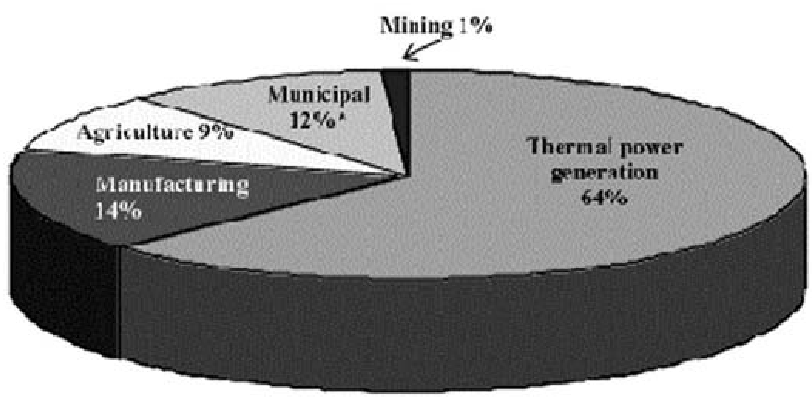
[3] For example, when one looks at the potential of a large lake as a water supply, it is tempting to see the whole water body as somehow "available". In fact, only the water flowing through the system can be accessed, a much smaller amount. Further, in order to maintain ecological functioning, only a limited amount of even that throughput may be usable.

[4] Primarily thermal power generation, but not including water used for hydroelectric power generation because it is not withdrawn from the aquatic ecosystem.

2.4 *Canadian water use by sector*

Fresh water is critical to sustaining life and vital to the industrial economy. In Canada, fresh water is used for many economic purposes, including energy production, agriculture, transportation, manufacturing, mining, and municipal supply (see Figure 2.3).

Figure 2.3: Water Use by Sector, 1996



The five main water users in Canada, 1996

* includes rural domestic use (2%).

Source: Environment Canada survey and statistics 1996.

Available at http://www.ec.gc.ca/water/images/manage/effic/a6f1e.htm

Thermal power generation is the single largest user, representing approximately 64 percent of total water withdrawals, followed by manufacturing at 14 percent. At 12 percent of water withdrawals, municipal water use is the third highest water use sector in Canada and encompasses water withdrawn for residences, public services, commercial and institutional enterprises (such as hospitals, schools, restaurants, government offices), and some local light industrial uses. Agricultural water use follows at nine percent, and mining represents a relatively minor one percent.

Many of the sectoral uses vary by region (see Figure 2.4). For example, Ontario and the Atlantic provinces use the bulk of the water withdrawn for thermal power generation, while in the Prairies the primary use is agriculture.

2.4.1 Thermal power generation

Power production is an intensive user of water. To produce one kilowatt-hour of electricity, fossil fuel plants use 140 litres of water, and nuclear plants use 205 litres. Since current technology and practices convert only 40 percent of the fuel's energy into usable electricity, the remaining heat energy must be dissipated, which is achieved through a continuous flow of cool water circulating through a condenser. Although this process returns large amounts of water to the source, it is at much higher temperatures (thermal pollution), and so may cause damage to aquatic ecosystems and marine habitats.

Figure 2.4: **Regional water use by sector, 1996**

Region	Thermal Power	Manufacturing	Municipal*	Rural*	Agriculture**	Mining	Total
Atlantic	2 372	480	285	134	15	206	**3 492**
Quebec	809	1 173	1 351	278	100	38	**3 749**
Ontario	23 228	3 011	1 496	291	186	56	**28 268**
Prairies	2 337	368	534	141	3 014	61	**6 455**
British Columbia ***	4	1 008	668	135	676	158	**2 649**
National Total	**28 750**	**6 038**	**4 335**	**979**	**3 991**	**518**	**44 611**
Percent of Total (rounded)	64	14	10	2	9	1	100

* These municipal and rural estimates include: residential, commercial/institutional, and other uses (i.e., not industrial).

** This agricultural estimate has not been updated (it is based on 1991 data).

*** Sectoral data for Yukon, Northwest Territories, and Nunavut are included with British Columbia.

Note: Data for some sectors have been extrapolated and rounded and are in million of cubic metres per year

Source: Environment Canada survey and statistics 1996 Available at.http://www.ec.gc.ca/water/en/manage/use/e_wuse.

2.4.2 Manufacturing

Manufacturing and the production of commercial goods also require large quantities of water. For example, 250,000 litres of water are used in the production of a single car, and 33,000 litres are required to make the average computer (Environment Canada 2003a). Water is used as a raw material, a coolant, a solvent, a transport agent, and as a source of energy. The three main industrial users of water are paper and allied products, primary metals and chemicals (Environment Canada 1996). Water is so important to most industries that proximity to a water source is a determining factor in the decision of where to locate an industrial plant. This results in the majority of Canadian manufacturing establishments being concentrated adjacent to large sources of water (Environment Canada 1996).

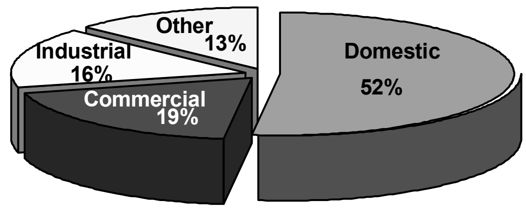
2.4.3 Municipal use

As a critical component of urban life, municipal water uses are diverse: drinking, cooking, bathing and sewerage, as well as maintaining lawns, cleaning streets and fighting fires. Commercial businesses and a variety of smaller scale enterprises such as bakeries, breweries, food processing and beverage production, also require high quality water.

Residential use is the most significant component of municipal water use, representing over half of the total volume used in the municipal sector (see figure 2.5). Ensuring a safe, high-quality supply of drinking water is costly. The majority of Canadians receive their domestic water from lakes and rivers, while 26 percent rely on groundwater resources (Environment Canada 2003).

While municipal use represents a significant portion of the water withdrawn in Canada (12 percent), as illustrated by figure 2.6, almost none of this supply is recycled or reused, in contrast to other primary users (except agriculture). Although there are a small number of small scale examples that draw from municipal systems and recycle some or all of their water for multiple uses[5], the overall amount is so minor and geographically dispersed that Environment Canada does not collect data on water reuse for this sector.

***Figure 2.5:* Canadian municipal water use by sector** (national averages)



Source: Environment Canada MUD database

2.4.4 Agriculture

Agricultural production in Canada consumes water primarily for irrigation (85 percent) and livestock watering (15 percent). Seasonally drier parts of Canada, such as the southern regions of Alberta, British Columbia, Saskatchewan, and Manitoba, could not be agriculturally productive without irrigation (Environment Canada 2003a). Water is also used for frost control on crops in Ontario and the Maritimes.

Agriculture accounts for nine percent of total withdrawals, but is also a highly consumptive user of water due to high levels of evaporation. This water is removed from the local landscape with little returned to surface and groundwater sources, except via precipitation.

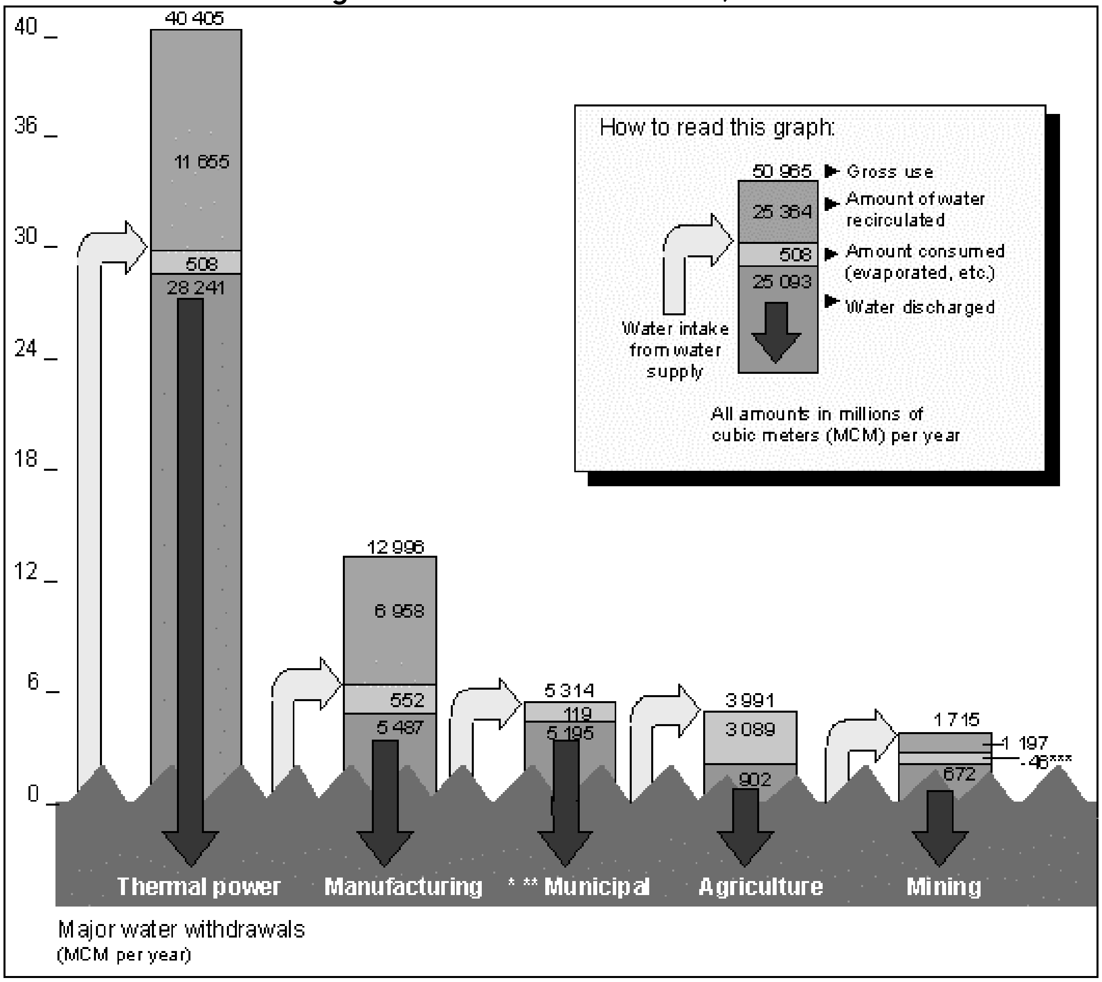
2.4.5 Mining

The mining industry consists of three sectors: metal, coal and other non-metal mining. Water is used to separate ore from rock, to cool drills, to wash the ore during production, and to transport unwanted material. The mining process recirculates and reuses the majority of its water intake, and therefore accounts for only about one percent of all water withdrawals.

Although this sector represents only a small percentage, it is important to note that oil production, though not considered mining directly, is an intensive water user (Griffiths and Woynillowicz 2003). Termed "oil field injections", water is used to displace and pump oil from deep wells. In Alberta, 133 million m^3 of water was used for oilfield injection in 2002 (Woynillowicz, personal communication, 2003). Once the well is depleted the now degraded water, containing concentrated minerals and pollutants from the oil drilling process, is left behind (and often removed from the hydrological cycle).

[5] Specific examples of residential and commercial enterprises include the Waterloo Region Green Home, Sooke Harbour House, Mt Washington Ski Resort, and the Conservation Co-op Residential Water Reclamation Project (an 84 apartment unit in the city of Ottawa). The Okanagan communities of Vernon, Osoyoos, Oliver, Armstrong, Penticton, Cranbrook and Kamloops reuse reclaimed wastewater for irrigation of agriculture, recreational lands and golf courses. An outstanding example of a closed loop system (full reuse of all incoming water) is the Toronto Healthy House, which is not connected to the city water system but instead draws on rainfall and snowmelt for its fresh water supply (see chapter 5, fig. 5.11 for more details).

Figure 2.6: Water use in Canada, 1996



* Municipal data exclude water supplied to industry.
** Municipal data include estimates for rural residential water use.
***Negative mining consumption value results from incomplete reporting of "mine water" intake or overall annual balance fluctuations in tailing ponds. An accurate mining consumption value is thus not available.

Notes: 1) Intake + Recirculation = Gross Use.
2) Intake - Discharge = Consumption (except in the municipal sector, where consumption has been estimated at 510 or 10% of intake (see #3).
3) Municipal consumption is an uncertain figure, but has been estimated. However, the difference between intake and discharge is not consumption, but non-metered sewage. If this non-metered sewage (including rainfall) was known, then the municipalities would be "net producers" of water, not consumers.
4) Data for some sectors have been extrapolated and rounded.

Source: Environment Canada survey and statistics 1999.
Available at: http://www.ec.gc.ca/water/images/manage/use/a4f1e.htm

2.5 Factors contributing to increasing demand and decreasing supply

Freshwater resources are subject to dual pressure: increasing demand on the one side, and decreasing supply on the other. Population growth, the associated expansion of irrigated agriculture, and other factors (such as changing standards of living associated with urbanization), have led to a seven-fold increase in freshwater withdrawals globally over the last century (Gleick 2000: 128). Growing populations and urbanization continue to increase demands for water in limited geographic regions where cities are clustered. At the same time, pollution and climate change are reducing the availability of new, high quality water supplies.

2.5.1 Population growth

Population growth has two significant impacts on the global availability of freshwater resources. The first, and most obvious, is a decrease in per capita availability of water. Current projections indicate that population growth over the next 25 years will reduce the availability of renewable water resources (which is historically constant) from 6,600 to 4,800 cubic metres per person. Some forecasts show that by 2025, 4 billion people – half the world population – will live in countries where more than 40 percent of renewable water resources are withdrawn for human uses (Cosgrove and Rijsberman 2000: 17).

The second and less obvious effect of population growth comes from the concomitant requirement for increased food production. As global food production, and the land employed for this purpose, increase, so too will the amount of water required for irrigation. In the twentieth century, land under irrigation increased from around 50 million to over 267 million hectares (Gleick 1998: 573). Although projections for future expansion of irrigated land are highly variable, a minimum increase of five to ten percent seems likely. The World Water Vision Report (Cosgrove and Rijsberman 2000: 27) concluded: "The conventional wisdom in agriculture is that based on the need to produce food for the growing world, irrigated agriculture will have to keep pace – and therefore expand some 30 percent in harvested area by 2025".

2.5.2 Urbanization

Urbanization directly affects demand on water resources. As individuals move to urban centres, access to water infrastructure increases, leading to a corresponding increase in use. Urbanization also often results in changing socio-economic patterns through economic growth and higher incomes (McNeill and Tate 1991). This raises individual/residential water demands as a result of lifestyle changes, ranging from additional reliance on timesaving appliances, such as washing machines and dishwashers, to luxury uses such as lawn watering and swimming pools (Suzenet et al. 2002). Increased economic activity and associated increased demands for electricity contributes to additional water demands. Furthermore, growing and highly concentrated urban populations put particular pressure on localized water sources and limited supply infrastructures.

2.5.3 Pollution

Pollution of surface and groundwater pose serious threats to freshwater quality and quantity. Algal toxins, pesticides, heavy metals, leachates, persistent organic pollutants, urban runoff[6], and industrial[7] and wastewater effluents, are just some of the many pollutants that affect water systems. Urban sewage treatment plants are heavy polluters, and municipal wastewater represents the largest source of effluent discharge to Canadian waters, totalling nearly 4.3 billion cubic metres in 1991 (Environment Canada 2001). Indeed, Canada's National Pollutants Release Inventory has found that seven of Canada's worst polluters (by volume of toxic chemicals dumped into water) are municipal sewage treatment plants (National Pollution Release Inventory

[6] Individual Canadians collectively dump about 300 million litres of used motor oil into Canadian waterways each year through urban runoff – more than seven times the oil spilled during the *Exxon Valdez* disaster (DeVillers 1999).

[7] The Pulp and Paper industry discharges two million kilograms of toxic chemicals into Canadian waters every year (Environment Canada 2003a) despite regulation under the *Canadian Environment Protection Act* and the *Fisheries Act*.

1999). Such a degree of pollution undercuts the natural ability of ecosystems to assimilate and purify wastes.

Although many of these discharges do not directly decrease the amount of water available, they reduce its utility and therefore effectively reduce the availability of high quality supplies, in addition to posing serious threats to human health and the environment. In a recent report analyzing economy-based projections of environmental pressures and conditions to 2020, the OECD categorizes groundwater pollution, especially from non-point sources, as a particularly urgent concern (OECD 2001) given the long-term systemic consequences of this type of pollution.

2.5.4 Climate change

Climate change has many implications, including a significant effect on freshwater supply. Planet-wide warming due to the build-up of greenhouse gases affects the global hydrological cycle, as warmer temperatures cause corresponding increases in evaporation and precipitation. Climatologists project that rainfall patterns will change, extreme weather events will intensify, and the sea level will rise from the warming of oceans and the melting of polar ice caps (Waggoner 1990).

While climate change will undoubtedly have a significant impact on water resources, its extent and timing in Canada are not well known. However, as Schindler (2001: 18) states, "climate warming will adversely affect Canadian water quality and water quantity." For example, Schindler suggests that temperature increases during the last 75 years have led to a 40 percent reduction in flow in many Alberta rivers. This decrease will continue as the glaciers in the Rocky Mountains, an important source for most western Canadian rivers, such as the Fraser, Columbia and Saskatchewan-Nelson river systems, continue to both "recede and thin". Amongst the changes will be a rise in water temperature, which will further adversely affect water quality and quantity, aquatic biota, river flows, and groundwater and lake levels.

Although most climate change models predict modest changes to overall levels of precipitation in Canada, water supply will nonetheless be influenced. Higher global temperatures will hasten evaporation, thereby reducing water availability in already water stressed regions (Smith 2002). Changes in precipitation/evaporation ratios could also result in declining water levels in ponds, lakes and wetlands, and may also result in changes to water chemistry, particularly as it relates to salination. Formerly perennial rivers may experience seasonal dry periods. Aquatic ecosystems will see increased levels of algal blooms and toxins. All of these factors will further affect future water supplies, especially in areas where water sources are already taxed.

Increasing frequency and magnitude of extreme precipitation, runoff and snowmelt will intensify current seasonal and localized water shortages, and affect urban water specifically. 'Extreme' events will also potentially compromise current containment storage, processing and water transportation infrastructure. The associated increasing urban runoff and nutrient loading will further threaten already taxed urban rivers and water supplies.

2.6 Ecological impacts of human water use

Freshwater ecosystems touch many aspects of the natural and human environment. At their most basic level, these ecosystems provide not only clean water, the foundation for all life, but are also a critical nexus between aquatic and terrestrial ecosystems, providing energy and nutrient flows. Some of the many benefits these ecosystems provide include supplying water for drinking, irrigation and other human purposes, habitat for a wide variety of species ranging from fish and waterfowl to wildlife and birds, and general services such as transportation, flood control, pollution dilution, hydroelectric generation and soil fertilization (Postel 1997a).

Human demands and use of water have increased in recent decades for many of the reasons discussed above. To accommodate the rising demand, dams, diversions and groundwater drilling have proceeded “at an unprecedented pace and scale” (Postel 2002: 942). For example, since 1950, the number of large dams - those at least 15 meters high - has increased from 5000 to 40 000 (McCully 1996) and humans withdraw about one-fifth of the normal (non-flood) flow of the world’s rivers (WRI 2000: 28). The diversion, storage and withdrawal of water, in addition to the returned used water, have had significant ecological impacts (Gleick 1998). Dams, dikes, levees, and other hydraulic infrastructures are primary destroyers of aquatic habitat and disruptors of ecological functions, both down and upstream (Postel 2000: 943). Negative impacts of high water use include (and this list is far from exhaustive): the physical alteration of watercourses and ecosystems; eradication of watershed ecosystems due to flooding associated with dam inundation; changes in floodplain ecosystems; introduction of exotic parasites and other organisms during interbasin transfers; irreversible aquifer decline and saltwater intrusion from over-pumping and depletion of underground aquifers; destruction of aquatic habitat due to changes in the flow and temperature of water; and the introduction of barriers which impede fish migration.

The amount of water returned to a watercourse is often significantly less than the amount extracted (due to inter-basin transfer or evaporation, for example). The resulting reduced flows affect aquatic habitats and may disrupt seasonal fluctuations leading to the drying up of previously perennial rivers. Wetlands and estuaries are also detrimentally affected. For example, decreased freshwater flows into estuaries can result in increased salination and alteration of estuary ecosystems.

As discussed above, depending on the level of human modification, the returned water itself can have an ecological effect. Pollution, such as irrigation or industrial runoff, or more concentrated point source pollution, such as effluent from municipal sewage plants and factories or cooling water from power plants, can result in abnormal loads of energy, silt, nutrients and toxins, potentially jeopardizing an entire water course. Such pollutants cause problems such as eutrophication (where increased nutrients can lead to algal blooms and plant growth which can diminish habitats such as aquatic beds, and the corresponding higher levels of decomposition can lead to lower levels of oxygen below that required by fish, for example) and bio-accumulation (where toxins accumulate to higher and potentially lethal concentrations up the food chain).

Cumulatively, these impacts have significant consequences. For example, more than 20 percent of all freshwater fish species are now threatened or endangered because dams and water withdrawals have destroyed the free-flowing river ecosystems where they thrive (Gleick 2002: 3). The World Resources Institute (2000: 57) reports that freshwater species and habitats are highly threatened, more so than other ecosystems. Beyond threats to individual habitats and species, projected changes to aquatic ecosystems could undermine the health of whole ecosystems, at least regionally. This broad ecosystem threat is manifested by a ‘distress syndrome’, which includes reduced biodiversity, altered primary and secondary productivity, and increased dominance by smaller, shorter lived opportunistic species (Naiman and Turner 2000: 961). Therefore, large-scale human use of water will have significant individual impacts, but it could also collectively undermine system function and limit its ability to sustainably provide water and other benefits in the future.

3. Water supply in Canadian cities

"We're all downstream"

Ecologists' motto adopted by Margaret and Jim Drescher,
Wind Horse Farm, New Germany, Nova Scotia

Municipal water provision and its infrastructure are critical elements in the urban landscape. The development of water resources has been an integral part of human existence since the dawn of civilization. The ability to capture, store, purify and redirect freshwater resources has allowed humanity to successfully deal with irregular river flows and unpredictable rainfall. It is a basic requirement and an integral part of the economic and social development mix. Indeed, water infrastructure is a little noticed, but fundamental, shaper of the cultural fabric of nations and societies (Swyngedouw 2002; 1999).

As cities have grown, so has the ability to transport water over ever-increasing distances and in greatly varied environments through increased knowledge and technology. All present-day industrialized societies substantially alter hydrological cycles through massive construction projects for flood control, water supply, hydropower and irrigation. Urban water infrastructure expanded particularly dramatically in the latter half of the nineteenth century to meet the exponential increases in industrial and municipal demands (Gleick 2000).

Canadian cities, like many cities around the world, are beginning to confront the strains that growing water use places on the environment and on the financial capacity of local governments. On the supply side, higher levels of withdrawal produce on-going stresses on water sources, which, if unsustainable, drive new construction projects to access new supplies which further stress water sources. The consequence of this vicious circle is a dependance on ever more extensive, expensive and destructive infrastructure.

In this light, it is necessary to consider the potential benefits of reducing water use while still meeting genuine urban water needs in a more efficient and less costly manner.

3.1 Why look at cities?

Urban water use, and residential water use in particular, are important areas for study. They pose considerable challenges such as the cost of increasing supply infrastructure to meet increasing demand and environmental problems due to high use, and also show potential for decreasing use, such as simply addressing the current high levels of wastage and inefficiency.

Problems associated with current urban water use include:

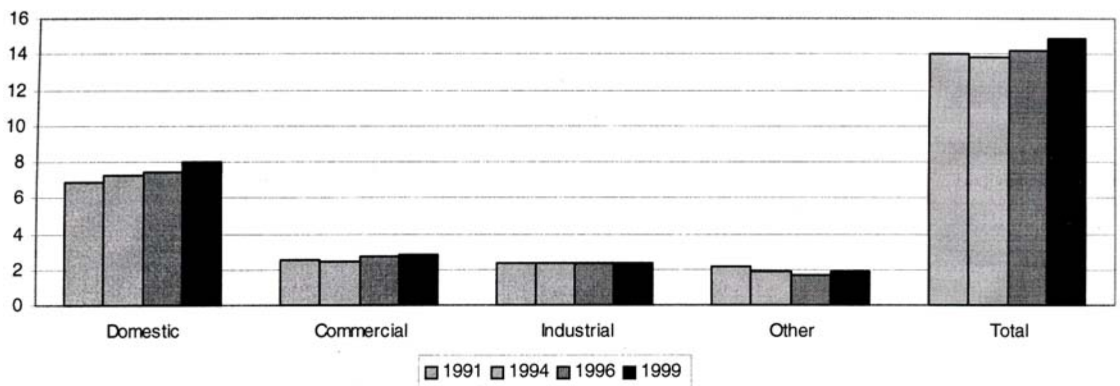
1) *The scale and scope of urban water use.*

   As discussed above, urban users in Canada consume over twice as much water per person as do those in many other industrialized countries, especially those in Europe. More than 80 percent of Canadians live in urban areas, and are served by municipal water supply (91 percent of total urban population) and some form of waste treatment systems, including simple forms of primary treatment such as screening (Tate 1997). As the third largest overall water user (12 percent of total water withdrawals in Canada), municipal use and disposal pose a serious threat to water supplies and aquatic environments (Environment Canada 2003).

2) *The rise in urban water use.*

Increasing populations and urbanization are two reasons for increasing urban water use, as discussed above. Between 1996 and 1999, total daily water use increased slightly in the residential (four percent), commercial (three percent), and 'other' (11 percent) sectors as a result of greater economic activity, warm summers (e.g. increased lawn watering), an increase in municipal population, and increased water supply connections to new residential areas (see Figure 3.1). A slight decrease occurred in the industrial sector over the same period (SOE 2001). Moreover, in Canada, per capita use is increasing. In 1999, total municipal water flows in Canada were the equivalent of 638 litres per person per day, an increase of approximately two percent from 1996 (SOE 2001).

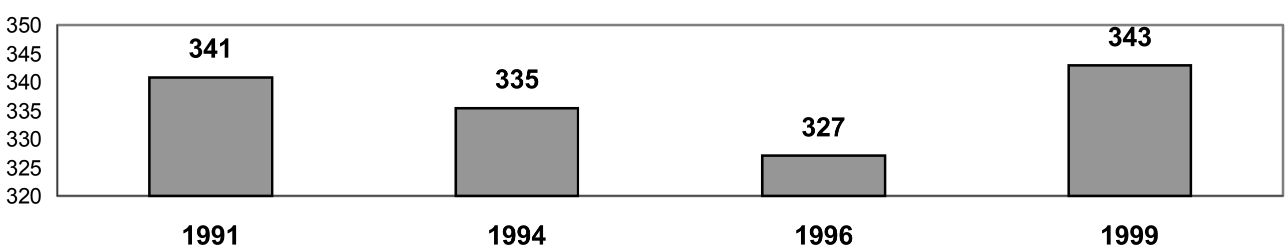
***Figure 3.1:* Total municipal water flows** (millions of cubic metres per day)



Environment Canada. 2001. *Municipal Water Pricing 1991-1999.* Ottawa: Environmental Economics Branch. [Electronic Version] Available at: http://www.ec.gc.ca/erad/.

Residential water use accounts for more than half of all municipal water use. As shown in Figure 3.2, following a steady decline from 1991 to 1996, per capita residential water consumption rose five percent to 343 litres per day in 1999. Commercial water use increased three percent from 2.74 to 2.84 million cubic metres per day between 1996 and 1999 (a fairly modest increase relative to the 13 percent commercial increase in water use between 1994 and 1996).

Figure 3.2: Canadian Residential Municipal Average Daily Water Flow *(Litres per Capita)*



Environment Canada. 2001. *Municipal Water Pricing 1991-1999.* Ottawa: Environmental Economics Branch. [Electronic Version] Available at: http://www.ec.gc.ca/erad/.

Urban Water Demand Management

3) *The cost of meeting future infrastructure needs.*

Most Canadian municipalities face problems related to water and wastewater services. About 26 percent of municipalities with water systems reported water shortages in the 1994 to 1999 period (the most recently available data), citing seasonal shortages due to drought, infrastructure problems and increased consumption as the most common reasons for these shortages (SOE 2001).

Expensive infrastructure expansion is one common response to increasing water shortages. According to the National Round Table on the Environment and Economy (1996), unmet water and wastewater infrastructure needs in Canada were $38-$49 billion in 1996. This is the estimated capital needed to ensure that existing capital stock and services are maintained. The Round Table projected that capital costs for the next 20 years would be in the order of $70-$90 billion, and such expenditures would be necessary just to maintain current levels of consumption. These levels of investment may not be sufficient if per capita consumption continues to increase according to projections.

4) *The ecological impact of urban water use.*

The ecological impacts of human water use, discussed in the previous chapter, are particularly applicable to urban water use because of the concentrated "full spectrum" stresses associated with developed urban areas. For example, bridges, drained wetlands and channelled rivers are all associated with urban development and have significant impacts on aquatic habitat. Industry and agriculture, often concentrated in and around urban areas, also affect local watercourses through withdrawals and pollution. Urban runoff (e.g. oil on streets, lawn fertilizers, and pet wastes) is washed into watercourses by rain or snowmelt and causes significant "non-point source" pollution in addition to point-source impacts coming from urban sewage. The cumulative negative impacts on urban watercourses are significant.

5) *The impact of high use on quality.*

The high quantity of urban use also affects the quality of urban water. Water quality issues have recently dominated the Canadian media. Outbreaks of waterborne disease have shaken many Canadians' confidence in the quality of their local drinking water. Incidents in Walkerton, Ontario and North Battleford, Saskatchewan, where poor treatment in municipal water facilities led to several deaths and thousands of residents becoming ill, have led many to question the capacity of local agencies to manage water supplies efficiently and effectively (see Figure 3.3).

The B.C. Auditor General's (1999) report noted four primary means for maintaining high drinking water quality:

- protection of the water sources,
- water treatment including disinfection,
- well designed and operated water distribution systems, and
- comprehensive testing of drinking water.

This 'multi-barrier' approach is important for ensuring high quality water from source to tap. Sierra Legal goes even further in suggesting important changes in the way we protect and treat drinking water in Canada (see figure 3.4). However, reducing the quantity of water used is another, and often forgotten, component to ensuring high quality water.

Figure 3.3: Surveying drinking water quality in Canada

After surveying jurisdictions across Canada, it is clear that there is tremendous variation in how different provinces and territories approach the important task of ensuring that public water supplies are safe for human consumption.

As things stand, the safety of drinking water supplies is a serious question in many parts of Canada. Not only are many provinces and territories found lacking when it comes to how frequently they require water to be tested, but the contaminants to be tested for are often narrowly defined and exclude potentially dangerous and, in some cases, carcinogenic substances… The inescapable conclusion from this first national drinking water report is that a number of provinces and territories are well behind pre-Walkerton Ontario. Unless things change, it is only a matter of time before circumstances combine to create another serious outbreak of waterborne disease.

Sierra Legal Defence Fund. 2001. *Waterproof: Canada's Drinking Water Report Card.* Vancouver: Sierra Legal Defence Fund, p.41.

In Canadian cities there really is no such thing as "drinking water". All of our municipal water is treated to drinking water standards, whether we flush it down the toilet, wash our cars with it, use it to water the lawn, or drink it. Thus, an inextricable link exists between quality and quantity: the more water flowing through the supply infrastructure, the more water must be treated to (costly) drinking water standards. Yet, only about one-quarter to one-third of municipal water use (for cooking, cleaning, bathing and some outdoor uses) requires such high quality standards. Increasing overall demand for water applies pressure to the supply infrastructure to ensure that all water is treated to the quality standards for drinking water. Conversely, decreasing the amount of water requiring treatment could result in an increase in available resources to treat drinking water.

3.1.1 Summary

Instead of increasing supply, with the associated infrastructure costs and increased ecological and quality problems, managing demand appears to be a compelling alternative for urban water. As previously indicated, Canadians are one of the largest per capita consumers of urban water in the world, and there is substantial evidence of inefficient use. For example, system leaks may comprise as much as 30 percent of some municipal water usage (SOE 2001). Many other industrialized nations have succeeded in lowering urban water use while Canada's level of consumption has continued to grow, suggesting that there may be significant room for institutional innovation for water conservation in Canada. A recent study on water conservation conducted by the Canadian Mortgage and Housing Centre concluded that, "water conservation programs are successful in reducing water consumption, as well as achieving savings in capital and operating costs. Such programs can be highly cost-effective and should be integrated into long-range water supply planning " (Waller et al. 1998).

3.2 Governance and municipal water management

Before one can understand the barriers and opportunities for change and innovation in the urban context, it is necessary to consider some of the special characteristics of urban water management. These include the different categories of municipal water use, the nature of governance and service delivery in cities, varied pricing structures, and water treatment.

3.2.1 Categories of municipal water use

Four different categories of use exist for municipal water: domestic (or residential), commercial and institutional, industrial, and "other".

Domestic (or Residential): Water used in the home or residential setting, including single and multi-family units. The terms 'domestic' and 'residential' are used interchangeably.

Commercial and Institutional: Water used by commercial entities such as businesses, stores and restaurants, and institutions such as universities, hospitals or care facilities (some municipalities include large multi-family units, such as apartment complexes, in this category).

Industrial: Water used by a broad range of industries in manufacturing or resource production. This category only includes those industries that draw water from a municipal source, usually smaller establishments with a requirement for high quality water, such as those in the beverage industry. Of all manufacturers surveyed in 1996, nine percent derived their water from public utilities (Environment Canada 1996). Many of the larger industrial water users (such as paper and allied products or chemical products) draw water directly from separate private sources and so are not included in the municipal use class. Industrial water users in the municipal context use a relatively smaller share of water.

Other: This catch-all category includes other municipal uses (firefighting, system flushing, etc.), system losses (such as leakages from the supply infrastructure) and unaccounted water use.

***Figure 3.4*: Changes needed to protect drinking water**

The survey results contained in *Waterproof: Canada's Drinking Water Report Card* point toward the need for some basic changes in the way we protect and treat drinking water in Canada. The key recommendations are:

- Make drinking water protection mandatory.
- Enact comprehensive watershed and wellfield protection.
- Make the *Guidelines for Canadian Drinking Water Quality* binding across Canada.
- Require training and certification for the operators of public water systems.
- Enact stringent reporting requirements and establish right-to-know provisions for water consumers.
- Give citizens the right to sue jurisdictions that fail to meet water standards, as is allowed in all US states and territories.
- Increase federal funding for the construction and renewal of water treatment and delivery infrastructures, making the funding contingent on meeting water protection requirements.

Sierra Legal Defence Fund. 2001. *Waterproof: Canada's Drinking Water Report Card.* Vancouver: Sierra Legal Defence Fund, p.5.

3.2.2 Governance and service delivery [8]

Urban water supply has traditionally been a local public service under provincial regulation, with the municipal utility directly managing water and wastewater services in most cities in Canada. Funding is usually shared by all three major levels of government. Many water utilities in Canada, especially those in larger urban centres where regional authorities are made up of several municipalities, manage the service and run on a not-for-profit basis. Where such regional authorities exist, water is delivered to the municipalities at a rate that covers the costs associated with the overall water supply system, and the municipalities then establish rates and billing policies for their individual customers.

Although the norm in Canada is for government-owned and operated water utilities, the level of autonomy is variable (Bakker 2002: 17). Corporatized municipal utilities that operate as autonomous financial entities, yet are accountable (at least politically) to local government, are one example (such as in Edmonton). The most widespread arrangement in Canada, however, is a water department that is under direct control of the Mayor's office and lacks a separate financial budget (such as in Charlottetown, Winnipeg, and Regina, to name a few).

[8] For an excellent discussion of governance in water and wastewater services in Canada, see Bakker with Cameron, 2002. *Setting A Direction In Hamilton: Good Governance in Municipal Restructuring of Water and Wastewater Services in Canada.* Like the present report, this publication is also a product of the Walter and Duncan Gordon Foundation's project on water.

3.2.3 Pricing: flat vs. volume-based rates

The rate schedule of individual water utilities governs the price charged to customers. Although there are a variety of rate schedules used throughout Canada, they fall into two general categories: flat and volume-based rates.

- *Flat Rates*

Consumers are charged a fixed amount in each billing period, regardless of the volume of water used. Many municipalities choose this option because it is perceived to be simpler for both customers and administration. Municipalities determine flat rate charges through estimates of expected consumption and the cost of providing the service. A flat rate can also be charged on an 'assessed' basis using property values or property taxes as a proxy. Flat rate pricing structures provide little incentive to reduce water use by individual customers. Instead, municipalities may try to control water demands through legal and administrative measures such as lawn watering restrictions, often with limited success (Environment Canada 2001).

- *Volume-Based Rates*

As its name implies, the consumer's water bill varies with the amount of water used. Various rate structures exist, ranging from a *constant charge* (individual unit prices remain constant regardless of the amount used), *declining block rates* (individual unit prices decrease in cost as more units are consumed) and *increasing block rates* (individual unit prices increase as more units are consumed). All these options require water meters be installed to measure consumption and all have different impacts on patterns of consumption.

3.2.4 Water treatment [9]

Prior to delivery, municipalities use a combination of procedures to purify and disinfect water to ensure its quality for domestic consumption. The authors of the *Guidelines for Canadian Drinking Water* emphasize control of sediment and organic material as a key element of an integrated water treatment program (Health Canada 1996). To deal with sediment (or cloudy water), water is filtered through various mediums such as sand or anthracite. In more advanced processes sediment is removed through coagulation. However, it is important to note that filtration of drinking water is not common in Canada (Boyd 2003)

Following filtration, most water providers and public health officials require the use of disinfectants such as chlorine, chloramine (a mixture of chlorine and ammonia), ozone, or ultraviolet light to kill potentially harmful micro-organisms. Due to the threat of re-growth in distribution pipes (which can contribute to outbreaks of disease) a 'residual' disinfectant is often left in drinking water. Water authorities and health officials also employ a variety of tests that involve assessments of chemical, physical and microbiological properties on a daily, weekly, or annual basis, depending on the type of test. Given that existing infrastructure treats all water to drinking water standards, significant disincentives exist for separating different forms of water use in order to provide varied levels of treatment as appropriate (such as lower quality water for certain non-drinking purposes).

[9] For a good discussion of the entire water treatment and delivery system, see Sierra Legal Defence Fund, 2001. *Waterproof: Canada's Drinking Water Report Card.*

4 Urban water: a snapshot of twenty Canadian cities

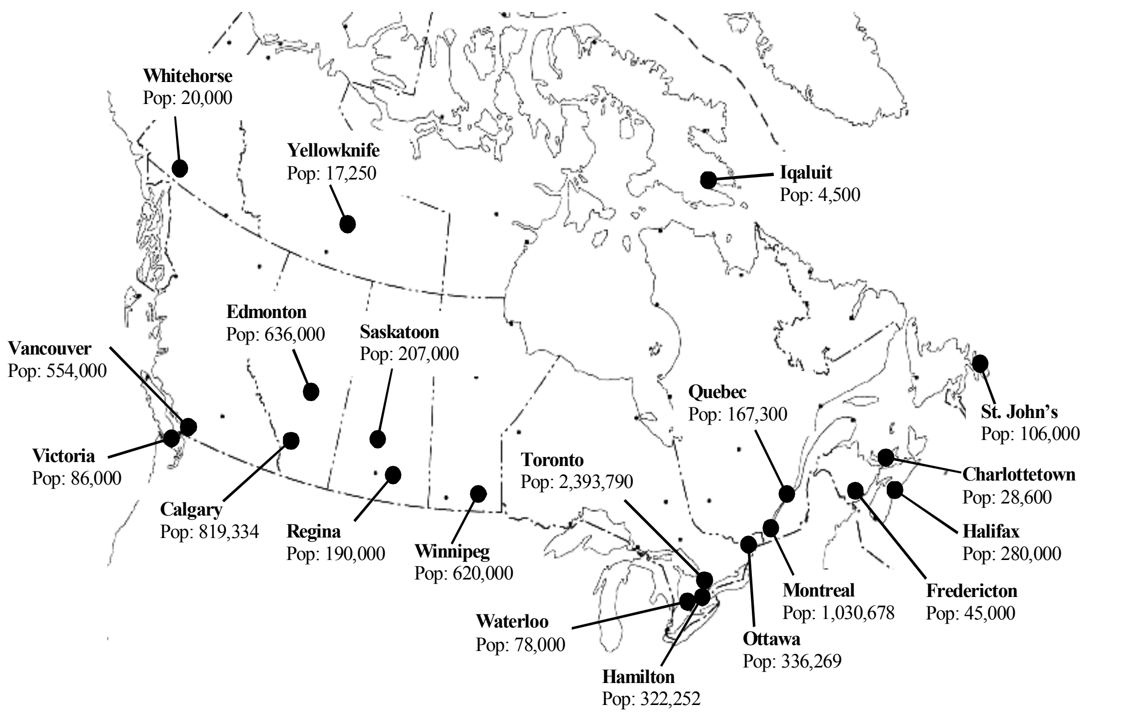
"Millions have lived without love. No one has lived without water"

Turkish businessman, quoted in Mark De Villiers, *Water* (2000)

In the previous chapters we have seen that water use in Canada is rising. An international comparison shows Canada to be one of the highest users in the world. Potential consequences of such high and rising use are ecological stresses, quality concerns, and regional and seasonal shortages due to over-extended local water supplies and supporting infrastructure. Furthermore, the scale and scope of urban water use coupled with the existing state of wastage and inefficiency in the urban setting suggest opportunities to reduce water use patterns with little impact on lifestyles or quality of living standards for Canadians.

To gain a better understanding of municipal water use in Canada, this chapter compares water use in twenty selected cities across Canada. These cities represent a total population of about eight million, approximately one-third of those Canadians who are supplied with water from municipal sources. Individual city water use profiles are included in Appendix A, and some broad observations from that data are presented here. The cities studied were chosen to provide a cross section of urban centres across the nation, and to represent cities with regional or national significance (see Figure 4.1).

Figure 4.1: **The 20 chosen cities and populations served by municipal water systems, 1999**



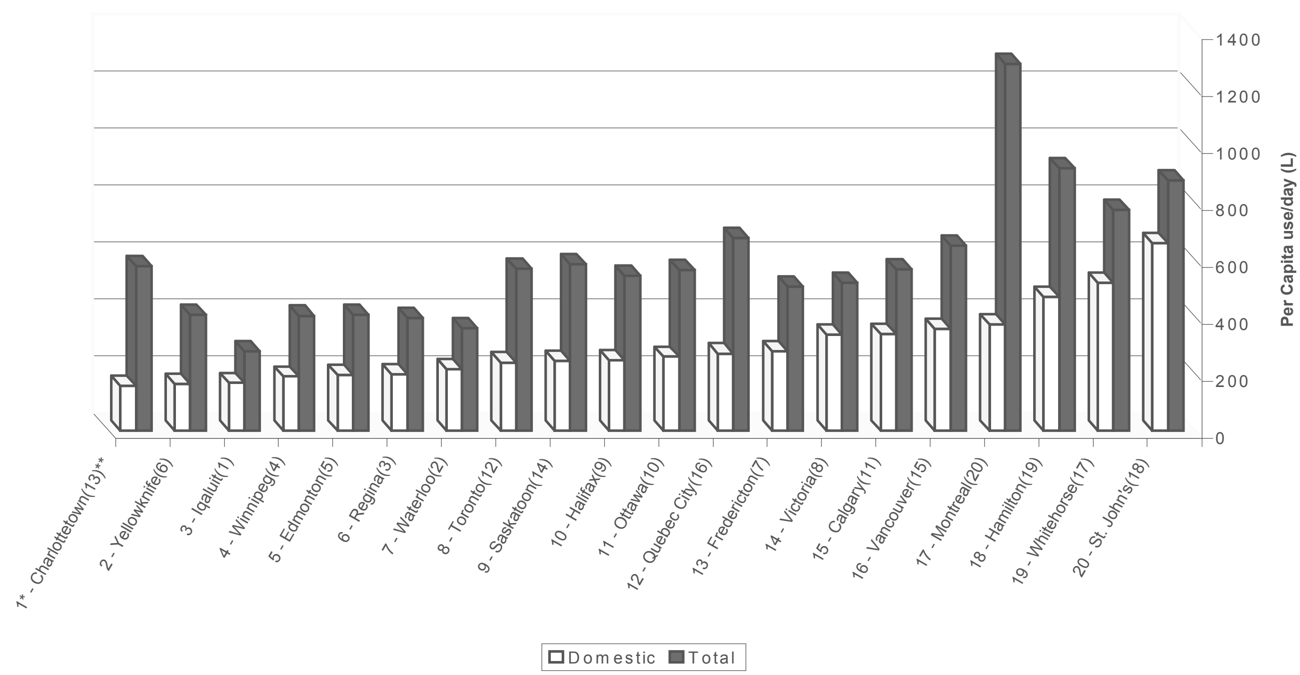
Urban Water Demand Management

The statistical information used in the city profiles is derived from Environment Canada's Municipal (Water) Use Database (MUD). The MUD database is "designed to provide easy access to basic data on municipal water and wastewater. This database currently contains water sewage systems information from 1,359 Canadian municipalities with populations over 1,000" (Environment Canada, 2003). Environment Canada updates this database every three years through the use of a voluntary survey and questionnaire. 1999 is the most recent data available.

4.1 Variations between Cities

In Figure 4.2, the twenty selected cities are ranked according to their total and domestic per capita daily water use in litres. Rankings have been compiled so that the city with the "best performance" (i.e. lowest per capita water use) is ranked 1st, and the worst ranked 20th.

Figure 4.2: **Domestic and total per capita daily water use and rankings for 20 selected Canadian cities, 1999**



*Cities ranked by *domestic* per capita daily water use
**The value in ( ) indicates the comparative ranking by *total* per capita daily water use
Data source: Environment Canada MUD database

A wide range in water consumption patterns exists amongst the cities examined. Charlottetown (156 litres), Yellowknife (164 litres), and Iqaluit (167 litres) were the lowest daily per capita domestic water users, while Hamilton (470 litres), Whitehorse (519 litres), and St. John's (659 litres) were the highest. This represents a fourfold difference between the highest and the lowest domestic users.

Urban Water Demand Management

In terms of total per capita municipal use, Iqaluit (278 litres), Waterloo (359 litres), and Regina (395 litres) were the three lowest users, while St. John's (878 litres), Hamilton (921 litres), and Montreal (1287 litres) were the three highest users. This again represents a fourfold difference from the highest to the lowest.

This substantial variation in water use across Canadian cities is not easily explained. Many factors could influence water use, from the physical environment and the nature of the city and its infrastructure, to local social attitudes, making it difficult to discern important common variables affecting use. Some potential factors are discussed in more detail below.

4.2 Trends

In addition to the wide variance in water use between the 20 cities, some cities reported significant changes in water use throughout the 1990s (see Figure 4.3). Some of these changes (which in some cases are reported as over 50 percent in a three year period) are due to inadequate data (such as population figures not being regularly updated), or because of changes in measurement and accounting techniques. The latter occurs, for example, where a municipality shifts a particular water use, such as apartment use, from one sector to another. because certain users shifted outside of municipal water supply to their own supply, or because of municipality boundary changes, etc. Clearly, better quality and more consistent data collection is required.

Figure 4.3: **Trends in water use in the selected cities through the 1990's**

	Total per capita use per day				Domestic per capita use per day			
	91-94	**94-96**	**96-99**	**91-99**	**91-94**	**94-96**	**96-99**	**91-99**
Charlottetown	-13.5%	-11.1%	5.7%	-18.7%	-13.5%	-0.5%	1.9%	-12.3%
Yellowknife	-2.5%	-27.3%	5.9%	-25.0%	-56.9%	-21.5%	4.3%	-64.7%
Iqaluit	-2.9%	-20.6%	-5.8%	-27.4%	94.2%	-29.5%	-20.4%	8.9%
Winnipeg	-1.6%	-15.7%	-1.2%	-18.0%	26.5%	-15.7%	-14.0%	-8.3%
Edmonton	-5.6%	-2.9%	4.3%	-4.4%	-1.9%	-17.7%	35.4%	9.3%
Regina	-11.2%	-12.4%	4.2%	-18.9%	-0.3%	-12.4%	13.3%	-1.1%
Waterloo	0.0%	-8.4%	0.0%	-8.4%	0.0%	-8.4%	-4.8%	-12.8%
Toronto	6.1%	17.5%	-19.9%	-0.2%	59.1%	17.5%	-25.2%	39.8%
Saskatoon	-26.6%	-6.5%	16.0%	-20.4%	-28.4%	7.8%	8.3%	-16.4%
Halifax	6.6%	-24.5%	2.1%	-17.8%	6.6%	-11.3%	-1.5%	-6.9%
Ottawa	-10.7%	-0.1%	-0.6%	-11.3%	-10.7%	0.0%	-0.7%	-11.3%
Quebec	0.3%	-1.8%	0.2%	-1.3%	0.3%	-34.5%	0.2%	-34.2%
Fredericton	-5.4%	4.7%	-1.3%	-2.3%	-5.4%	14.2%	-9.5%	-2.3%
Victoria	24.4%	-18.4%	-4.3%	-2.8%	24.4%	47.3%	-4.3%	75.4%
Calgary	-15.9%	-0.8%	7.5%	-10.2%	-15.9%	32.3%	15.2%	28.3%
Vancouver	-13.5%	-5.9%	1.3%	-17.6%	-13.5%	-9.0%	-4.0%	-24.5%
Montreal	0.8%	-2.2%	1.4%	0.0%	0.8%	9.6%	5.1%	16.1%
Hamilton	0.0%	3.8%	17.8%	22.2%	15.9%	3.8%	17.8%	41.7%
Whitehorse	-22.9%	-1.2%	-4.9%	-27.6%	-78.4%	67.6%	59.3%	-42.2%
St. John's	9.3%	0.6%	3.4%	13.7%	63.9%	0.6%	3.4%	70.5%
Average	**-4.2%**	**-6.7%**	**1.6%**	**-9.8%**	**3.3%**	**2.0%**	**4.0%**	**2.7%**

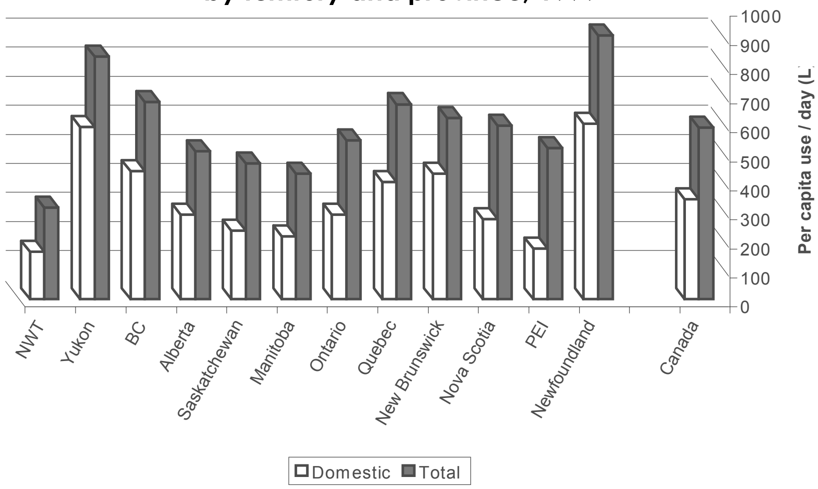
Source: Environment Canada MUD Database

Keeping in mind the data quality concerns just mentioned, Figure 4.3 suggests an average decrease in total per capita municipal water use for the 20 cities throughout the 1990s, and an average steady increase in domestic use. The latest period, 1996-1999, however, shows an increase in both total and domestic use, with about half the cities registering a significant increase in both.

4.3 Regional differences

Figure 4.4 shows the territorial, provincial and national averages for domestic and total per capita daily municipal water use. The data exhibits some regional differences in water use across Canada. In particular, the Prairie provinces (Alberta, Saskatchewan, and Manitoba) use relatively less water, while some of the wetter coastal provinces (such as British Columbia, New Brunswick and Newfoundland) use relatively more water. Urban water use in other coastal provinces, however, such as domestic use in Nova Scotia and Prince Edward Island, are relatively low.

Figure 4.4: **Domestic and total per capita daily water use by territory and province, 1999**

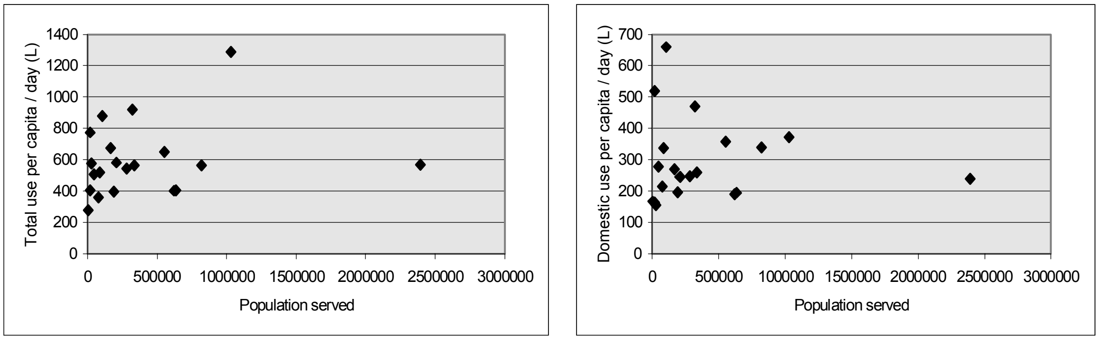


Source: Environment Canada MUD database

Additionally, there are many significant intra-regional differences. For example, Calgary and Edmonton, similar sized cities that are relatively close geographically, have noticeably different per capita daily water use (Calgary uses 339 litres domestically and 566 in total, whereas Edmonton uses 195 domestically and 406 in total). In the north, Yellowknife and Iqaluit residents (164 and 167 litres per day domestically) use less than a third of the water used by Whitehorse residents (519 litres per day). The Atlantic region is similarly varied. Charlottetown, for example, has the least domestic per capita use, Halifax is in the middle (ranked 10th in domestic water use), and St. John's has the highest domestic per capita use of the cities studied.

In conclusion, although regional differences and associated water availability possibly affect municipal water use, other important factors are at play.

Figure 4.5: **Total and domestic per capita daily water use by population served, 1999**



Source: Environment Canada MUD database

4.4 City size

The size of the city was also a non-determinative factor in the water use comparisons. As shown in Figure 4.5, no correlation exists between city size and water use for the 20 studied cities. Some smaller cities like Regina and Waterloo had relatively low domestic (approximately 200 litres) and total (between 350 and 400 litres) per capita daily water use, while other similarly sized cities, such as Hamilton and St John's, had per capita water uses two to three times higher. The larger cities (populations over 500,000, namely Winnipeg, Edmonton, Toronto, Calgary, Vancouver and Montreal) were also varied, ranging from a low in Winnipeg of 190 litres per capita per day in domestic use to a high in Montreal of 470 litres, and a low total per capita per day use in Winnipeg of 403 litres to a high of 1287 litres in Montreal.

4.5 Municipal water use by sector

Figure 4.6 shows each city's percentage of municipal water use by sector, ranked in order by total litres per capita per day (lcd) water use. Although the table indicates substantial variance between cities and the percentage of water that is used in the different municipal sectors, little correlation seems to exist between the city rank and the proportion of water use in any given sector.

Figure 4.6: **Municipal water use percentages by sector, 1999**

Domestic Water Use (lcd) Rank	Total Water Use (lcd) Rank	City	Domestic %	Commercial & Institutional %	Industrial %	Other %
3	1	Iqaluit	60	10	25	5
7	2	Waterloo	60	19	14	7
6	3	Regina	50	15	22	13
4	4	Winnipeg	47	25	13	15
5	5	Edmonton	48	24	23	5
2	6	Yellowknife	41	28	30	1
13	7	Fredericton	55	30	10	5
14	8	Victoria	65	23	1	11
10	9	Halifax	46	17	17	20
11	10	Ottawa	46	29	1	24
15	11	Calgary	60	21	2	17
8	12	Toronto	42	29	21	8
1	13	Charlottetown	27	53	10	10
9	14	Saskatoon	42	28	14	16
16	15	Vancouver	55	30	5	10
12	16	Quebec City	40	25	15	20
19	17	Whitehorse	67	20	13	0
20	18	St John's	75	10	10	5
18	19	Hamilton	51	30	11	8
17	20	Montreal	29	15	19	37
		Canadian Average	**52**	**19**	**16**	**13**

Source: Environment Canada MUD Database

A potential reason for the lack of correlation may relate to the reporting of information by the individual municipalities. For example, as noted above, some municipalities include large apartment blocks in the 'commercial and institutional' sector while others include them as part of the 'domestic' sector. Further, some cities (likely those without full metering) may be including some leakages or unaccounted water in the domestic, commercial or industrial sector. Again, more consistent data collection is required.

Despite the lack of conclusive sectoral influence, two important conclusions can be drawn. First, domestic (or residential) water use is a significant sector of water use in all the cities. It is generally the largest sectoral use of municipal water, ranging from 27 percent in Charlottetown to 75 percent in St. John's, with most cities between 45 and 60 percent, consistent with the Canadian average of 52 percent.

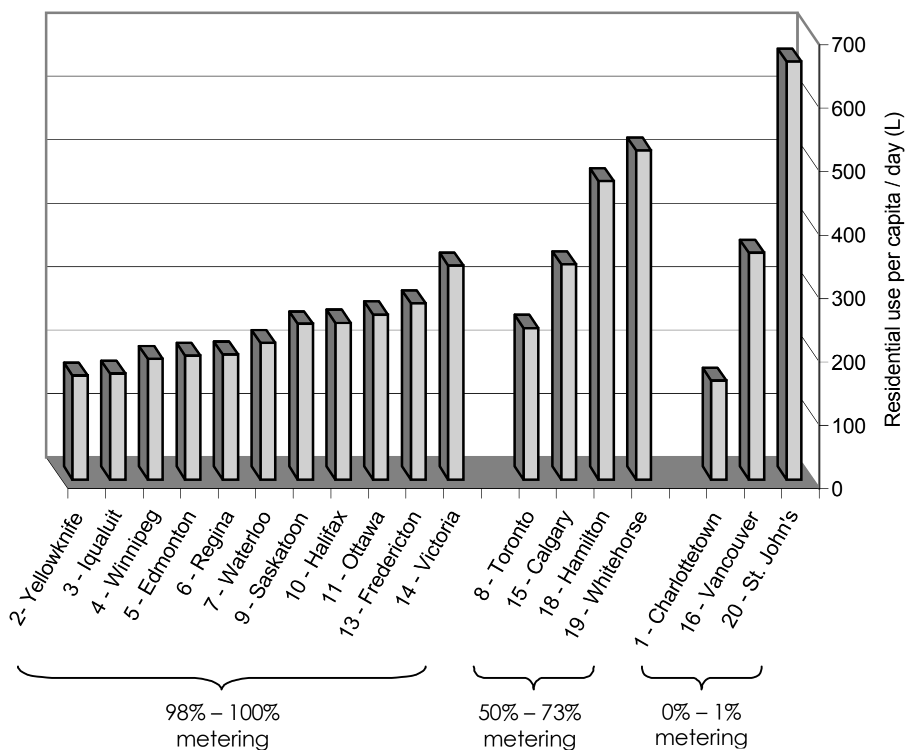
Second, unaccounted water (included in the 'other' category in Figures 2.5 and 4.6) is a noteworthy portion of total municipal water use. It is natural to expect some water losses from any water supply system, since some are likely beyond the control of the water service provider. Others, however, are within the control of the service provider and require monitoring and action. Given the wide variance of this category in the studied cities (with a high of 37 percent in Montreal, a low of 0 percent in Whitehorse, and an average of 13 percent in Canada) it is likely that many opportunities to reduce water wastage exist by simply locating sources of unaccounted water and fixing leakages.

4.6 *Meters and pricing*

Residential water metering is prerequisite to any volume based pricing structure. Of the municipalities surveyed only 11 of the 20 studied cities (55 percent) had full, or near-full, domestic metering. An additional four had at least half metering. The existence of meters generally corresponded to the use of volume-based pricing structures.

The presence of meters and volume-based pricing structures roughly correlated with lower domestic per capita water use. As shown in Figure 4.7, eight of the 10 lowest per capita domestic water users had full domestic metering and employed a volume-based pricing structure. Only Charlottetown, of the lower users, employs an exclusively flat rate pricing structure. Conversely, only three of the 10 higher per capita water users had full domestic metering (Note: no information was available for Montreal or Quebec City).

Figure 4.7: **Residential use grouped by percentage metered, 1999**

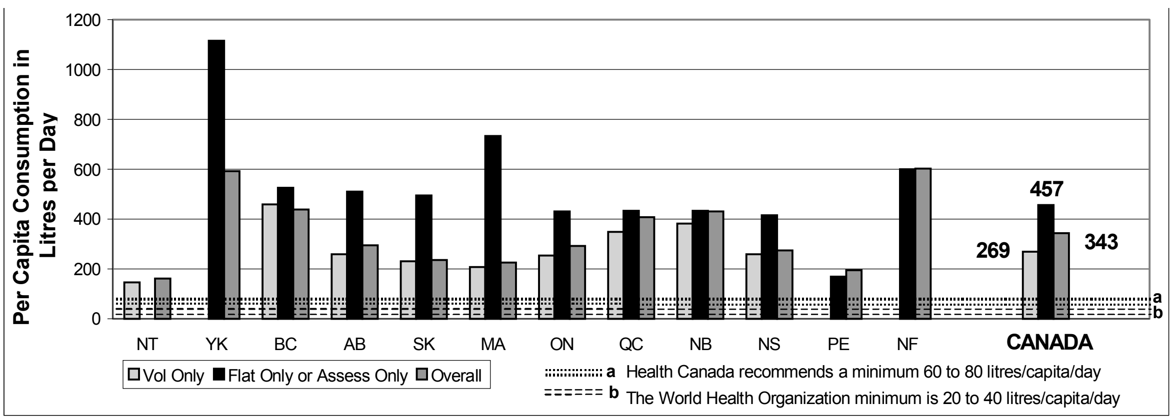


Source: Environment Canada MUD database

A relationship between pricing structure and per capita water use can also be seen at more aggregate levels. As shown in Figure 4.8, in 1999, Canadians whose pricing structure was volume-based, used on average 269 litres per person per day residentially. Those paying flat or fixed assessed rates used 457 litres per person per day (70 percent more water than those under a volume-based structure). This relationship is similarly apparent in most provinces and territories, where significant differences between per capita water use are observed when volume based and flat rate pricing structures are compared.

The above city comparisons, together with these national and provincial averages, provide compelling evidence that increased use of individual household metering and volume-based pricing correlates to decreased water use.

Figure 4.8: **Residential water consumption by pricing method by province, 1999**



Environment Canada. 2001. *Municipal Water Pricing 1991-1999.* Ottawa: Environmental Economics Branch, at p.10

4.7 The need for further study and better information

To understand the full causes of the fourfold variance in water use in cities across Canada will require further study. To allow for such studies, and to assist water managers to better compare and assess water use in their region and across Canada, a number of improvements in data gathering and dissemination are required. In particular, universal metering and national, harmonious data collection on water use would provide detailed and consistent information.

Currently, only aggregate municipal level water use (broken down into the four broad sectors outlined above) is collected on a national basis. This data is provided voluntarily by mail-out survey and phone contact, with limited quality control. The ability to monitor water flow at various scales (from aggregate municipal use to neighbourhoods to individual households), by category of use (such as outdoor versus indoor use, or drinking water versus water used for toilet flushing), and by user (water delivered to categories of businesses with similar functions, for example, retail stores or restaurants) could provide water managers with valuable information to target specific end uses, and institute appropriate water use reduction programs.

Such data could also enhance water demand forecasts and models to ensure accurate and responsive strategies, opportunities to compare conservation programs, and provide insights into variables determining the levels of water use. It would also be useful to collect data on the cost of conservation and efficiency measures from various locations, using a consistent methodology. Finally, it is also necessary to agree on a set of nationwide category and sector definitions, to ensure common understanding among researchers, regional managers and data users.

4.8 Summary

The underlying reasons for the high variance in water use across the cities in the study are not immediately obvious. Factors such as city size and the proportions of each sector have no apparent correlation. However, regional differences, metering and pricing structure did exhibit some correlation. Many other factors potentially influence water use at the municipal level, such as local climate, nature of the source (e.g. river, reservoir, or groundwater), availability and quality of supply, the existence and character of downstream users, ownership of the catchment area, reserve storage, age of infrastructure, prices, governance and decision-making structure, demographics, housing types, and other socio-economic factors.

Although there are few clear connections, aside from pricing structure, between the cities studied and the causes of their water use differences, an important conclusion can be drawn. The existence of a fourfold variance in water use across the 20 cities suggests that a significant potential exists to reduce urban water use without necessarily affecting the quality of urban life, by simply adopting readily available best practices and programs. This conclusion is reinforced when one considers the significantly lower per capita water use in most foreign jurisdictions.

Urban
Water
Demand
Management

5 The potential for demand-side management

"The water crisis is essentially a crisis of governance"

Water for People Water for Life
The United Nations World Water Development Report – 2003

In most parts of the world, increasing the supply continues to dominate as the strategy of response to rising demand for water. However, motivated by an understanding that freshwater resources are finite, many regions are rethinking this historical approach to managing freshwater resources. In addition, water policy increasingly points to the importance of incorporating ecological values into water management, and the need to break the link between economic growth and growth in water use (Gleick 2000).

Faced with growing populations and infrastructure costs associated with urbanization and urban sprawl, many foreign municipalities are shifting their attention to strategies that promote improved efficiency (see Figures 5.1 and 5.2). They seek to reduce short-term pressures for water supply, meet future needs by managing demand, and reallocate water among users. Many jurisdictions in western Europe, Israel, Australia and parts of the United States are structuring their water management regimes based on the understanding that it is *how* the resource is used that affects a region's water welfare.

Figure 5.1: **Water conservation**

In general, water conservation programs that focus aggressively on each customer sector can expect to see the largest savings, with overall demand reductions averaging about 20 percent after the first five years of the program. Such savings reflect the amount of waste in a system, the resources committed to water efficiency, and the effectiveness of the program's design and management.

Vickers, A. 1993. "Municipal Water Conservation: Designing a Program to Meet Your System's Needs". In D Shrubsole and D Tate (Eds.). *Every Drop Counts*. Cambridge: Canadian Water Resources Association, p.93.

Peter Gleick (2003: 1), a prominent international water expert, in a recent statement before the Subcommittee on Water Resources and Environment (part of the Committee on Transportation and Infrastructure of the United States Congress), expressed a commonly held sentiment among many progressive water managers and policy observers: "Water conservation and efficiency arethe greatest untapped sources of water in the nation – cheaper, cleaner, and more politically acceptable than any other alternative". Sandra Postel (1997: 191), author and water researcher at the World Watch Institute, put this sentiment in its broad context: "The 'last oasis' of conservation, efficiency, recycling, and reuse is large enough to get us through many of the shortages on the horizon, buying time to develop a new relationship with water systems and to bring consumption and population growth down to sustainable levels."

***Figure 5.2:* Benefits of water efficiency**

Wringing more work from each drop of water sustains vital water supplies, lowers water bills, reduces the need fo wastewater treatment, protects the environment, and creates wealth. Everybody wins:

- **Consumers.** Installing water-efficient faucets, showerheads, toilets, and other devices can substantially reduce household water and sewage bills, and it can save even more money on energy for heating water. The use of these devices may also reduce or eliminate such problems as an overflowing septic tank. And don't overlook the comfort factor—an efficient showerhead lets twice as many people use the shower before the hot water runs out!
- **Communities.** Some communities are physically short of water, or at least of uncontaminated water; some must pay expensive pumping costs; and many are seeking ways to avoid paying enormous capital costs to increase water storage or wastewater treatment capacity. Local budgets can be stretched only so far. A community that avoids building a larger water or wastewater facility will have more money for other services.
- **Utilities.** Increasing water efficiency can enable utilities to reduce baseload and peak demand, making it possible to postpone or avoid tapping new supplies, expanding storage, or expanding treatment facilities. Programs that promote efficiency can enable a utility to achieve more predictable patterns of demand and buy time for effective long-term planning. For these reasons, many utilities offer rebate programs that enable customers to install efficient fixtures at a reduced price or for free, thus saving consumers even more money.
- **Companies.** Using water more efficiently can reduce operating costs, often including fuel, chemicals, and labour.
- **The environment.** Water not consumed can save a river from a dam and a wetland from destruction. Water not heated with fossil fuel means oil or gas not depleted, coal not burned, carbon not released to cause global warming, and sulphur not deposited as acid rain.
- **The economy.** Money not spent on wasted water and energy is used more productively to create jobs and strengthen local businesses.

Rocky Mountain Institute.
Available at http://www.rmi.org/sitepages/pid280.php

5.1 What is demand-side management?

Supply-oriented approaches treat water as a virtually limitless resource, resulting in water policy that continually seeks out new sources of supply to respond to increasing demand. This approach assumes demand is a given, and often results in the construction of large-scale projects such as dams or water diversion projects, and high throughput urban water systems. Relying primarily on growth projections and financial costs, this supply side orientation rarely takes full account of environmental or economic impacts.

In general, demand-side management (DSM) fundamentally differs from supply-side management in that it considers that new supplies may be too costly, and that consumer demand is subject to influence on a more cost-effective basis. Generally, DSM is defined as "reducing the demand for a service or resource, rather than automatically supplying more of the service or resource being sought", and is increasingly viewed as a tool for promoting sustainability in sectors such as transportation and energy provision (Curran 2000: 18) (see Figure 5.3).

In the water context, DSM involves a broad range of measures that aim to increase the efficiency of water use. Brooks and Peters (1988: 3) define water demand management as "any measure that reduces average or peak withdrawals from surface or ground water sources without increasing the extent to which wastewater is degraded". Experience in both the US and Canada has shown that DSM can be very effective in the water sector (see Figures 5.4 and 5.5)

***Figure 5.3:* A parallel with energy**

There are many analogies between the post 1973 experience with energy and what is now occurring with water. Both water and energy have been priced below true costs; in both cases, environmental damage occurs at the production and release stages; both are governed by institutions that are geared to augment supply rather than to manage demand; and both are so widely used that many people doubt that conservation can be an effective force.

Brooks D, and Peters R. 1988. *Water: The Potential for Demand Management in Canada.* Ottawa: Science Council of Canada, p.3.

5.2 The water 'soft path'

DSM, when viewed as a comprehensive water management approach, is often associated with the concept of the 'soft path' for water (Hawken et al. 1999, Brooks 2003, Gleick 2002a). The water soft path, which is similar to and takes its name from, the energy soft path of the 1970s (Lovins 1977) (see Figure 5.6), places an emphasis on increasing efficiency in end use, avoiding system losses or leakage, providing incentives to reduce use, and matching supply quality and quantity with appropriate end use. To illustrate this last point, supply and treatment could provide water of varying character by integrating downstream treatment facilities with reuse opportunities, whether in individual households for toilets and lawns, or across sectors such as irrigation in agriculture.

***Figure 5.4:* DSM reduces water use**

- Metropolitan Water District of Southern California dropped water use 16 percent from 1990, despite a 14 percent increase in population.
- Smart conservation and smart watershed management has saved New York City billions of dollars in avoided expenditures for new supply and water and wastewater treatment plants. Total water use in 2001 was 25 percent below the level of 1979, a savings of 375 million gallons per day.
- Water-efficiency programs in Boston area have reduced water use 30 percent since the late 1980s and eliminated the need for a new dam.
- Albuquerque reduced per-capita water use 30 percent between 1989 and 2001 with toilet and washing machine rebate programs, and landscape retrofits.
- The City of Seattle has grown 30 percent since 1975 but total water use has remained the same through strong conservation programs. Over this period per-capita use has dropped from 150 gallons per person per day to around 115 gallons per person per day.
- Steel manufacturing in the US used to require 200 tons of water to make a ton of steel. Today, the best steel plants use 3 to 4 tons of water per ton of steel.
- Drip and precision sprinkler systems can both boost crop yields and reduce water demands.

Gleick, P. 2003. "Water: Is it the 'Oil' of the 21st Century". *Testimony of Dr Peter Gleick before the Subcommittee on Water Resources and Environment of the Committee on Transportation and Infrastructure, United States Congress,* p.3. June 4, 2003. Available at www.pacinst.org

Figure 5.5: Waterloo, a Canadian water conservation example

Waterloo is Canada's largest metropolitan area dependent on groundwater for its supply. In the mid-seventies, signs of over pumping led officials to explore other options. Through pricing, education, and the distribution of water-saving devices to make home plumbing fixtures more efficient, the Waterloo program has made conservation an effective part of its long-term water strategy. Overall Waterloo's per capita water use fell 10 percent in just the first three years.

Postel, S. 1997. Last Oasis – Facing Water Scarcity. New York: Norton and Company, p.152

Ultimately, this 'soft path' aims to provide the water requirements for both society and the environment, and goes beyond efficiency by asking managers and policy makers to rethink how, and what, we use water for (Gleick 2002b). For example, water itself is rarely an end (except for drinking, food preparation and bathing), but instead it is often simply 'used' to accomplish certain tasks, like sanitation (e.g. toilet flushing), food production (e.g. irrigation to grow cash crops that might not be appropriate to a given area), or providing pleasing environments (e.g. lawn watering). Such water 'uses' beg the question of why use water at all? Viable alternatives would include dry sanitation, developing appropriate agriculture with rain-fed techniques, and landscaping with drought resistant native plants. The soft path approach uses a method known as 'backcasting' (Brooks 2003). Rather than forecasting future demand based on previous trends, a preferred and sustainable future is defined, and the analysis then works backwards to find feasible paths from the present to that future situation.

5.3 DSM measures

Tate (1990) classified water DSM measures into three categories: socio-political, economic and structural-operational strategies (see Figure 5.7 for examples of each category).

5.3.1 Socio-political strategies

Socio-political strategies include efforts to change consumers' attitudes and behaviour towards the use of water. This is accomplished through education, public awareness campaigns, developing water policies, water use permits, appliance standards, watering restrictions, regulations and standards (such as provincial plumbing codes). A good recent example that holds some promise in Ontario is the new *Sustainable Water and Sewage Act* that mandates a move towards full-cost pricing, including environmental costs[10].

Figure 5.6: The soft path

The energy soft path is characterized by highly efficient end-use technologies and widespread use of small-scale renewable energy resources – photovoltaics, wind power, biogas, hydrogen cells, etc. – in contrast to continued proliferation of large, centralized fossil-fuel and nuclear power plants and continued reliance on fossil fuels for motive power.

Rocky Mountain Institute.
Available at http://www.rmi.org/sitepages/pid278.php

…and for water

We refer to the traditional path as the 'hard path' and the newer, alternative path as the 'soft path'. The adjective *soft* refers to the non-structural components of a comprehensive approach to sustainable water management and use, including equitable access to water, proper application and use of economics, incentives for efficient use, social objectives for water quality and delivery reliability, public participation in decision making, and more.

Gleick, P. 2002b. *The World's Water: 2002-2003: The Biennial Report on Freshwater Resources.* Washington, DC: Island Press, p.3.

[10] Ontario, Minister of the Environment, 2002. Available at: http://www.e-laws.gov.on.ca/dblaws/statutes/english/02s29_e.htm

Figure 5.7: **Water demand management measures**

General Categories	Specific Examples

Socio-political	• Information and education
	• Water policy
	• Water use permits
	• Landscaping ordinances
	• Water restrictions
	• Plumbing codes for new structures
	• Appliance standards
	• Regulations and by-laws
	    o Turf limitation by-laws
	    o Once-through cooling system bans

Economic strategies	• Rebates for more efficient toilets, showers, faucets and appliances
	• Tax credits for reduced use
	• High consumption fines and penalties
	• Pricing Structures
	    o Seasonal rates
	    o Increasing block rates
	    o Marginal cost pricing
	    o Full-cost recovery polices
	    o Daily-peak hour rates
	    o Sewer charges

Structural-operational	• Landscape efficiency
	    o Soil moisture sensors
	    o Watering timers
	    o Cisterns
	    o Rain sensors
	    o Efficient irrigation systems
	    o Soaker hoses
	• Metering
	• Leak detection and repair
	• Water audits
	• Pressure reduction
	• System rehabilitation
	• Efficient technology
	    o Dual flush toilets
	    o Low flow faucets
	    o Efficient appliances (dishwashers/washing machines)
	• Recycling and Reuse – ranging from cooling and process water, to grey water for toilets or irrigation, to treating and reclaiming wastewater for reuse

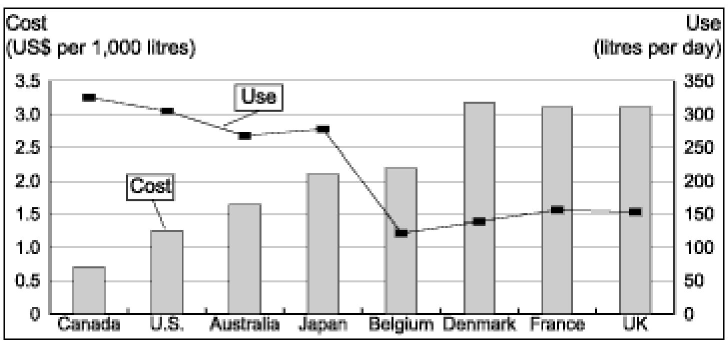
5.3.2 Economic strategies

Economic strategies include monetary incentives such as rebates and tax credits, and disincentives for high levels of consumption such as fee increases, penalties and fines. These strategies are often believed to be among the most effective means of reducing water demand.

Water conserving price structures, such as increasing rates with higher use, marginal cost pricing, full-cost recovery polices, higher peak hour rates, summer use surcharges, and sewer charges, can also act as motivators for rationing use and reducing waste.

Such pricing structures are effective because they more accurately convey to water users the true value or cost of the resource that they are using. Canadians currently pay less for water than citizens of most industrialized nations and an inverse correlation exists between the price of water and water use (see Figure 5.8). Many believe that reforming pricing structures is an especially effective option to help realign water use in Canada. Renzetti (2003: 5), a Canadian water economist, suggests that there "is a growing body of empirical evidence that moving to efficient water prices can promote water conservation, provides a number of benefits to water utilities, and often raises social welfare."

***Figure 5.8:* Canadians use more water and pay less for it**



Source: OECD—All data are from 1994 to 1999 except data on U.S. use, which are from 1980.

Commission on the Environment and Sustainable Development (CESD). 2001. *Report of the Commissioner of the Environment and Sustainable Development*. Chapter 1, section 3. Office of the Auditor General of Canada. Minister of Public Works and Government Services, p.24.

Changing prices alone, however, may not be sufficient. To be effective in assuring long-term water conservation, economic strategies often require additional non-price measures such as metering or educational campaigns. This was emphasized by Brooks *et al.* (1990) who stated, "water users will not respond to market forces alone."

5.3.3 Structural and operational strategies

Structural and operational strategies aim to increase efficiency through technological and engineered measures, such as water efficient fixtures, showers, toilets and appliances. For example, water used in toilets (the single largest indoor water user representing approximately 40

***Figure 5.9:* Xeriscaping**

From the Greek word xeros, meaning dry, Xeriscaping designs draw on a wide variety of attractive indigenous and drought-tolerant plants, shrubs, and ground cover to replace the thirsty green lawns found in most suburbs. A Xeriscape yard typically requires 30-80 percent less water than a conventional one, and can reduce fertilizer and herbicide use as well. One study in Novato, California, found that Xeriscaped landscaping cuts water use by 54 percent, fertilizer use by 61 percent, and herbicide use by 22 percent.

Postel, S. 1997. *Last Oasis – Facing Water Scarcity.* New York: Norton and Company, p.159

percent of household use) could be reduced from 90 litres per capita per day to 9 litres per capita per day if state-of-the-art, water efficient technology were employed (Shrubsole and Tate 1993). This is a prime example of current levels of existing waste and leads us to question whether we are needlessly "flushing the future". Efficiency can also be improved dramatically when lawns, another major consumer of urban water, are replaced with native drought resistant plants to reduce sprinkling requirements (a process called Xeriscaping, see Figure 5.9).

Other strategies in this category include leak detection, metering and water recycling. As indicated earlier, metering of water supplies is a necessary component in moving towards conservation-based pricing arrangements. But it can also be useful even when there is no change in pricing arrangements. Brooks and Peters (1988) found that metering, in the absence of any rate increase, resulted in water use reductions of 10 to 40 percent because individuals became aware of exactly how much they were consuming.

Water recycling and reuse is yet another untapped and compelling alternative to current approaches in urban water management. As the examples in figures 5.10 and 5.11 demonstrate, recycling and reuse can be undertaken at various scales, from an individual house to an entire city. Israel, for example, treats 70 percent of its wastewater, which is then used for agricultural irrigation (Gleick 1998).

***Figure 5.10:* Closing the loop**

By using municipal water supplies twice – once for domestic use and again for irrigation – would-be pollutions become valuable fertilizers, rivers and lakes are protected from contamination, the irrigated land boosts crop production, and the reclaimed water becomes a reliable, local supply. Unfortunately, conventional sanitary engineers tend to emphasize the linear approach to managing water and sewage – use, collect, treat thoroughly, and then dispose of - while the benefits of closing the cycle - use, collect, treat partially, and then use again – go unrealized. (128)… St Petersburg, Florida, is apparently the only major U.S. city to have closed its cycle completely by reusing all its wastewater and discharging none to surrounding lakes and streams. The city has two water distribution systems – one that delivers fresh water for drinking and most household uses, and another that distributes treated wastewater for irrigating parks, road medians, and residential lawns, and for serving other functions that do not require drinking-quality water. For residents hooked up to the dual system, the reclaimed water costs only about 30 percent as much as the drinkable supply, and, because of the nutrients it contains cuts down on their lawn fertilizer costs as well.

Postel, S. 1997. *Last Oasis – Facing Water Scarcity.* New York: Norton and Company, p.134.

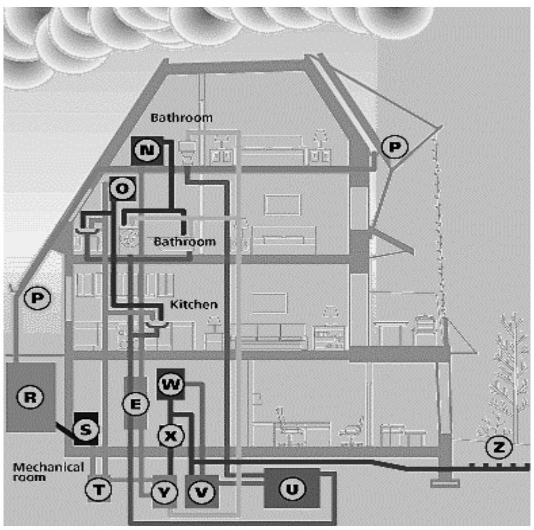
Figure 5.11: Toronto Healthy House

CMHC's Healthy House in Toronto provides clean water for all household and landscaping needs - without using municipal services.

Rain and snow collected from the roof provides all of the water supply. Water is stored in an underground cistern and purified without the use of chemicals.

All wastewater, which would ordinarily drain into the municipal sewage system, is treated in the home in a system that duplicates the soil's natural filtration process. It is then recycled for use in toilets, showers, and the washing machine. Water is typically recycled up to five times, with a small amount being safely released into the soil each day. Microorganisms, oxygen, ultraviolet light and charcoal are used to treat wastewater flowing into the soil so that it is not harmful to the environment.

In addition, the house features appliances, fixtures and devices that use less water.



O - DRINKABLE-HOT-WATER TANK
Supplies kitchen and bathroom sinks.
P - EAVESTROUGHS
Collect roof rainwater, which passes through filter screens and then to cistern.
R - RAINWATER CISTERN
20,000 litres (normally sufficient for 6 months consumption).
S - COMBINATION FILTER
The rainwater passes through a combination roughing, slow sand, and carbon filter, and then through an ultraviolet light disinfection unit before being stored for drinking.
T - DRINKABLE-COLD-WATER TANK
Supplies kitchen and bathroom sinks; overflow to reclaimed-cold-water tank.
E - GREY WATER HEAT EXCHANGER

N - RECLAIMED-HOT-WATER TANK
U - SEPTIC TANK
Anaerobic bacteria transforms waste water for treatment by the Waterloo Biofilter ™
V - RECIRCULATION TANK
Provides de-nitrification in an aerobic environment.
W - WATERLOO BIOFILTER ™
Aerobic bacteria transforms effluent to a semi-treated condition.
X - TWIN COMBINATION FILTERS
Water passes through two combination roughing, slow sand and carbon filters.
Y - RECLAIMED-COLD-WATER TANK
Supplies tub, laundry, showers and toilets.
Z - GARDEN IRRIGATION
Site gravel pack disperses overflow water under front garden (about 120 litres per day).

Canadian Mortgage and Housing Corporation – Toronto Healthy House. Available at http://www.cmhc-schl.gc.ca/popup/hhtoronto/frame.html

Urban Water Demand Management

5.4 Summary

At the very least, DSM offers the potential to address the issue of water scarcity without having to resort to traditional and costly approaches, such as constructing new water and sewage treatment facilities. In addition to cost savings, DSM also addresses non-monetary social concerns for water conservation, such as uncertainties about future needs, preserving options for future development, ecosystem benefits, and sustainable development of water resources. As the above examples have demonstrated, DSM can be very effective at reducing per capita water use, and the 'soft path' that it represents can be a part of an overall shift in societal thinking and management.

Figure 5.12: **Water ethic**

Adopting [a water ethic] would represent a historic philosophical shift away from the strictly utilitarian, divide-and-conquer approach to water management and toward an integrated, holistic approach that views people and water as related parts of a greater whole. It would make us stop asking how we can further manipulate rivers, lakes, and streams to meet our insatiable demand, and instead to ask how we can best satisfy human needs while accommodating the ecological requirements of healthy water systems.

Postel, S. 1997. *Last Oasis-Facing Water Scarcity*. New York: Norton and Company, p.185.

Urban
Water
Demand
Management

6 Summary and future directions

"When the well's dry, we know the worth of water"

Benjamin Franklin, Poor Richard's Almanac, 1746.

International efforts are slowly emerging to deal with the looming global water crisis. Growing population, rising consumption, increasing pollution, climate change and poor management of water resources are some of the major factors that contribute to this situation. Even so-called 'water rich' nations, like Canada, must grapple with ecological and social consequences of regional and seasonal scarcity.

Water use in Canadian cities is over twice as high as many European cities, and it is on the rise. Within Canada, municipal water use patterns are highly varied. A study of 20 cities across the country found a fourfold difference in the quantity of both total domestic and municipal water use. Reasons for such large variations are not immediately obvious, although some correlation between volume-based pricing (which includes metering) and lower use was found. Many other factors likely contribute to the differences in use, such as local climate, availability of supply, specific prices and pricing structures, governance and decision-making structures, social attitudes, and regional conservation initiatives.

The variation in municipal water use between these cities, and in comparison with many foreign cities, suggests that an opportunity exists to reduce the volume of water used by many Canadian cities with minimal impact on quality of life standards. Curbing the increasing trend of water use and reducing water demand can provide significant ecological, social and economic benefits.

Demand-Side Management (DSM) is a key tool for reducing current levels of water use. Some DSM measures are being used in Canada but, along with the need for a broader debate about the merits of a "soft path" approach, DSM still awaits more general recognition as a viable alternative to traditional efforts to increase/expand supply. An appropriate DSM regime can, at the very least, mitigate the need for spending on additional expensive supply infrastructures such as reservoirs, treatment plants, and groundwater pumping stations. Within the DSM framework, such capital-intensive structures to increase supply should only be developed after less costly attempts to lower demand have been exhausted. More broadly, DSM can reduce current high levels of water use, reduce ecological damage, and help create an ethic of conservation rather than limitless consumption.

To help advance the understanding of DSM in Canada, the Urban Water Demand Management team at POLIS is currently interviewing water experts on the possibilities for DSM, the obstacles to implementing it, and how those obstacles might be overcome. This research will result in a second report that develops an integrated set of strategies and legal/institutional reform opportunities, reflecting expert opinion on the role for DSM in the Canadian water management scene.

The project is guided by the principles that water resources are finite, there is a fundamental need for an ethos of conservation. We believe evolving technologies might be harnessed to focus future policy on efficiency and reuse, while new governance institutions should be considered that can achieve a more appropriate level of local control and accountability. Future research will focus on the potential for DSM to act as a catalyst to reorient the existing Canadian water management regime to one that is more holistic, ecologically sustainable and locally accountable.

Urban Water Demand Management

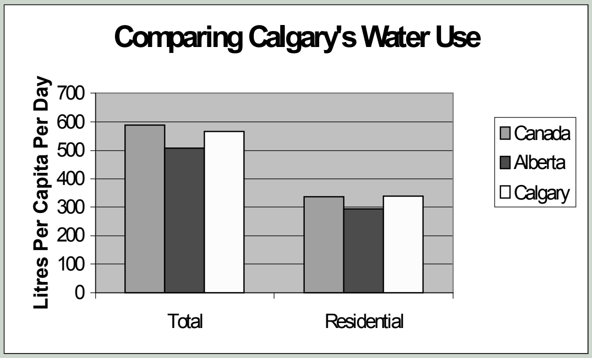
Appendix A: Canadian city snapshots

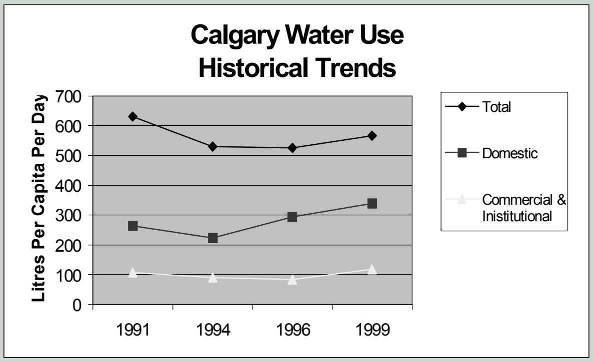
All Statistical Data taken from Environment Canada Municipal Water Use Database (MUD): *http://www.ec.gc.ca/water/mud/en/index.cfm*

For each city:

- Residential water use is shown (the terms 'residential' and 'domestic' are used interchangeably) in litres per capita per day (lcd), along with its rank among the 20 cities, the proportion of individual households that are metered, and the pricing structures that are used (classified as volume based, flat or both).
- Total municipal use is shown (which includes residential, commercial and institutional, industrial and unaccounted water), along with its rank among the 20 cities.
- Historical use trends for three periods (1991-1994, 1994-1996, and 1996-1999) are shown graphically for two sectors (domestic and commercial/institution) and for total water use.
- Provincial and national averages were calculated by dividing total average daily flow of water by the population served, with aggregate data taken from Environment Canada (2001: 41).

Calgary, Alberta



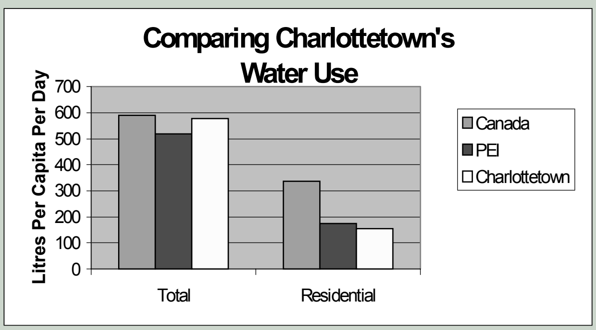


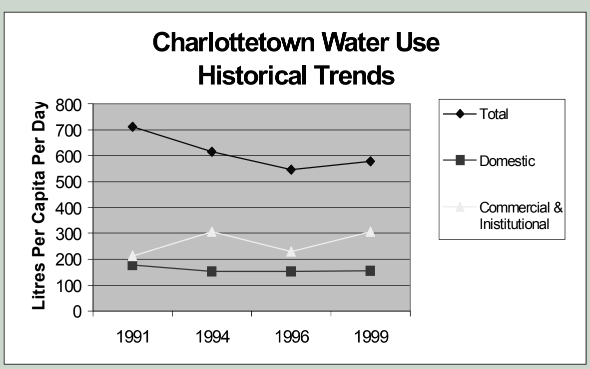
Population Served: 819,334

Residential Water Use (lcd): 339
- Rank: 15th
- Provincial Average: 285
- National Average: 343
- Degree Metered: 57%
- Pricing Structure: Mixed volume and flat

Total Municipal Water Use (lcd): 566
- Rank: 11th
- Provincial Average: 508
- National Average: 589

Charlottetown, Prince Edward Island





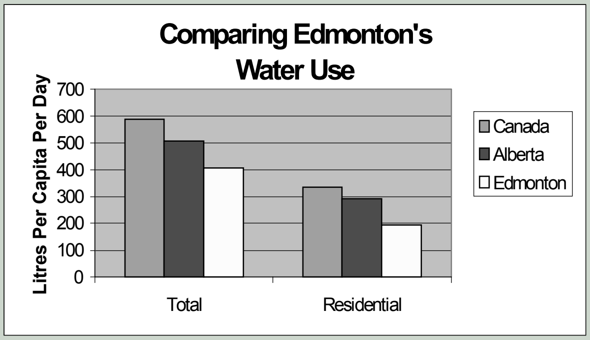
Population Served: 28,600

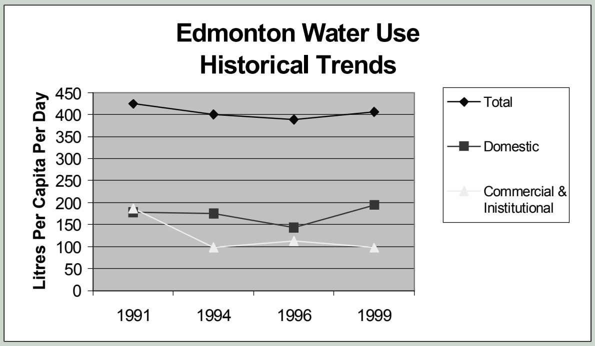
Residential Water Use (lcd): 156
- Rank: 1st
- Provincial Average: 173
- National Average: 343
- Degree Metered: 0%
- Pricing Structure: Flat

Total Municipal Water Use (lcd): 578
- Rank: 13th
- Provincial Average: 519
- National Average: 589

Urban Water Demand Management

Edmonton, Alberta



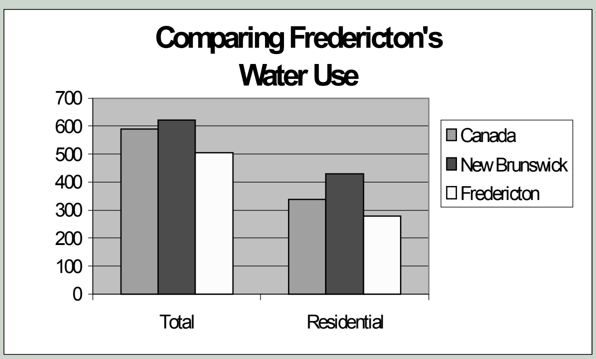


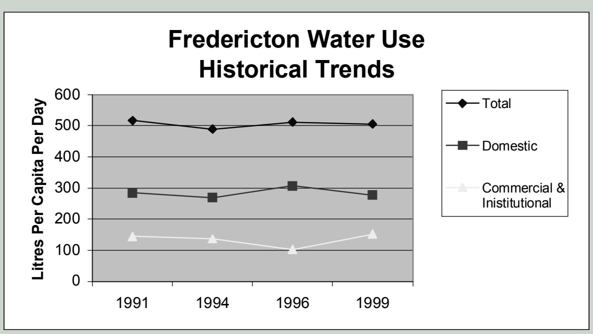
Population Serviced: 636,000

Residential Water Use (lcd): 195
Rank: 5th
Provincial Average: 285
National Average: 343
Degree Metered: 100%
Pricing Structure: Volume

Total Municipal Water Use (lcd): 406
Rank: 5th
Provincial Average: 508
National Average: 589

Fredericton, New Brunswick





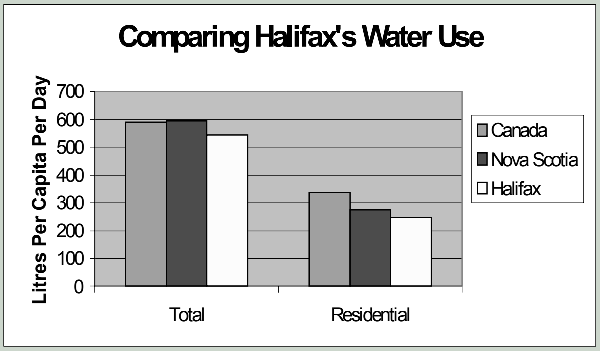
Population Served: 45,000

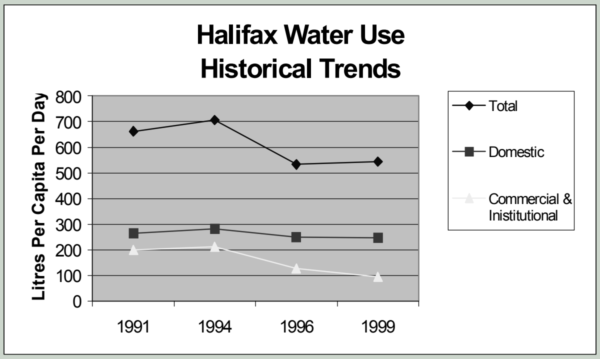
Residential Water Use (lcd): 278
Rank: 13th
Provincial Average: 430
National Average: 343
Degree Metered: 98%
Pricing Structure: Mixed volume and flat

Total Municipal Water Use (lcd): 505
Rank: 7th
Provincial Average: 622
National Average: 589

Urban Water Demand Management

Halifax, Nova Scotia



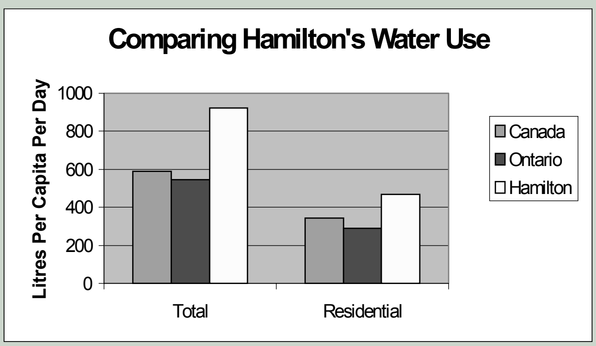


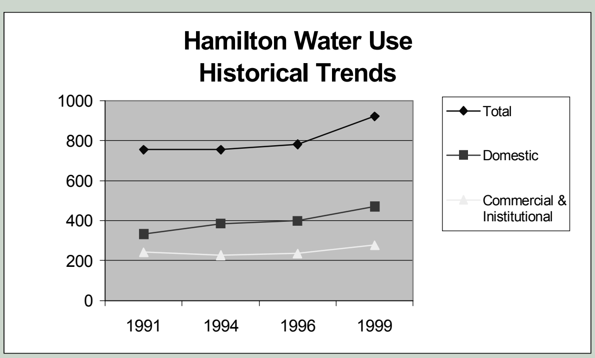
Population Served: 280,000

Residential Water Use (lcd): 247
- Rank: 10th
- Provincial Average: 275
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 544
- Rank: 9th
- Provincial Average: 595
- National Average: 589

Hamilton, Ontario





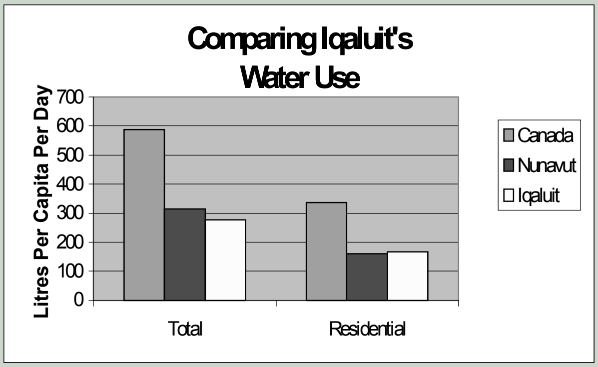
Population Served: 322,252

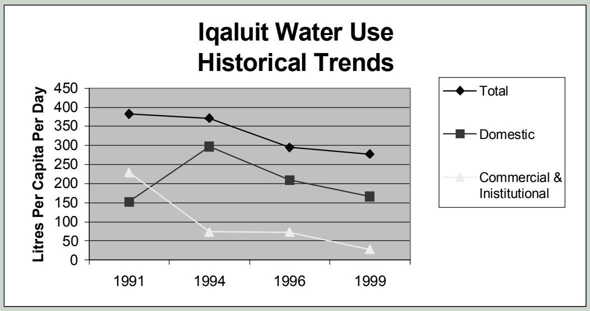
Residential Water Use (lcd): 470
- Rank: 18th
- Provincial Average: 290
- National Average: 343
- Degree Metered: 65%
- Pricing Structure: Mixed volume and flat

Total Municipal Water Use (lcd): 921
- Rank: 19th
- Provincial Average: 546
- National Average: 589

Urban Water Demand Management

Iqaluit, Nunavut



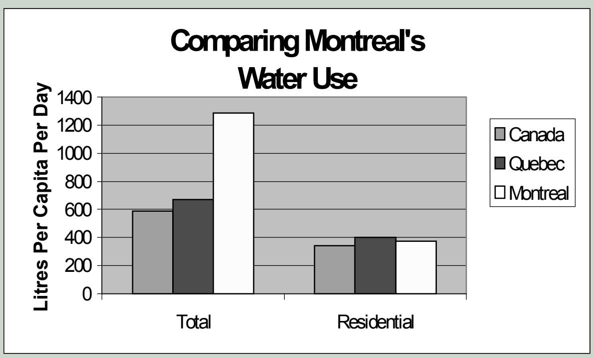


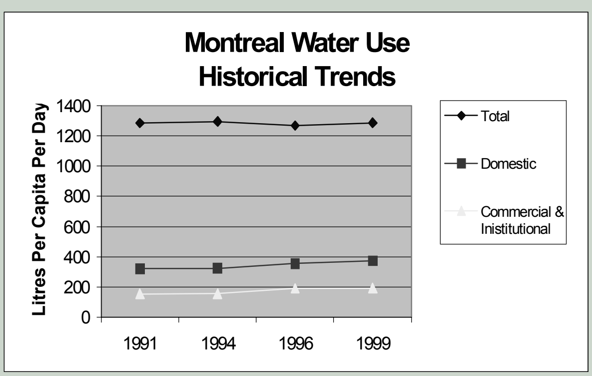
Population Served: 4,500

Residential Water Use (lcd): 167
- Rank: 3rd
- Territorial Average (NWT): 161
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 278
- Rank: 1st
- Territorial Average (NWT): 315
- National Average: 589

Montreal, Quebec





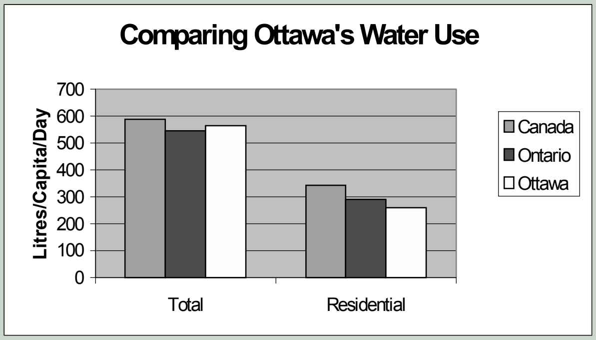
Population Served: 1,030,678

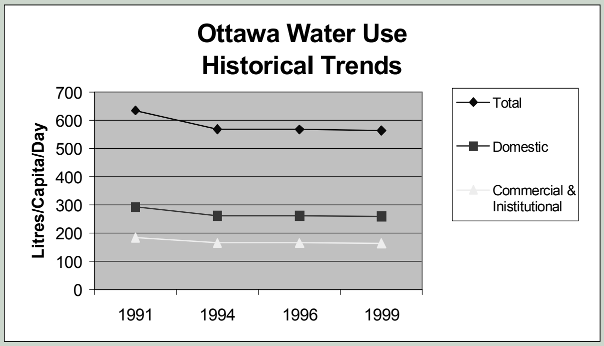
Residential Water Use (lcd): 373
- Rank: 17th
- Provincial Average: 401
- National Average: 343
- Degree Metered: 0%
- Pricing Structure: Not Available

Total Municipal Water Use (lcd): 1287
- Rank: 20th
- Provincial Average: 670
- National Average: 589

Urban Water Demand Management

Ottawa, Ontario



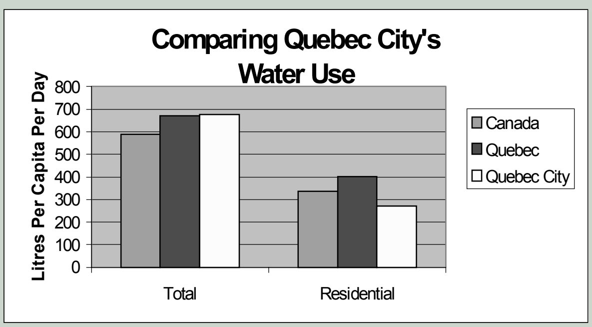


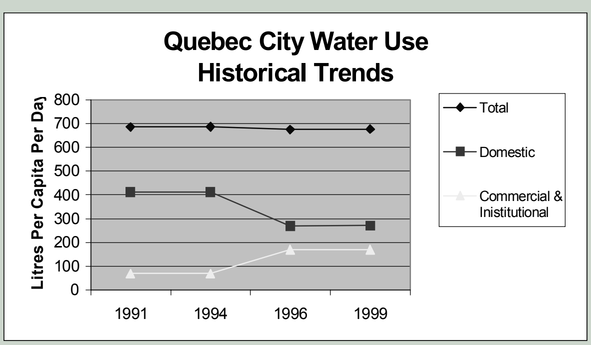
Population Served: 336,269

Residential Water Use (lcd): 259
- Rank: 11th
- Provincial Average: 290
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 563
- Rank: 10th
- Provincial Average: 546
- National Average: 589

Quebec City, Quebec





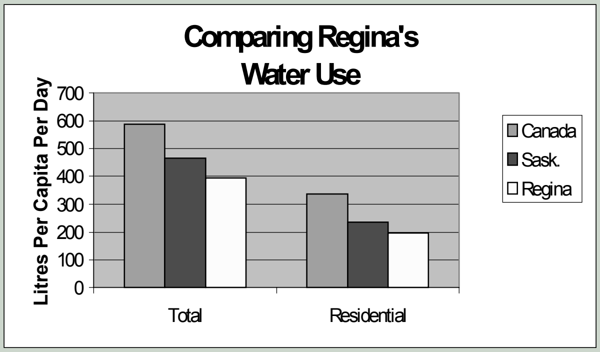
Population Served: 167,300

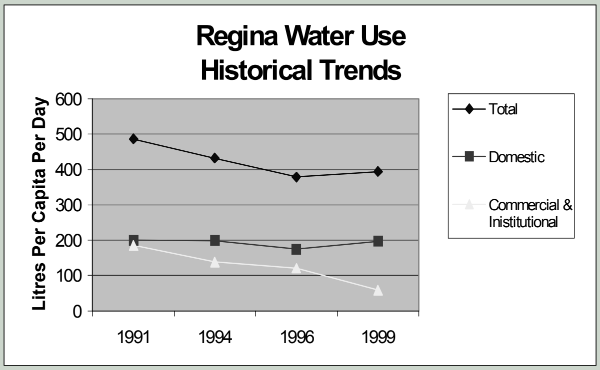
Residential Water Use (lcd): 270
- Rank: 12th
- Provincial Average: 401
- National Average: 343
- Degree Metered: 0%
- Pricing Structure: Not Available

Total Municipal Water Use (lcd): 675
- Rank: 16th
- Provincial Average: 670
- National Average: 589

Urban Water Demand Management

Regina, Saskatchewan



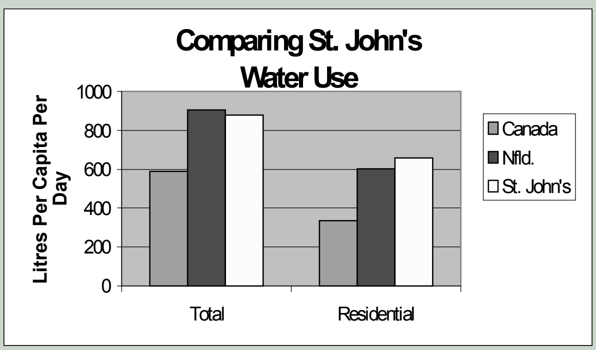


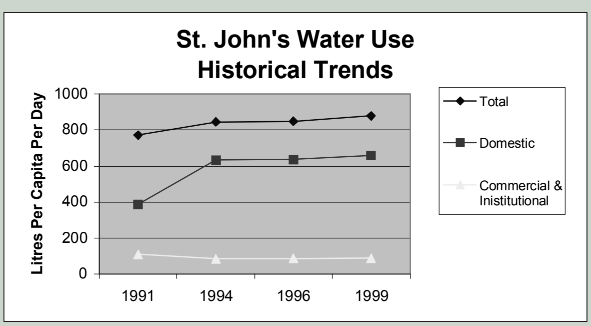
Population Served: 190,000

Residential Water Use (lcd): 197
- Rank: 6th
- Provincial Average: 235
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 395
- Rank: 3rd
- Provincial Average: 466
- National Average: 589

St John's, Newfoundland





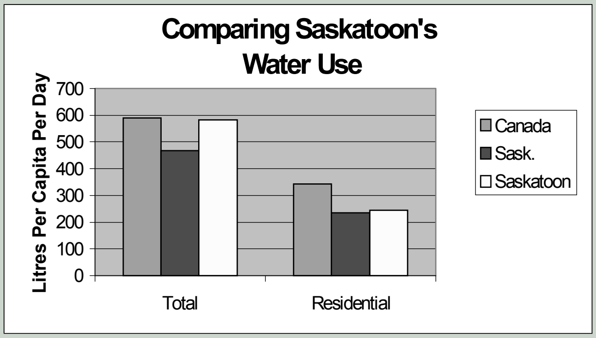
Population Served: 106,000

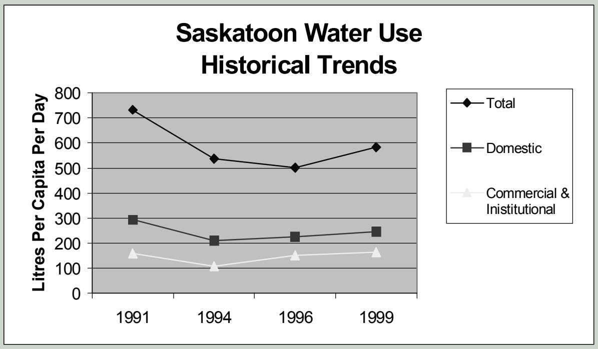
Residential Water Use (lcd): 659
- Rank: 20th
- Provincial Average: 603
- National Average: 343
- Degree Metered: 0%
- Pricing Structure: Flat

Total Municipal Water Use (lcd): 878
- Rank: 18th
- Provincial Average: 906
- National Average: 589

Urban Water Demand Management

Saskatoon, Saskatchewan



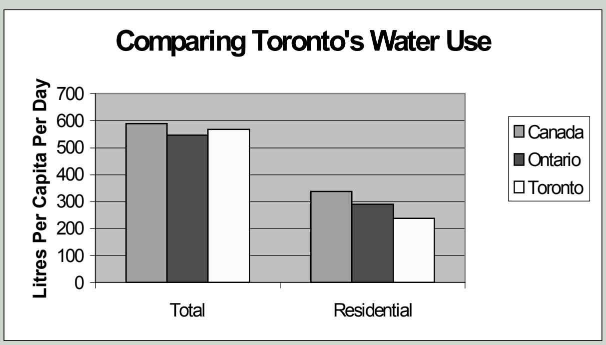


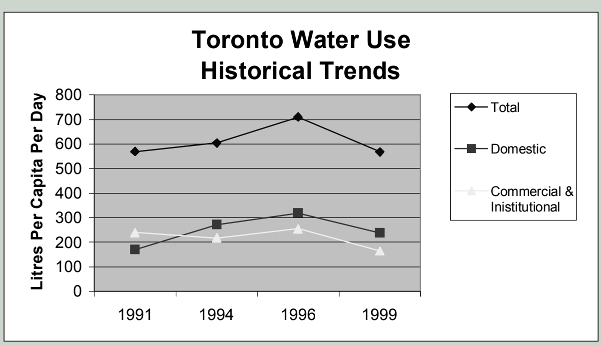
Population Served: 207,000

Residential Water Use (lcd): 245
- Rank: 9th
- Provincial Average: 235
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 583
- Rank: 14th
- Provincial Average: 466
- National Average: 589

Toronto, Ontario





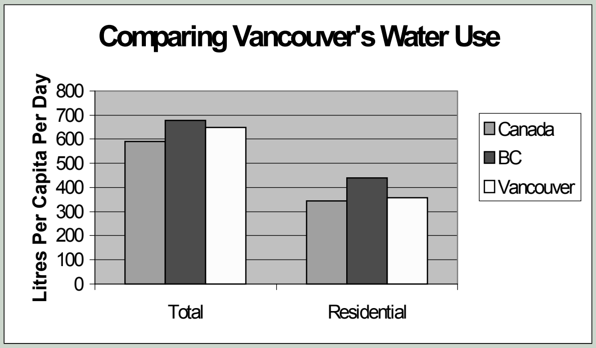
Population Served: 2,393,790

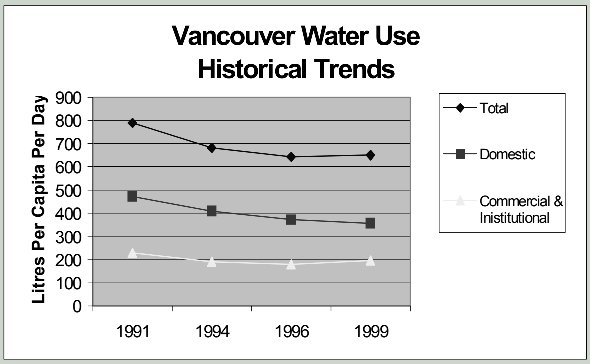
Residential Water Use (lcd): 239
- Rank: 8th
- Provincial Average: 290
- National Average: 343
- Degree Metered: 73%
- Pricing Structure: Mixed volume and flat

Total Municipal Water Use (lcd): 568
- Rank: 12th
- Provincial Average: 546
- National Average: 589

Urban Water Demand Management

Vancouver, British Columbia



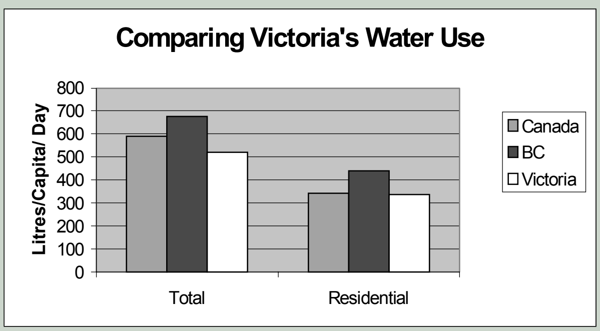


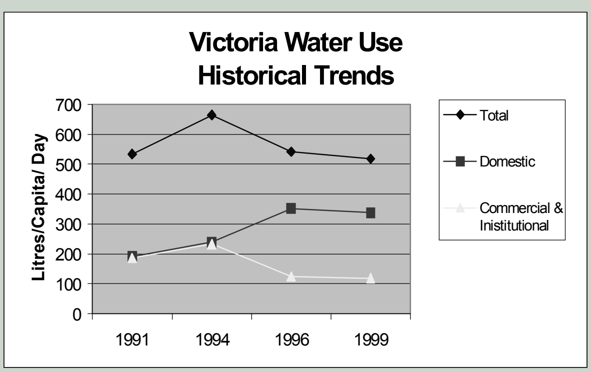
Population Served: 554,000

Residential Water Use (lcd): 357
- Rank: 16th
- Provincial Average: 439
- National Average: 343
- Degree Metered: 1%
- Pricing Structure: Mixed volume and flat

Total Municipal Water Use (lcd): 650
- Rank: 15th
- Provincial Average: 677
- National Average: 589

Victoria, British Columbia





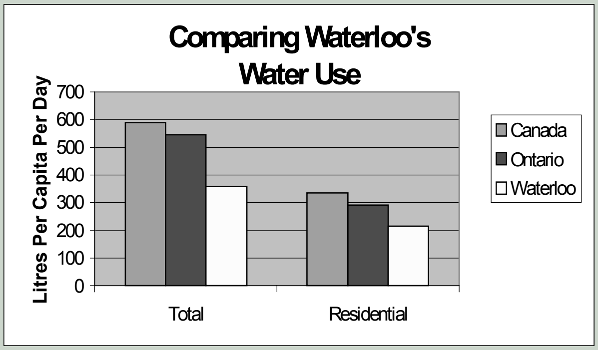
Population Served: 86,000

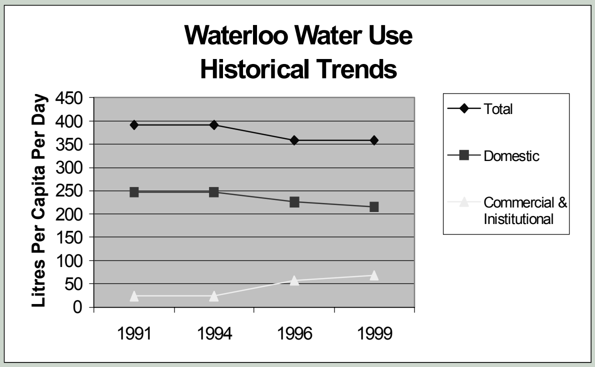
Residential Water Use (lcd): 340
- Rank: 14th
- Provincial Average: 439
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 519
- Rank: 8th
- Provincial Average: 677
- National Average: 589

Urban Water Demand Management

Waterloo, Ontario



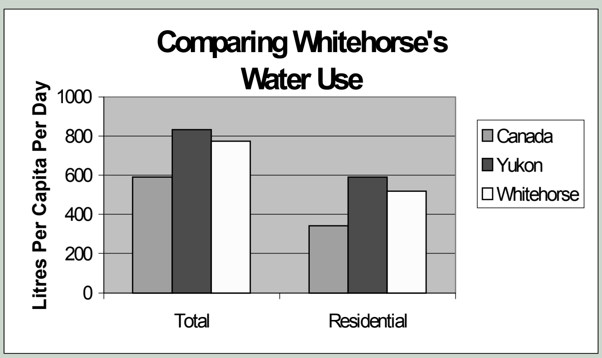


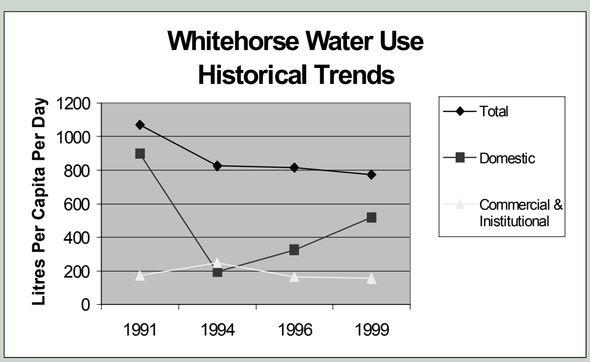
Population Served: 78,000

Residential Water Use (lcd): 215
Rank: 7th
Provincial Average: 290
National Average: 343
Degree Metered: 100%
Pricing Structure: Volume

Total Municipal Water Use (lcd): 359
Rank: 2nd
Provincial Average: 546
National Average: 589

Whitehorse, Yukon Territory





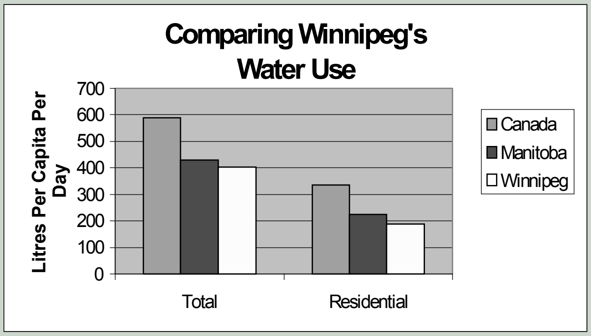
Population Served: 20,000

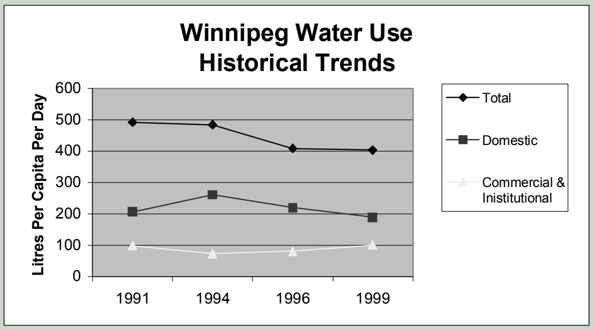
Residential Water Use (lcd): 519
Rank: 19th
Territorial Average: 591
National Average: 343
Degree Metered: 50%
Pricing Structure: Mixed volume and flat

Total Municipal Water Use (lcd): 775
Rank: 17th
Territorial Average: 834
National Average: 589

Urban Water Demand Management

Winnipeg, Manitoba



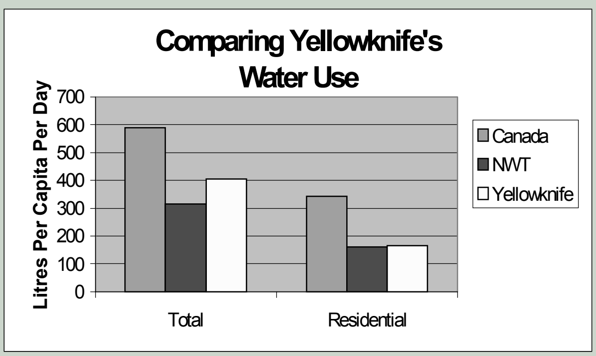


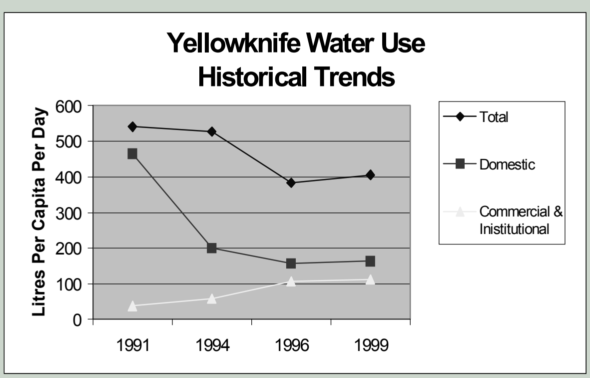
Population Served: 620,000

Residential Water Use (lcd): 190
- Rank: 4th
- Provincial Average: 215
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 403
- Rank: 4th
- Provincial Average: 430
- National Average: 589

Yellowknife, Northwest Territories





Population Served: 17,250

Residential Water Use (lcd): 164
- Rank: 2nd
- Territorial Average: 161
- National Average: 343
- Degree Metered: 100%
- Pricing Structure: Volume

Total Municipal Water Use (lcd): 406
- Rank: 6th
- Territorial Average: 315
- National Average: 589

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Urban Water Demand Management

POLIS Project on Ecological Governance: An Organization for Transformative Solutions

Created in 2000, the POLIS Project on Ecological Governance, seeks to discover and implement solutions to pressing issues that can build healthy and sustainable communities. Among the many research centres investigating and promoting sustainability world-wide, POLIS is unique in its focus on multidisciplinary research and action and in that its work strives to blend academic research with community engagement.

The concept of ecological governance is exciting in that it offers an alternative to extractive, linear and unsustainable systems that continue to level ancient forests, displace indigenous and local communities and clog and choke our global cities. Instead ecological governance asks how we might foster circular systems in which we reduce our demands on distant (and local) ecological systems.

Whether it be through investigating the shift from supply to demand management in our use of minerals or water, re-imagining new forms of urban "smart growth" such as the eco-innovative university campus, or reforming local land tenures for indigenous and local community, revitalization or overhauling national environmental laws, the thrust of all of our research is guided and informed by the concept of ecological governance.

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