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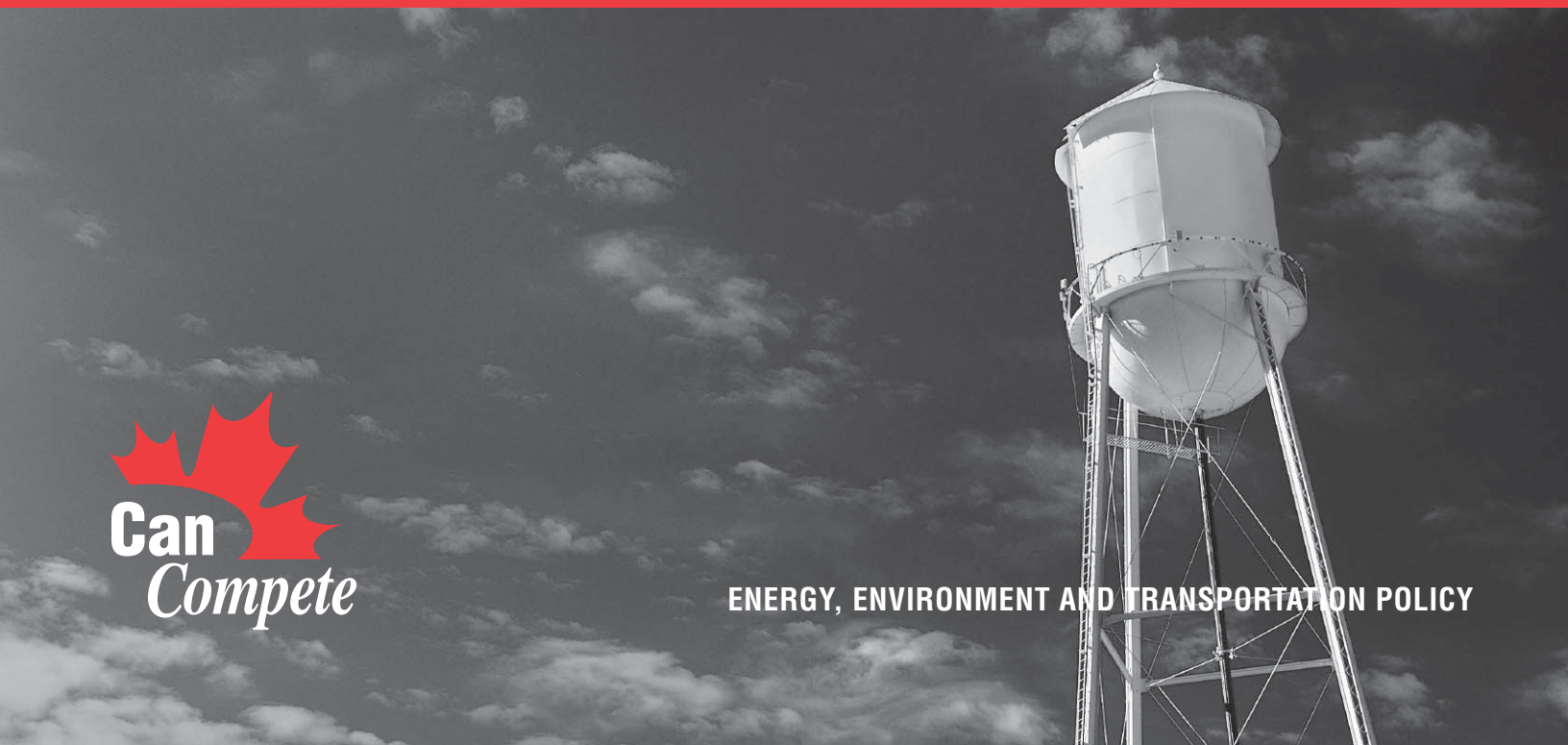
Improving Infrastructure Management
Municipal Investments in Water and Wastewater Infrastructure



Can Compete

ENERGY, ENVIRONMENT AND TRANSPORTATION POLICY

Improving Infrastructure Management: Municipal Investments in Water and Wastewater Infrastructure
by *Len Coad*

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Preface

The primary focus of *Improving Infrastructure Management: Municipal Investments in Water and Wastewater Infrastructure* is on investment in municipal water infrastructure. The investment funds come from a variety of sources. Given the long-term and capital-intensive nature of water infrastructure, many observers stress the importance of long-term stability in revenue sources and financings. There is broad evidence of a water infrastructure deficit in Canada, suggesting that an imbalance currently exists. As a starting point, the report describes the broad revenue sources and financing methods available to municipal water providers. To prepare this report, Conference Board researchers interviewed representatives of the water and/or wastewater organizations of 15 municipalities across Canada to gain insight into their infrastructure planning, management, and financing practices. The report concludes with recommendations for making effective investment decisions.

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Acknowledgements

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The author remains responsible for any errors or omissions in the report.

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EXECUTIVE SUMMARY

Improving the Infrastructure Management: Municipal Investments in Water and Wastewater Infrastructure

At a Glance

- Water and wastewater infrastructure planning is based on the essential services that water provides. Access to potable water, wastewater gathering, and wastewater treatment are key contributors to healthy citizens and communities.
- There is broad evidence of a water infrastructure deficit in Canada, suggesting that an imbalance currently exists.
- In addition to a variety of revenue sources, municipal water and wastewater systems in Canada rely on a range of financing options.
- The potential for municipal influence over water system financing and investment decisions is real and unavoidable.

Water and wastewater infrastructure planning is based on the essential services that water provides. Access to potable water, wastewater gathering, and wastewater treatment are key contributors to healthy citizens and communities. A reliable supply of water that meets appropriate quality standards is considered essential in Canadian society.

The primary focus of this report is on investment in municipal water infrastructure. The investment funds come from a variety of sources. Given the long-term and capital-intensive nature of water infrastructure, many observers stress the importance of long-term stability in revenue sources and financings. There is broad evidence of a water infrastructure deficit in Canada, suggesting that an imbalance currently exists. As a starting point, the report describes the broad revenue sources and financing methods available to municipal water providers.

There are several revenue sources available to meet the cost of water and wastewater services, including:

- a portion of municipal tax revenues;
- provincial grants or revenue sharing agreements;
- federal grants;
- municipal development fees or funding agreements; and
- user fees/service charges.

Each revenue source carries implications for decision making and infrastructure planning. Relying on municipal tax revenues to fund water infrastructure interferes with price signals and can lead to over consumption and over building of infrastructure. This is because water users do not pay, directly, the full cost of the services

they receive. Therefore, the potential for efficient use of water may be reduced. Water systems, which depend on tax revenues, also are more likely to see investment decisions influenced by budget allocations or political processes that are not related to the water system. Revenues may fluctuate because of budget priorities or may not match long-term investment requirements because of short-term budget constraints.

Provincial and federal funding are most often tied to specific programs or investment projects. They tend to be large amounts and irregular in timing. Such revenues may help reduce pressures that upgraded or expansion projects might otherwise create. But they also have the potential to result in assets whose capital and operating costs are high, relative to the water system's financial capacity.

If systems that use full cost recovery rates implement appropriate planning processes and rate structures, funds are available to meet investment requirements.

Municipal development fees are a common source of funding for water system expansion into new neighbourhoods. The fees have the advantage of allocating a portion of the cost of new infrastructure to the developer—who then passes the cost to the end customer. This places the primary burden of expansion costs on the customers who cause them to be incurred. The challenges include ensuring that the costs allocated are appropriate given the complexity of determining the fees, and negotiating any agreements that might be required.

Water use charges or rates are the most direct means of allocating the costs of providing water services directly to customers. In a full cost recovery model, water rates include all costs of providing water and wastewater services. These costs may consist of the direct investment cost, interest costs, operating costs, source protection, and ecosystem restoration. If systems that use full cost recovery rates implement appropriate planning processes and rate structures, funds are available to meet investment requirements and keep the water and wastewater system up-to-date and efficient. The available funds can also provide necessary upgrades and expansions, often with very little impact on short-term rates. The two primary challenges are to find a rate design and user charge level that fully recovers costs and to ensure that water—an essential good—is affordable to low-income Canadians.

In addition to a variety of revenue sources, municipal water and wastewater systems in Canada rely on a range of financing options. Municipal ownership links the debt position of the water provider to the debt capacity of the municipal government. This link occurs even when the water system debt is entirely for capital expenditures, incurred by a corporation, and funded entirely through service charges. The potential for municipal influence over water system financing and investment decisions is therefore real and unavoidable.

Improving Infrastructure Management: Municipal Investments in Water and Wastewater Infrastructure introduces the principles and issues in water infrastructure planning, presents an overview of the role that water and wastewater infrastructure plays in Canadian society, and describes the challenges we face. The report also discusses investment criteria that apply to water infrastructure and presents the results of interviews with the representatives of 15 Canadian municipalities. The report concludes with recommendations for making effective investment decisions.

CHAPTER 1

Introduction

Chapter Summary

- Most Canadian cities have water and wastewater infrastructure that has been operating for 50 years or more. Therefore, the capital investments must be amortized over very long periods, suggesting a strong need for long-term planning horizons.
- Because the need for water infrastructure follows population and industrial development, effective infrastructure planning requires growth projections for both.
- Emerging societal preferences or trends can play an important role in infrastructure planning.
- In most Canadian municipalities, revenues and investments require the approval of municipal councils.

PRINCIPLES AND ISSUES IN WATER INFRASTRUCTURE PLANNING

A reliable supply of water that meets appropriate quality standards is considered essential in Canadian society. As a result, these services—and the infrastructure required—are often directly operated or controlled by municipal governments or by corporations owned by municipal governments.

Planning decisions are based on a desire to provide essential services and protect the public at all times.[1] Recently, there has been an increased focus on also protecting the natural environment, and implementing practices that contribute to sustainable development. These factors suggest both a long-term view and a precautionary approach.

Most of Canada's cities have water and wastewater infrastructure that has been operating for 50 years or more.

Water and wastewater services are capital-intensive and have very long service lives. The ratio of infrastructure investment to revenues has been estimated at 5:1 for water and wastewater services, compared with 3:1 for electricity or telephone services, and 2.5:1 for natural gas distribution.[2] One might argue that the relationship between investment and revenues for water is higher because water services are under-priced—consequently, revenues are lower than they should be. On the other hand, most of Canada's cities have water and wastewater infrastructure that has been operating for 50 years

1 Main, *2008 National Water & Wastewater Benchmarking Initiative*. See this Earth Tech report for a detailed presentation of a framework that places infrastructure investment within a broad range of service objectives. The report also includes benchmarking results.

2 Ontario SuperBuild Corporation, "Organization of Municipal Water and Wastewater Systems in Ontario."

or more. Therefore, the capital investments, once made, must be amortized over very long periods, suggesting a strong need for long-term planning horizons.

Because the need for water infrastructure follows population and industrial development, effective infrastructure planning requires growth projections for both. Careful risk assessments are essential elements of any long-term plan because of the uncertainties involved in projections and the lead times required to build or expand water facilities. Technology developments and transitions also impose uncertainty. They may require infrastructure to be upgraded or replaced before the originally expected service life is completed. And, unplanned infrastructure failures can require adjustments to the plan. For example, several of the municipal representatives we interviewed indicated that they are currently dealing with the consequences of early replacement of steel pipes installed in the 1950s. But, fortunately, because there is sufficient commonality between water and other infrastructure risk issues, risk assessment and management models and tools have been developed and are readily available to water planners.

Current water infrastructure investments place greater emphasis on demand reduction, demand management, and reducing system losses than they did in the past.

Emerging societal preferences or trends can also play an important role in infrastructure planning. Urban sprawl provides a common example. Water infrastructure is currently planned based on low-density housing patterns. Therefore, planning and design need to be reconsidered to adapt to changes in municipal planning that encourages higher population density. Mounting pressures on the natural environment have also focused attention on issues such as source water protection, wetlands protection, and demand management programs. For example, initiatives such as rooftop gardens in urban areas help reduce urban runoff and reduce the stresses on wastewater collection caused by storms. Current water infrastructure investments place greater emphasis on demand reduction, demand management, and reducing system losses than they did in the past. Analyses of the overall quality of water returned to our waterways focus mainly on fitness for human consumption. Currently, these issues also include increased emphasis on the overall impact that returned water has on the ecosystem. These considerations might include flow patterns, nutrient content (the prime human-based contribution to eutrophication[3]), or other issues.

In most Canadian municipalities, water and wastewater services are provided by the municipality directly—or through an entity that is owned by the municipality—so that revenues and investments require the approval of municipal councils. At the very least, this involves approval of service rates and investment plans, although the municipal influence may go further.

In this report, Chapter 2 presents an overview of the role that water and wastewater infrastructure plays in Canadian society, and describes the challenges we face. An infrastructure deficit that has arisen through the years is profiled briefly. Chapter 3 discusses investment criteria that apply to water infrastructure, and Chapter 4 presents the results of interviews with representatives from 15 Canadian municipalities. Recommendations are presented in Chapter 5.

3 Eutrophication is a complex process that involves increasing levels of nutrients in water bodies. The most common nutrients are nitrogen and phosphorous. Eutrophication may be caused by human activities or may have natural sources. Human sources include fertilizer in runoff water, manure management, sewage treatment, and industrial effluents. Heightened nutrient levels lead to increased growth of certain plants, reduced oxygen in water, and changes in the ability of the water bodies to support certain species.

CHAPTER 2

Overview of Water and Wastewater Infrastructure in Canada

Chapter Summary

- Efficient water and wastewater infrastructure systems contribute to public health, are a critical component of economic activity for a range of sectors, and can protect the natural environment and human health by treating municipal wastewater effluents.
- Most water and wastewater infrastructure assets are owned and maintained by municipal governments, were built between the 1950s and 1970s, and are due for replacement.
- Although the federal government has increased funding for water and wastewater infrastructure in recent years, a number of financing issues that need to be addressed over the long term still remain.

IMPORTANCE OF INVESTING IN WATER AND WASTEWATER INFRASTRUCTURE

Efficient water and wastewater infrastructure systems significantly contribute to public health. They are essential for providing safe, reliable, non-contaminated drinking water. They are also crucial for the proper treatment and disposal of wastewater for municipalities and communities across Canada. Water and wastewater infrastructure supplies and transports the water resource and protects the water supply for human consumption.

Water and wastewater infrastructure is also a critical component of economic activity for a range of sectors such as agriculture, industry, manufacturing, power generation, and transportation. Investing in Canada's water and wastewater infrastructure not only improves drinking water quality and protects water resources, but it also creates jobs. It has been estimated that investing in the maintenance and rehabilitation of Canada's water and wastewater infrastructure would create more than 30,000 jobs for the Canadian economy.[1] For example, water and wastewater projects generate construction activity and rely on materials and equipment such as pipes, valves, meters, and other monitoring equipment.

Wastewater infrastructure can also protect the natural environment and human health by treating municipal wastewater effluents. According to Environment Canada, municipal sewage is a significant source of nutrients, such as phosphorous, in our waters.[2] Inadequate waste-

1 Federation of Canadian Municipalities, *Municipal Infrastructure Projects.*

2 Environment Canada et al., *Canadian Environmental Sustainability Indicators.*

water treatment and sewage overflows release nutrients into our waterways. The nutrients contribute to the growth of algae, interfere with ecosystem balances, and are potentially harmful to biodiversity.

In 1999, combined secondary[3] and tertiary[4] wastewater treatment was provided to 78 per cent of the population, up from 56 per cent in 1983. By 2004, 85 per cent of the population was served by water treatment and, of this, 47 per cent received secondary treatment.[5] However, in a number of cities and communities across Canada, treatment of wastewater is insufficient or nonexistent, and municipalities are discharging untreated liquid waste into waterways.

CURRENT CONDITION OF WATER AND WASTEWATER ASSETS AND INVESTMENT NEEDS

Most water and wastewater infrastructure assets are owned and maintained by municipal governments, were built between the 1950s and 1970s, and are due for replacement. The average age of municipal water and wastewater infrastructure has increased since the end of the 1970s. The increase occurred because investment was insufficient to replace and maintain deteriorating infrastructure, although the situation has improved marginally in recent years. A 2008 study by Statistics Canada outlined the current age of public infrastructure in Canada.[6] The study reported that in 2007, the age of the water supply systems—including pumping and filtration systems—was, on average, 15 years. Statistics Canada also reported that the average age of wastewater treatment plants in Canada was 18 years. Additionally, in 2007, these assets exceeded 63 per cent of their useful life.

Studies by the Canadian Water Network (CWN) and the Canadian Water and Wastewater Association (CWWA) have identified infrastructure deficits in water and wastewater facilities.[7] Assets in this category include water treatment; supply and distribution systems (water mains, distribution pipes, pressure reducing stations, water meters, treatment plants, storage capacity, and pumping stations); sanitary and storm sewers; and related treatment facilities (sewage pipes and interceptors, storm water pipes and interceptors, combined sewage pipes and interceptors, manholes, treatment plants and associated facilities and equipment, retention basins, septic tanks, and lift stations).The Federation of Canadian Municipalities also has estimated that Canada would need $88.5 billion to upgrade existing infrastructure and build new water and sewer systems between 1997 and 2012.[8]

According to a 2007 Federation of Canadian Municipalities–McGill survey, the deficit related to the water supply and wastewater and storm water systems in Canada was estimated at $31 billion for the existing capital stock. Required new investments were estimated at an additional $56.6 billion.[9]

WATER AND WASTEWATER REGULATIONS AND INFRASTRUCTURE INVESTMENT

In addition to aging and deteriorating infrastructure and maintenance requirements, provincial and federal regulatory requirements will spur new investments in water and wastewater infrastructure. For example, Ontario has introduced the *Clean Water Act,* which will have implications for water and wastewater infrastructure planning. Also, updated federal water quality guidelines are motivating water and wastewater treatment plant upgrades across the country.

3 Secondary treatment is the use of biological processes to break down organic material and remove additional suspended solids.

4 Tertiary treatment is an advanced treatment that uses additional filtering or chemical or biological processes to remove specific compounds or materials that remain after secondary treatment.

5 Environment Canada, *2007 Municipal Water Use Report,* pp. 5–8.

6 Gagnon, Mychèle et al., "Age of Public Infrastructure: A Provincial Perspective."

7 Canadian Water Network, *2004–2005 Annual Report: Bringing Water Research to Life*, and Canadian Water and Wastewater Association, *Municipal Water and Wastewater Infrastructure: Estimated Investment Needs.*

8 Mirza, *Danger Ahead*, p. 12.

9 Ibid.

The Ontario *Clean Water Act* (2006) requires municipalities to develop source water protection plans by 2012, and implement them by the beginning of 2013.[10] These plans will protect drinking water sources based on risk identification and mitigation, and will be developed through consultations with stakeholders.[11]

Source water protection has implications for water and wastewater infrastructure planning and for environmental assessments.[12] Future infrastructure plans must be consistent with Source Water Protection Plans, and may need adjustment as the plans develop and are implemented.

Provincial water authorities are responsible for implementing the *Guidelines for Canadian Drinking Water Quality* within their jurisdiction. The guidelines set out the basic parameters that every water system (public, semi-public, and private) should aim to achieve in order to provide a clean, safe, reliable drinking water supply to municipalities.[13] In addition to the federal guidelines, provincial and territorial water authorities enforce water quality and drinking water standards.

Source water protection has implications for water and wastewater infrastructure planning and for environmental assessments.

Municipal water utilities are responsible for ensuring provincial water quality regulations and objectives are being met. To safeguard drinking water supplies, more stringent water quality regulations have been enacted, and the costs of maintaining water quality standards have risen substantially. For example, the capital costs of meeting Ontario's regulatory water quality requirements—enacted after the Walkerton Inquiry—were estimated at over $800 million. [14]

In February 2009, the Council of Ministers of the Environment endorsed the Canada-Wide Strategy for the Management of Municipal Wastewater Effluents, which includes managing wastewater facility discharges.[15] The strategy consists of a multilateral agreement between the federal government and the provinces and territories.[16] All wastewater facilities will be required to meet minimum national performance standards that are equivalent to secondary treatment and to develop and manage site-specific effluent discharge objectives. Over the next three years, each jurisdiction will be responsible for making legislative changes necessary to implement the strategy. The strategy will be implemented over a 30-year period, and the capital and non-capital costs have been estimated at $10 to $13 billion.[17] Although the strategy represents a step in the right direction, a 30-year implementation period in a rapidly changing world suggests that the strategy will require periodic updating to remain current. One might wonder how much the implementation period might be compressed. Perhaps facilities could be upgraded early in the period, and then replaced with state-of-the-art facilities as they come to the end of their useful life.

CURRENT INFRASTRUCTURE FINANCING PROBLEMS

Over the past 30 years, capital investments in municipal water and wastewater infrastructure have been in decline. Until recently, federal, provincial, and municipal funding for water and wastewater infrastructure has been inadequate to account for infrastructure needs as a result of rising population growth and urbanization. Under-investment in this critical infrastructure can be attributed to the financing challenges confronted by Canadian municipalities, under-pricing of water services, and a lack of government priority. One might argue that there is a fundamental disconnect between the

10 CBC News Online, "Inside Walkerton."

11 Conservation Ontario, "Protect Water."

12 Canadian Environmental Law Association, "Ontario Source Water Protection Statement."

13 Health Canada, "Environmental and Workplace Health."

14 Ministry of Public Infrastructure Renewal, *Watertight: The Case for Change*, p. 40.

15 Canadian Council of Ministers of the Environment, "Canada-Wide Strategy."

16 Eleven of the fourteen federal, provincial and territorial governments endorsed the "Canada-Wide Strategy." (Quebec, Newfoundland and Labrador, and Nunavut did not sign the deal.)

17 Canadian Council of Ministers of the Environment, "Canada-Wide Strategy."

long-term nature of water infrastructure planning and the short-term priorities of elected municipal councils. The evidence presented below indicates that there has been a tendency to under-invest in maintaining underground water infrastructure, and that this infrastructure may be overlooked.

Some analysts point to a lack of funding from all levels of government as a key issue in water and wastewater infrastructure planning. However, this ignores the role of user charges in providing the primary source of incremental revenues for water infrastructure investment. Municipalities face a trade-off between significant rate increases and increasing the infrastructure deficit if historical rates have not been full cost recovery, or if an infrastructure deficit has become significant.

Some of Canada's larger cities have already moved to user pay funding models and are recovering the full cost of providing water services directly from water customers.

A more compelling argument can be made that the current water infrastructure deficit exists because water has been under-priced. Most Canadians pay less than $0.02/litre (including both fixed and variable costs) for the water and wastewater services they receive. It is often true that water consumers pay only a portion of the full financial cost of serving their requirements, and that water revenues are insufficient to fully fund required maintenance and expansion plans. The implication might well be that as federal and provincial governments have reduced their funding for water infrastructure, the municipally owned utilities have been unwilling or unable to transfer the funding burden fully to consumers. Therefore, an infrastructure deficit has been allowed to develop. As Chapter 4 illustrates, this argument does not apply to all municipal water utilities. Some of Canada's larger cities (with Toronto as a notable exception) have already moved to user pay funding models and are recovering the full cost of providing water services directly from water customers. These cities do not rely on federal, provincial, or municipal taxpayers to fund infrastructure investments.

There is also a strong contrast between the approaches to water infrastructure and other essential utility services in some cities. There is greater management independence granted to electric utilities owned by the city or to private companies providing natural gas distribution services. In either case, reliance on municipal revenues is often unthinkable: the electric utility or natural gas distributor often contributes significant tax revenues or franchise fees to the city. Further, infrastructure planning is based on full cost recovery through user charges. Although this study is limited to water infrastructure, a basic comparison between utilities in any given city would show the benefits of relying on users to fund the full cost of infrastructure.

Recently, the federal and provincial governments increased their financial support of water and wastewater infrastructure. In the federal government's 2009 budget, a two-year, $4-billion Infrastructure Stimulus Fund was established to repair provincial, territorial, and municipal infrastructure—which includes water and sewage systems. The federal funding is intended for the short term and must be matched by the municipalities. Projects must begin before 2010. In addition, the federal government has committed $515 million over two years for First Nations projects, and $500 million over the next two years for infrastructure projects in small communities.[18] Under the Building Canada Fund, the federal government will also provide medium-term funding for drinking water and wastewater treatment. Specifically, the federal government will provide $2 billion annually to municipalities through the federal gas tax rebate.

Although the federal government has increased funding for water and wastewater infrastructure in recent years, a number of financing issues that need to be addressed over the long term still remain. Grant programs alone can be criticized for subsidizing inefficient planning and investment practices, or for creating "white elephant" assets. If grants are linked to appropriate steps toward full cost measurement and prices that fully recover those costs, grants can help close the infrastructure gap and move toward financial sustainability. However, in isolation, grants

18 Department of Finance, *Canada's Economic Action Plan.*

could be seen as enabling or extending the planning approaches and pricing mechanisms that contributed to the infrastructure deficit.

From 1988 to 2007 municipal water revenues fell short of expenditures.[19] Overall, capital costs have been underestimated and the investment rates have not fully covered the costs of maintaining and replacing aging water supply networks. In addition, the economic costs of environmental externalities, such as water pollution from sewage operations, have not been fully accounted for.

Grants could be seen as enabling the planning approaches and pricing mechanisms that contributed to the infrastructure deficit.

Over the long term, municipal water and wastewater infrastructure will become vulnerable to climate change, resulting in increased infrastructure financing needs. Specifically, the climate change impacts on water and wastewater infrastructure include increased water demands, water distribution issues, loss of potable water supplies, increased water quality problems, increased risk of flooding, and sewer overflows from high-intensity rainfalls.[20]

Water and wastewater infrastructure is under pressure from the sources canvassed above, as well as others. Although this report focuses on infrastructure financing and planning, complementary approaches are necessary. For example, the POLIS project at the University of Victoria has recently completed studies pointing to the importance of the "soft path" toward municipal water sustainability. The POLIS group research points out that building more infrastructure is not always the best solution. Measures that reduce and manage demand can result in an additional water supply without additional infrastructure. Combining demand-management, full cost pricing, and appropriate regulatory mechanisms can reduce infrastructure requirements and improve the economic efficiency of water and wastewater services.

19 Statistics Canada, "Local Government Revenue and Expenditures."

20 Infrastructure Canada, *Adapting Infrastructure to Climate Change*, p. 8.

CHAPTER 3

Key Requirements for Making Effective Investment Decisions

Chapter Summary

- Expanding asset inventories to include a list of assets already in place, and the condition of facilities, would provide better information for risk analyses and long-term investment plans.
- Numerous price structures have been devised for essential services such as water and energy—some of which are designed to provide consumers with incentives to be efficient in their resource use.
- The role of sustainable development in water infrastructure planning is gaining greater prominence across Canada, but is still at an early stage.

ASSET MANAGEMENT AND INVESTMENT PLANNING PRACTICES

An accurate and complete inventory of the assets in place and their condition might be considered an essential element of investment planning. However, some Canadian municipalities may not have an inventory, or do not have information regarding the condition of facilities.[1] Expanding asset inventories to include such factors would provide better information for risk analyses and long-term investment plans.

Once there is an accurate inventory of the water and wastewater assets, a needs assessment is required. The assessment should take account of the current and future capacity of existing assets and the capacity required to meet future population growth. This needs assessment should reflect the impact of conservation programs, technological advancements, industrial growth, maintenance requirements, upgrade plans, system extension requirements, etc. Each of these elements would require decision criteria such as return on investment, and should be based on the full range of resulting costs and benefits—including appropriate consideration of environmental issues. The needs assessment for many Canadian municipalities could include an indication of the current infrastructure deficit and a plan to reduce and eliminate that deficit over time. Long-term infrastructure and investment priorities should be based on the findings of the needs assessment. The resulting infrastructure plan should be long term in nature, follow a clear set of priorities, be measured against the planned

1 Infrastructure Canada, *Water Infrastructure: Research for Policy & Program Development.*

objectives, and be updated on a regular basis as conditions change. The planning toolbox will likely require traditional investment and risk analysis approaches as well as a broader cost–benefit assessment to prioritize major new capital projects.

A fundamental principle of market economies is that prices are an effective tool for rationing scarce resources.

Water planning priorities and needs are different in each municipality. For some, source water quantity is a key issue; for others, source water quality might be more important. Municipal growth, conservation initiatives, capital replacement, upgrading, and system expansion requirements also vary. The key is to properly link all factors to an integrated plan and base investments on water infrastructure priorities. This report deals specifically with the municipal level component of the overall plan. There are parallel efforts at the provincial and regional level. Integrated water resource management is the practice of viewing water within the overall context of a region's natural resources and resource development. It considers all aspects of water use and management as they interact with agriculture, forestry, mining, recreational land use, and municipal development. Alberta, for example, is currently in the process of developing land use management frameworks for a number of regions. These frameworks are integrated with the Water for Life strategy for water resource management.

PRICING, WATER CONSERVATION AND DEMAND MANAGEMENT

One of the fundamental principles of market economies is that prices are an effective tool for rationing scarce resources.[2] This principle can be applied to water, even though it is an essential resource that is required to support human life. It is not a matter of pricing water beyond the reach of Canadian consumers. It is more a matter of recognizing that water is a scarce resource and that costs must be incurred to make water available to consumers. Numerous price structures have been devised for essential services such as water and energy—some of which are designed to provide consumers with incentives to be efficient in their resource use.

If water pricing is to encourage conservation, water consumption must be measured. Universal metering is a prerequisite for pricing mechanisms that reflect costs and encourage conservation. As described in Chapter 4, universal metering is not universally implemented in Canada, even in its major cities. Environment Canada reports that, based on 2004 data, only 63 per cent of Canadian residential water users have meters installed.[3] Their survey included all municipalities with populations of 1,000 or greater—except those on Canada Lands (Canada Lands include the Yukon Territory, the Northwest Territories, and Nunavut; over 2,600 reserves; Canada's national and historic parks; and Canada's offshore area)—as well as 660 municipalities whose populations were smaller than 1,000. Although there is a long-term, gradual trend toward increasing metering, 37 per cent of Canadian residences did not have water meters as of 2004. They paid a flat monthly fee, regardless of the volume of water they received. In such cases, conservation programs or demand management initiatives represent the primary influence over consumption decisions.

Although metering is a prerequisite to any pricing formula other than a flat monthly charge, metering alone is not enough to influence consumption decisions. Consumers must be aware of their consumption, and the price must provide a clear incentive to limit consumption, for the price of water to allocate the resource to its highest value uses. Having a meter installed, and receiving a monthly bill indicating the volume delivered, is an improvement over flat billing because it can make consumers aware of their consumption. However, the most common pricing mechanism used in Canada, based on the 2004 survey data, is a constant unit charge. This pricing formula applied to 45 per cent of residences.[4]

2 Note that this report deals only with municipal water price mechanisms. There are also wholesale water allocation mechanisms that determine who has access to water resources and how much water they may take. These wholesale allocation mechanisms do not use price to promote efficiency.

3 Environment Canada, *2008 Municipal Water Pricing Report*, p. 2.

4 Ibid., p. 5.

In 2004, the average monthly bill for a household consuming 25 cubic metres (a typical consumption level) was only $40.47.[5] Based on the Environment Canada data, a large segment of Canadian residences either pay a flat monthly fee for water or pay a constant price per unit of water consumed. In 2004, only 23.3 per cent of residences paid water rates that increased per unit as consumption increased.

The most aggressive conservation measures may come through water bylaws, which in some cases mandate installation of low-flow faucets and efficient dual-flush toilets.

The available data suggest that water pricing is not being used to its full potential to encourage conservation and efficient use of a scarce and valuable resource. Because it is essential, water demand—particularly at low levels of consumption—may not be responsive to price signals.[6] Water is like energy in that a certain basic amount is required, and additional volumes are often considered to be a near necessity. This often means that consumers respond slowly to price increases—maintaining their accustomed consumption patterns until the price increases enough to impinge on household budgets.

There are several price mechanisms used in other industries that do not appear to be implemented by water utilities. Seasonal pricing is the simplest and would reflect the fact that water demand peaks in the summer, requiring greater infrastructure capacity. The portion of capacity that exists only to meet the summer peak demand remains idle in winter. Seasonal pricing allows the cost of peak facilities to be recovered fully from summer water users. This sends an important price signal to consumers that water is more expensive to use during the summer and provides an incentive to manage summer use. Similarly, time-of-use pricing is beginning to be implemented in the electricity sector. It is not clear whether hourly water consumption patterns would justify the required investment in metering and billing infrastructure. But time-of-use pricing, if appropriate, would provide consumers with more direct price signals and encourage better demand management. Finally, zoned or distance-based water rates could help to address some of the cross-subsidization issues related to replacing inner-city mains or urban sprawl. Because of the low level of demand response to price, conservation or demand management measures are often used as well. There is a broad range of conservation measures in place in Canada, with the measures varying among municipalities.[7] Some of these initiatives focus almost entirely on providing information to consumers and encouraging them to reduce water consumption. These measures might consist of information bulletins included with water bills: monthly bills that contain information regarding actual consumption and methods of reducing consumption; general conservation advice, available through websites or phone lines; advertising; school presentations; or efficiency kits that help homeowners assess their water consumption patterns. Other initiatives provide direct incentives to reduce water consumption. These initiatives might include water use audits, rebates for conversion to low-flow appliances, retrofit programs, or voluntary use restrictions. The most aggressive conservation measures may come through water bylaws. In some cases, these bylaws mandate installation of low-flow faucets, efficient dual-flush toilets, or reduced water pressure. The bylaws may also include automatic seasonal restrictions on outdoor water use, prohibitions on washing vehicles outdoors, etc.

5 Ibid., p. 7.

6 Renzetti, Steven, *Wave of the Future: The Case for Smarter Water Policy.* This report makes the case that the price elasticity of water demand is less than 1. This means that a 1 per cent increase in price leads to a reduction in demand of less than 1 per cent.

7 Canadian Water and Wastewater Association, and CWWA Efficiency Network, *Water Conservation and Efficiency Performance Measures.* The CWWA report presents the results of a survey of 300 municipalities regarding specific conservation and efficiency measures. The report is based on 39 surveys that were completed and returned.

The most common demand management measure is provisions in bylaws permitting municipal authorities to restrict outdoor water use in periods of scarcity. Fines and penalties are often attached to strengthen the incentive to comply. This study does not examine the effectiveness of such policies or the optimal mix of price, financial incentives, and use restrictions. In fact, the finding is that the municipalities in our study implement such measures independently. Each measure should be reviewed to determine its impact or return on investment, but municipalities do not attempt to optimize the mix. Each measure needs to be evaluated based on its own cost and effectiveness because some demand management measures are expensive or have high monitoring and enforcement costs. (See box "Combining Price and Regulatory Measures.")

Decision makers must consider pricing and conservation measures as they develop their investment plans.

Conservation measures may also be implemented within the water treatment or delivery system, rather than at the consumer level. For example, some Canadian municipalities have active programs to repair or replace leaking mains, which increases the percentage of water flowing through the mains that actually reaches the consumer. This can be a non-trivial investment and can significantly influence the need for facility expansions.

Pricing and conservation initiatives bear a direct and important link to infrastructure investment.[8] When such measures reduce consumption, they reduce the need for water treatment, water distribution, and wastewater treatment facilities and related investment. Decision makers must therefore consider pricing and conservation measures as they develop their investment plans.

8 POLIS Project on Ecological Governance, et al., "Clean Water, Green Jobs." The link is further explored, including policy prescriptions, in the POLIS publication.

Combining Price and Regulatory Measures

Water is an essential part of daily life. Our consumption decisions are often more influenced by essential requirements than by price. Economists would call water a "price inelastic good," meaning that the percentage change in demand is smaller than the original percentage change in price. The inelasticity is greater in the short term than in the long term. One reason is because demand adjustments often require capital investments and capital is not often replaced before the end of the service life (plumbing fixtures, for example). Another reason is because behaviour changes take time to implement. (People often don't respond if they think a price increase is short term.) This is common for goods that we consider necessities such as water, energy, or transportation services. As a result, changing behaviour using price alone often requires prices to rise by a multiple of the desired percentage reduction in consumption. Therefore, the most effective incentives often combine pricing initiatives with conservation programs and regulatory measures.

The town of Cochrane, Alberta, provides an example. Cochrane is located just west of Calgary, is one of Canada's fastest growing municipalities (current population approximately 16,000), and depends on the heavily allocated Bow River for its water supply. All water consumption is metered and subject to increasing block pricing. For residences, there are three blocks, with the highest priced at double the rate per cubic meter of the lowest block. One might argue that the rates are low or that the block structure is generous, but the overall pricing structure is a clear signal to consumers to avoid waste because the price increases significantly with increasing consumption.

In addition to metering and increasing block pricing, Cochrane's water bylaw mandates conservation and demand management measures. New construction or retrofits of industrial and residential buildings are required to install efficient plumbing fixtures such as low-flow taps and efficient dual-flush toilets. Homeowners must ensure that when they use outdoor water they don't waste it by allowing excessive runoff. They are encouraged to collect and use rainwater since the regulations are aimed at outdoor use of potable water. The town also has the ability to restrict outdoor water use during periods of drought. The first level of restriction limits outdoor water use during summer months (the allowed times are 5:00 a.m.–10:00 a.m. and 7:00 p.m.–1:00 a.m.) to help ensure that the water is absorbed by plants rather than evaporating. Outdoor water use can also be prohibited if required. Mandating conservation measures and implementing use restrictions can reinforce price signals, help to manage growth in consumption, and result in more efficient and effective investment in water services infrastructure.

INFRASTRUCTURE FINANCING AND FULL COST RECOVERY

The relationship between infrastructure investment, financing, and cost recovery is surprisingly varied and complex for Canadian water providers. At the municipal level, one of the greatest challenges is to optimize the infrastructure that is required and set appropriate investment priorities. Municipalities play a key role in water management issues outside of their borders, and their investments do not always fully reflect those issues. For example, wastewater that is treated and returned to the watershed from one municipality becomes source water for downstream municipalities. The level of treatment is therefore an operating decision that impacts other municipalities.

Economists would identify three broad cost categories to consider: fixed costs, variable costs, and externality costs related to environmental impacts or other items that the water system does not pay directly.

A simple progression from infrastructure needs planning to cost determination, cost allocation, rate design, and financing options should exist. However, issues such as the decision-making authority of the water utility, financial independence, and policy priorities can influence the progression. Previous chapters of this report have considered infrastructure planning, and subsequent chapters will detail the state of play in Canadian municipalities. This section focuses on what full cost means, how costs are recovered, and how cost recovery methods influence investment plans in the long term.

Although full cost recovery is notionally simple, it is complex in practice. One fundamental, yet challenging, question is, Which costs are to be recovered? This is typically answered through cost studies. Another question is, How and from whom to recover those costs? This is answered through cost allocation and rate design studies. A third issue is the relationship between cost recovery and investment plans.

Economists would identify three broad cost categories to consider: fixed costs (costs associated with assets that have a long, useful life), variable costs (typically labour costs and any other cost related to goods or services that are consumed over a short period), and externality costs related to environmental impacts or other items that the water system does not pay directly.[9] This approach has been used in economic theory and in many industries for decades. As a starting point, most water pricing models used in Canada follow this general pattern. However, the implementation leaves much to be desired, particularly with respect to matching the marginal cost[10] of providing service with the price. If one considers a typical budget period to be one year, fixed costs would be those costs associated with elements of the water system that will provide services for more than one year. Variable costs would be those costs that are short term in nature, and that would be eliminated if the water system delivered no water for an entire year. Externality costs would be costs to the environment or to society that are caused by the water system operating, but that are not paid by the water system. Fixed costs would typically include treatment facilities, mains, pressure-regulating stations, land, equipment, and anything else that has a long service life. Capital maintenance, or facilities maintenance with significant costs and long-term benefits, would also be considered a fixed cost. Variable costs might include annual operating costs of treatment facilities, billing costs, salaries, and any other costs that would be avoided if the water system did not operate in the short term. Such costs are readily identified. The challenge arises in determining when and how to recover them.

Externality costs present an entirely different problem, both for identification and for quantification. The water system operator is typically not required to bear these costs, or bears only a portion. Provincial water management and governance systems take different approaches to in-stream flow requirements or source protection, for

9 Marbek Resource Consultants Ltd., and Dr. Steven Renzetti, "Analysis of Economic Instruments for Water Conservation." Figure ES-1 identifies a value gap resulting from a practical definition of full cost that falls short of including external costs.

10 Marginal cost is the cost of providing an incremental unit of water or wastewater service.

example. In some instances, water licensing is expected to limit water abstractions and use to a level that does not harm ecosystems. However, this is not always the case, and harmful environmental impacts may occur as a result of water use. The cost of protecting or restoring the environment is seldom included in the definition of full costs for water systems, although one might argue that sustainability requires such costs to be reflected. Similarly, water quality guidelines regarding the water delivered by the system are clear and targeted primarily at human health. Source protection guidelines are less common, and if effectively implemented, would be likely to impose additional costs on water systems.

Ideally, full cost recovery would reflect the concept of sustainability. All costs would be included to ensure that the water system operates for generations, expands as required, replaces infrastructure as needed, and protects the environment without restricting the options available to future water consumers. In practice, full cost recovery means different things to different service providers, as will be detailed in Chapter 4. Even a more narrow definition of full cost, including only the replacement cost, expansion cost, and operating cost of the system, is not as commonly used as one might expect.

Water quality guidelines regarding the water delivered by the system are clear and targeted primarily at human health.

Once full cost has been determined, costs must be allocated between system users. Recovery mechanisms—fixed charges and volumetric charges, as appropriate—must be designed. (The focal point here is on retail cost allocation and pricing because this study focuses on municipal infrastructure and pricing.) Cost elements or economic instruments that would normally be considered as part of water allocation schemes are outside the scope of this report.[11] Cost allocation is a challenging activity. The basic principle is to allocate costs to those users that cause them to be incurred. Each user should be responsible for their own meter cost, connection cost, and an appropriate share of cost of the delivery mains and treatment facilities. However, the costs of common facilities (treatment plants, mains, etc.) may be allocated among customer groups (residences, commercial establishments, and industrial customers) on a basis that represents something other than purely the share of total costs that is caused by each user. The costs allocated to each group of users must then be recovered through user rates, whether monthly fixed charges, volumetric rates, or a combination.

With costs allocated among user groups, fixed and volumetric charges can be determined to ensure that all costs are recovered in a timely manner. An intervening step occurs in many Canadian municipalities because a portion of the costs of the water system is collected through taxes or other municipal levies. The intervening step is to determine what share of the cost will be recovered through taxes. In most water systems, fixed costs are much larger—even on an annual basis—than variable costs. This occurs even though the fixed component of monthly bills (where volumetric charges are used) is typically much smaller than the usage charge. Rate design is often based on the principle of recovering fixed costs through a monthly fixed charge that doesn't depend on use and recovering variable costs through a volumetric rate. Some rate design methods place greater risk on the service provider by allocating fixed costs to the volumetric portion of the rate.

Finally, the link between cost recovery, long-term investment, and financing is self-evident. Municipalities with water systems that are separate self-financed corporations—recovering the full cost of the system through consumer rates—typically have greater ability to match infrastructure investment to the need, and face fewer financing constraints. Municipalities that are heavily dependent on municipal taxes for funding face greater constraints in planning their infrastructure requirements and financing the required investment.

11 See Marbek and Renzetti, Tables ES–1 and ES–2, for a more complete presentation of economic instruments and pricing mechanisms.

INVESTMENTS IN SUSTAINABLE WATER INFRASTRUCTURE AND SUSTAINABLE PRACTICES

The role of sustainable development in water infrastructure planning is gaining greater prominence across Canada, but is still at an early stage. The broad objective of sustainable development is that the decisions made today do not constrain the options of future generations. In order to meet this objective, environmental, economic, and social factors must be considered together in such a manner that the cumulative effects and impacts of human activities are understood and managed. This is a very challenging task, and we are at the early stages of understanding how to develop and pursue sustainable water infrastructure plans.

For this report, there are two key issues to consider: water quantity and water quality. Water quantity refers to the quantity of source water available; the quantity of processed water consumed; and the quantity of wastewater generated, processed, and returned to the natural environment. In much of Western Canada, the quantity of source water available is declining, and the population continues to grow. In some regions of Eastern Canada this is also true, although in other regions, the quantity of source water available is not considered an issue. Sustainability requires that municipalities in each watershed limit their water abstractions to a level that maintains a healthy aquatic ecosystem. For many watersheds, ecosystem requirements are not fully understood, making this a difficult objective to meet. Additionally, the volume of water that can be used is a shared responsibility between provincial and municipal governments, with the provincial government having the primary responsibility.

Water quantity is also affected by conservation, efficiency, and demand management initiatives. Any steps that can reduce the volume of water used per capita or relative to the level of economic activity can contribute to sustainability. These initiatives include, among others, universal metering, installing water efficient devices, improving industrial processes to reduce water requirements, reducing outdoor water use, reducing losses in the delivery network, and water recycling. As already indicated, Canadians are profligate users of water, suggesting that conservation and demand management could contribute significantly to sustainability. This is not to say that conservation for its own sake is the best approach. As argued earlier, conservation incentives and programs are most effective when combined with effective price signals. This ensures that water resources are allocated to uses with the highest commercial value. And, the integrated package of price structures, incentives, and regulatory measures should be examined within an overall cost benefit analysis that would enable decision makers to choose the most effective programs.

Rooftop gardens, judicious placement of green spaces, reduced use of concrete driveways, and other practices that reduce the tendency for rainwater to flow immediately into wastewater gathering systems could also be included.

Water quality includes sustainability practices such as preserving wetlands, recycling grey water, improved processing of sewage to remove nitrogen and phosphorous, and developing and implementing source water protection plans.

CHAPTER 4

Overview of Current Practices in Managing Investment Decisions Across Canada

Chapter Summary

- Representatives of 15 municipal water and wastewater authorities across Canada were interviewed to gain insight into the municipalities' infrastructure planning, management, and financing practices.
- A basic understanding of the current condition of assets and their future capital maintenance requirements is a prerequisite to effective asset management and investment planning. However, in the case of municipal water systems, this is very complex.
- Two key issues have emerged that are changing the approaches taken to asset management. The first is integrating conservation and demand management into infrastructure planning. The second issue is source water protection.

We interviewed the representatives of 15 municipal water and wastewater authorities across Canada for this report. The purpose of the interviews was to gain insight into the municipalities' infrastructure planning, management, and financing practices. The interviews were conducted with representatives from:

- Calgary
- Charlottetown
- Edmonton
- Halifax
- Hamilton
- London
- Ottawa
- Québec City
- Moose Jaw
- St. John's
- Toronto
- Vancouver
- Victoria
- Winnipeg
- Yellowknife

Our interviews included representatives from 9 of the 10 largest census metropolitan areas (based on Statistics Canada's 2006 census data), representing a total population, in the 15 municipalities, of just over 14 million inhabitants and 5.6 million households. Although our study included six smaller cities, we did not include any exceedingly small municipalities. There are issues such as efficient scale of operations that are not investigated because of the large municipality bias in our sample.

ASSET MANAGEMENT AND INVESTMENT PLANNING PRACTICES

ASSET INVENTORIES AND CAPITAL MAINTENANCE

A basic understanding of the current condition of assets and their future capital maintenance requirements is a prerequisite to effective asset management and investment planning. However, in the case of municipal water systems, this is a very complex set of issues, as our interviews with water system managers revealed. Most municipalities have differing levels of information regarding the current state of network assets as compared with processing assets (whether for water or wastewater). They also have different planning requirements. The network assets typically have much longer service lives.

Most of the municipalities in our study focus on reducing the number of line breaks as a key metric.

In Canada's older cities (for example, Ottawa, Victoria, and Québec City), a significant portion of water delivery and wastewater collection systems has been in place since the mid-twentieth century or longer. The condition of the pipes is often discovered through failures or replacement programs, rather than being regularly tracked. For some of Canada's younger cities, such as Calgary, older pipes represent a smaller proportion of the total assets. There are also different growth patterns. Cities such as Charlottetown and Québec City have grown historically by amalgamation. This type of growth can result in a mix of asset ages, replacement strategies, and monitoring or information gathering approaches. It can also indicate a need to bring previously rural areas onto the water and wastewater systems. Other cities, such as Calgary, have grown more by constructing new neighbourhoods, relying more on asset planning, and providing better information regarding the age and condition of the pipes.

Almost all of the municipality representatives we interviewed indicated that they have an asset inventory in place, yet an infrastructure deficit still exists. This suggests a disconnect between their knowledge of the state of assets and their ability to invest. Hamilton, for example, has a formal asset management program. But overall asset condition is poor because the pipes are beyond their useful life and resource constraints have meant inadequate investments. St. John's, at the other end of the scale, has an up-to-date asset inventory and an active program to inspect and improve the condition of water delivery assets.

Most of the municipalities in our study focus on reducing the number of line breaks as a key metric. In the last decade, Calgary has reduced water main breaks from 700–800 per year to just 300. Similarly, Winnipeg pursues a strategy of reducing water main breaks (from 25,000 in 1983 to 500 in 2008). Some municipalities, such as Calgary and Edmonton, extend the focus to include system losses (water that is delivered into the distribution network but never reaches an end consumer, primarily because of small leaks that don't require immediate repair). Calgary has published its 30-in-30 target of accommodating 30 per cent growth in population between 2003 and 2033 without increasing water demand. Reducing system losses is a key element of the plan (as much as 20 per cent of the water entering the system in 2003 was accounted for as system losses). The situation is somewhat different for water and wastewater treatment assets, and there are several reasons for the difference, including the following:

- The treatment assets have a shorter life.
- Water and wastewater treatment technologies change more rapidly than piping technologies.
- Capacity requirements follow a different growth path.
- Water and wastewater treatment facilities are more directly linked to protecting health than is the delivery system.
- Water and wastewater treatment facilities in Canadian municipalities are generally in better condition than the underground mains and pipes, and their condition is more frequently assessed and more aggressively managed.

Almost all of the representatives interviewed indicated that they have upgrading plans and investment programs for water and wastewater treatment facilities.

Two key issues have emerged that are changing the approaches taken to asset management. The first is integrating conservation and demand management into infrastructure planning.[1] Canadians are not efficient or effective in their use of water. Water managers understand that the soft path of demand management needs to play a more significant role in influencing behaviour, thereby reducing stresses on infrastructure. They also recognize that conservation reduces the need for incremental supplies. The second issue is source water protection. Growing industrial and recreational use of land and water has implications for the quality and quantity of water available to municipalities. Growing populations mean increasing stress on water and wastewater treatment facilities. Larger volumes of water used, processed, and returned to waterways result in a greater human impact on the natural environment. This is changing the role of wastewater treatment and increasing the need to protect water that will be a source for downstream ecosystems and communities.

Our interview results suggest a broad range of "states of play" in terms of asset inventories and asset management programs. Municipalities generally have a better understanding of the state of water and wastewater processing assets than they do of the underground network of pipes. Excessive line breaks are often the signal that monitoring and replacement programs are inadequate and need to be accelerated, sometimes subject to capital availability.

Despite the water and wastewater infrastructure deficit described above, only three of the municipalities in the study (Halifax, Hamilton, and Toronto) indicated that they have experienced deferral of capital maintenance expenditures. For Halifax, the deferrals have been mostly in wastewater facilities. For Hamilton, deferrals have been driven by budget constraints, with rates being increased to attempt to solve the problem. For Toronto, rates have been low and a no-debt-financing policy has meant that assets must be maintained, replaced, and expanded from current revenues only. (See box "Recent Capital Investments and Future Requirements.") Charlottetown has also seen expansion projects deferred because of funding constraints. The picture that emerges in several municipalities is one where revenues have been barely enough to keep up with current maintenance and limited replacement programs, and there has been little ability to close the infrastructure gap that has accumulated through time. Funding growth often receives higher priority even though resources are often insufficient to accommodate the full range of funding priorities.

As one would expect, all of the municipalities in the study have future investment plans in place. The plans include both existing and future assets, with future assets based on a formal review of replacement requirements as well as probable capacity expansions. However, there is a broad range of approaches to financing water and wastewater infrastructure. Similarly, municipalities use a broad range of processes to set investment priorities.

Our interviews identified numerous factors that influence investment decisions. Listed from most frequently cited to least cited, they include:

- maintaining and meeting water quality standards to protect public health and safety;
- investing to meet current and future capacity requirements;
- age and condition of the assets;
- triple bottom line objectives (social, economic, environmental);
- minimizing releases of untreated or partially treated sewage;
- risk mitigation;
- budget constraints;
- cost benefit analysis;
- customer satisfaction;
- managing the potential impact of investments on consumer rates;
- flooding and flood management;
- results of pressure loss monitoring;
- return on investment;
- scheduled replacement of a fixed percentage of assets each year;
- conservation targets;
- regulatory requirements;
- service standards;
- operating costs;
- a formal grid to set priorities between projects.

1 See the POLIS project website at the University of Victoria for some excellent work in this field. www.POLISproject.org/.

Recent Capital Investments and Future Requirements

Toronto provides an interesting case study in water financing. Toronto has taken a pay-as-you-go approach to funding water infrastructure. Fees generated each year from service billings in that year are used to pay for system requirements, including investments in new and replacement infrastructure. Municipal taxes do not provide income for water services. There is a reserve fund that could be used to provide a measure of stability in expenditures versus revenues from year to year, but the city does not finance water infrastructure through debt. Further, water rates in Toronto are lower than most major Canadian cities. In its 2005 business plan, Toronto Water indicated:

> Upon examination of the proposed capital expenditures for the period 2005 through 2009, the main areas of increase are escalating capital requirements to fund rehabilitation of the aging and deteriorating underground infrastructure, as well as increased amounts for plants and facilities. The primary rationale for the increased level of expenditures on the underground infrastructure is the increasing costs of maintaining water mains and sewers as well as the increasing levels of breaks due to the fact that significant parts of this infrastructure have exceeded or are approaching their normal useful life.[1]

The average age of water mains in Toronto is 54 years; 23.5 per cent of the water mains are 80 years or older. Sewer lines average 48 years old; 11 per cent are 80 years or older.[2] Toronto Water currently faces an infrastructure deficit of $1.85 billion, of which $1.3 billion relates to underground infrastructure and $550 million relates to water and wastewater treatment facilities. This deficit will begin to shrink in 2009 as water rates are increased to a level that will meet operating and expansion costs and allow some funds to reduce the backlog. Toronto Water's residential rates have increased by 9 per cent in 2003, 6 per cent annually in both 2004 and 2005, and 9 per cent per year thereafter.[3] Further rate increases will be required for at least the next 5–10 years.

Given the long life of water infrastructure, a no-debt funding approach makes sense, as long as an infrastructure deficit is not allowed to accumulate. If only 1–2 per cent of assets must be replaced each year, the annual capital expenditure can be recovered through current rates. The desire to keep water rates as low as possible might also make sense in that it contributes to economic competitiveness. However, a long-term reliance on the twin strategies of low rates and debt-free investment has contributed significantly to an infrastructure deficit borne by current and future water consumers.

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1 Toronto Water, *Multi-Year Business Plan 2005*, p. 93.

2 City of Toronto, "Toronto Water at a Glance."

3 Ibid.

Many of the criteria relate to the physical capacity, condition, or performance of existing or future assets, taking into account known and foreseeable risks. Individual investments must meet predetermined standards (which may or may not be based on economic efficiency), or might be required to ensure continued compliance with those standards. Other criteria such as operating costs, cost benefit analysis, triple bottom line, or budget constraints represent standards that might be used to rank investments against each other in search of an optimal allocation of scarce resources. Some of the criteria are even broader in scope and respond to customer perceptions, service standards, or social and environmental performance (triple bottom line).

The processes used to set investment priorities are also different among municipalities. In most cases, the water service provider is a corporation whose management and accounts are separate from the municipal government, suggesting a measure of independence. The corporation may have a board of directors including municipal appointees, a steering committee—including municipal representatives—that has stewardship over capital decisions, or a formal process to consult with civic departments before finalizing investment plans. Governance and operating relationships are complex and need to be considered individually within the context of municipal bylaws, operating objectives, and financial accountabilities.

PRICING, WATER CONSERVATION AND DEMAND MANAGEMENT

Appropriate pricing, conservation, and demand management measures can contribute to a soft path approach to water management. These measures can make better use of water by reducing per capita residential consumption and reducing the water required to achieve a given level of industrial production. The first step is to ensure that consumption is measured. Although not all of the municipalities we examined have implemented universal metering, most are on their way to that objective. Edmonton, Halifax, Hamilton, London, Moose Jaw, Ottawa, Victoria, Winnipeg, and Yellowknife require all customers to have meters. Calgary has announced plans to achieve 100 per cent metering by 2014 and is well on the way. Charlottetown meters 70 per cent of water consumption, but hasn't yet made a decision to meter all consumption. Québec City has meters for commercial and industrial water customers, but does not meter residential consumption. Toronto has meters installed for 85 per cent of customers and will raise that to 100 per cent over the next six years. Universal metering is a prerequisite for accurate price signals and effective conservation programs. The end user must be able to see the financial benefits of reducing water consumption as an incentive to ration resources. That is only possible if consumers are billed for actual consumption. On balance, the municipalities we examined understand the importance of universal metering and have installed meters for all customers or are moving in that direction.

Universal metering is a prerequisite for effective conservation programs—the end user must be able to see the financial benefits of reducing water consumption.

Once consumption is measured, an appropriate price structure can be used to encourage efficient levels of water use and appliance purchases. First, the prices charged must reflect the full cost of providing the service to each customer or group of customers. This is a critical element of efficient resource allocation that is often ignored in water pricing. Twelve of the 15 municipalities in our study indicated they work on a full cost recovery model, yet there was a broad range of answers regarding what is included in full costs.

The second element of pricing is a rate design that discourages excessive consumption. Canadian municipalities typically offer one of three price systems to their customers. In some cases, it is a flat monthly charge, independent of the volume consumed. In other cases, there is a monthly basic fee plus a charge per unit of water consumed. Third, the most aggressive price system is a basic monthly fee plus a charge per unit of water consumed, with the unit charge rising as consumption rises (usually through an increasing block structure). The third option provides the strongest signals to consumers to conserve water. A basic monthly rate plus a constant charge per unit of water consumed is the typical residential rate structure for a Canadian municipality. Further, the charge per cubic metre of water delivered is most often $1.00 or less, which translates into one-tenth of a cent per litre.

The information programs communicate the options to reduce water waste, whether through changing behaviour or through replacing existing water fixtures and appliances.

Given that prices are low, water charges alone are insufficient to encourage conservation practices. Most of the municipalities examined also have information programs and financial programs to encourage conservation. The information programs communicate the options to reduce water waste, whether through changing behaviour or through replacing existing water fixtures and appliances. The financial programs offer rebates to consumers who invest in water-efficient fixtures. In the commercial and industrial market segments, some service providers offer assessment/audit services to help large water consumers identify ways to reduce their water consumption and their costs.

INFRASTRUCTURE FINANCING AND FULL COST RECOVERY

Each of the municipalities in our study has made significant water infrastructure investments over the past five years and has plans for future investments. In several cases, these investments carry the burden of dealing, at least partially, with a backlog of deferrals. Recent investments have focused on upgrades to water treatment plants to improve water quality, water treatment capacity expansion, wastewater treatment capacity and, to a lesser extent, the network of underground water and sewer pipes. Plans for future investment follow a similar pattern—perhaps with a stronger emphasis on expanding the distribution system.

Water infrastructure is most often financed through a combination of:

- municipal property taxes and related levies;
- development charges;
- service charges to consumers;
- debt;
- provincial grants;
- federal grants.

The choice of funding mechanisms and the distribution between sources appear to be a matter of policy within each organization. For network expansions into new neighbourhoods, most municipalities share the cost and risk with land developers through development charges. The developers' share of the cost is passed through in the cost of servicing land and is at least partly recovered in the sale price of building lots. The water system's share is funded through rates, debt, grants, or property taxes and levies. Development charges may be negotiated based on a set of broad parameters, or they may simply be based on the number of connections. From the perspective of the water and wastewater system, development charges are a means of transferring at least a portion of system expansion costs directly to those who cause the costs to be incurred—a familiar principle in utility rate design.

The practice of using property taxes to fund water and wastewater services is not widespread among the cities we considered. The practice may possibly be viewed as somewhat anachronistic and inappropriate where services are provided through a separate corporation. In fact, several of the water system representatives we interviewed pay a franchise fee to the city. If water and wastewater services are financially supported through municipal taxes, the end consumer may not see the impact of the funding on monthly bills and may not be aware of the full cost of providing the services. This interferes with price signals and can impair efficient resource allocation decisions. Almost all of the municipalities we examined use the more direct path of funding water and wastewater services through direct levies.

Provincial and federal grants have been used by several of the municipalities in our study. The grants are used to reduce the capital cost of facilities (most often water or wastewater treatment plants or upgrades) that must be borne by users or financed through other sources. Transfers of provincial gas tax funds are also used by some municipalities to fund system upgrades or expansions. Some municipalities may be reluctant to rely on provincial or federal funding that could create "white elephant" assets or assets whose operating costs might be a burden on water consumers.

If water and wastewater services are financially supported through municipal taxes, the end consumer may not see the impact of the funding on monthly bills.

Among the group of municipalities in our study, Toronto stands alone in financing all system costs through current charges. Toronto Water does not rely on provincial or federal financing, receive revenues from property taxes, or incur debt. A reserve fund is used to manage the annual impacts of required investments. Other municipalities use funding from higher levels of government when they consider such funding appropriate or necessary. They also rely on debt. Because the

water and wastewater utility is a municipal corporation, any debt incurred is directly or indirectly supported by the municipality. This results in a strong municipal influence over the types and amount of debt the water corporation can incur. In some cases, this is achieved through municipal government approval of the investment plan. In other cases, the municipal government appoints members to a board of directors that oversees water and wastewater investment decisions. In all cases, the rate increases required to fund a given level of investment is a key decision criterion.

One of the most telling parts of our interviews related to cost recovery. The universal response to our question regarding full cost recovery was that all costs are being recovered, but that such a simple term as "cost" is defined differently by different water authorities. Charlottetown, for example, relies on demand loans to fund at least a portion of system upgrades and expansions, and annually pays the interest on the loans. Charlottetown uses groundwater for its entire water source, and the groundwater is of sufficient quality that very little treatment is required. Assuming that groundwater abstractions are less than the sustainable level (i.e., no negative impact on the aquifer), full cost recovery for Charlottetown's water system could be as simple as recovering operating costs. A more complete definition might include amortization of the principal on the demand loans, as well as the environmental impacts of wastewater treatment and return to waterways.

Most municipal representatives indicated that their combination of revenue sources—relying primarily on user charges—is sufficient to recover all direct costs of water and wastewater services. Many indicated, like Toronto, that rates have increased. They also pointed out that rates will need to increase in the future to recover all costs, including expansions, and to reduce the current infrastructure deficit. Of course, the mere presence of an investment backlog, or infrastructure deficit, suggests either a narrow definition of full costs or a changing approach toward water and wastewater infrastructure planning.

The costs of protecting the environment produced a broad range of answers—the most common being that environmental protection is not included in investment planning or in user charges. Other responses were given as well. In Halifax, the impacts of water and wastewater services on the environment are explicitly considered, despite the historical practice of dumping raw or partly treated sewage into the ocean. In that case, considering environmental impacts might be interpreted as awareness of the impacts with a commitment to reducing them through time. Vancouver includes the environmental impacts of wastewater released into the ocean as a part of waste management plans and has long-term targets for improvement. These measures are part of the planning process. However, there is not a separate consideration of ecosystem water demands or protection measures for the wastewater system overall. Victoria takes a triple bottom line approach to expanding or replacing network assets, such as using trenchless technologies to reduce environmental impacts and disruptions. Victoria also has a greenhouse gas reduction program. However, the issue of sewage disposal into the ocean is not entirely resolved at this point.

In all cases, the rate increases required to fund a given level of investment is a key decision criterion.

One very important environmental issue across Canada is source water protection. Ontario has taken action with recent requirements that municipalities develop source water protection plans and implement them by 2013. Two of the key sub-issues are the growing cumulative impacts of development on water availability and quality and the impact of returned wastewater on the downstream ecosystem.

Calgary provides an example of the combined impacts of water scarcity and increasing land use pressures. Calgary relies primarily on the Bow and Elbow rivers for its source waters. Declining flow rates, changing seasonal flows, and population growth have resulted in a need to carefully manage the quantity of water

withdrawn. Part of the solution exists in conservation programs to reduce per capita water use. Other parts comprise reducing water losses by replacing leaky water mains and upgrading water treatment facilities to deal with inlet water of declining quality. The emerging part of the solution lies in collaborating with other stakeholders in developing watershed management plans for the two rivers. Under the provincial Water for Life program, integrated water resource management has received increased attention. Watershed management plans can contribute to multi-stakeholder understanding of the need to protect source water and cooperative efforts to implement that need.

Ontario municipalities are in the process of developing source water protection plans. In an ideal situation, source water protection would ensure that the ecosystem impacts of human use of water are minimized (keeping in mind that waste water from one municipality will be part of the source water for another). This is an issue across Canada, although Ontario is taking a leadership role in developing source water protection plans. Source water protection must include proper representation of in-stream flow requirements, or ecosystem demands for water. The essential element is to ensure that water abstractions for human use do not have a negative impact on the ecosystem. Water quality must also be considered, with eutrophication[2] being a key concern. (See box "Eutrophication: What We Put Back Matters.")

2 Schindler, David W. and John R. Vallentyne, *The Algal Bowl*. A thorough and accessible treatment of eutrophication is outlined in this book.

Eutrophication: What We Put Back Matters

Eutrophication provides an example of one of the environmental impacts of human use of water that is not currently priced into water rates and that creates significant pressures on ecosystems as well as downstream water users. One of the most significant water issues Canada faces is the role of the increasing density of human development activities. In the context of eutrophication that results from human activities, it is a combination of agriculture, urbanization, and the density of activities that creates the problem. Human-induced eutrophication results primarily from increased levels of nutrients being released into lakes and rivers. The nutrients with the greatest impact are phosphorous and nitrogen. Increasing nutrient content encourages growth of plants such as blue-green algae, which impacts oxygen levels in the water. The unwanted plants also affect aquatic animals, make the water appear murky, and fill it with algae. Phosphorous plays a strong role in encouraging plant growth, the primary reason for removal of phosphorous from detergents once the link had been clearly established.

Currently, agriculture and sewage treatment are the two largest sources of nutrients that result from human activity. Fertilizers applied to crops or lawns that are not absorbed into plants may be washed into water bodies as runoff, or may find their way into groundwater. Animal dung also contains nitrogen and phosphorous that can be absorbed into lakes and rivers. In urban settings, fertilizer and pet dung are sources of nutrients returned through wastewater. More importantly, municipal sewage treatment does not typically remove nutrients before returning water to the natural environment.

The good news for source water protection is that if the nutrient sources are eliminated or the supply of nutrients sufficiently reduced, lakes and rivers often respond with a return to more normal nutrient levels and the impacts on the ecosystem can be significantly reduced.

CHAPTER 5

Key Recommendations for Making Effective Investment Decisions

Chapter Summary

- One of the clear messages in water management is that the most sustainable incremental water supply is water that does not need to be provided.
- With respect to pricing, there is a gap between what is currently considered to be full cost recovery and what is required to ensure long-term sustainability.
- The current situation for water pricing and metering is in sharp contrast to essential energy services.
- The review of water infrastructure management and investment practices has identified some encouraging trends and many remaining challenges.

Our brief survey of water and wastewater infrastructure management and investment practices in Canada identified a broad range of practices and priorities. To most water managers or practitioners, there are probably no surprises, either in the list of issues canvassed or in the recommendations presented. Many will agree that our renewable freshwater resources are less abundant than most Canadians seem to believe—especially if our use of freshwater is compared to that of other developed nations. To an economist, Canadians' profligate use of water goes hand-in-hand with under-pricing and charges based on billing periods rather than consumption. Some of the simplest analytical solutions have not been implemented, have been partly implemented, or do not have clearly defined target outcomes. The barriers do not appear to be conceptual or analytical, but are most likely social, political, or cultural.

Water is an essential service. Charges must always take account of the economic burden placed on consumers. On the other hand, we found no evidence that cost-based rates, when they have been implemented, create financial hardship for water users. The challenge is to move toward full cost recovery while keeping water affordable for low-income consumers. The question of affordability has been well studied for other essential services, and numerous rate structures have been devised to ensure fair, equitable, and affordable services. Similarly, it is a widely accepted principle of economics that when consumers do not pay the entire cost of a good or service, economic efficiency is compromised. Many of the challenges in managing, funding, pricing, and financing water and wastewater have arisen in other industries, providing examples of potential solutions.

Canadians' attitude toward water has not supported many of the recommendations made, and that is perhaps a contributing factor to the very slow pace of change. If water is viewed as an entitlement—to be paid for from taxes—the incentives to optimize investments

are less compelling than if water services are viewed as a commercial component of a broader resource management process.

Our recommendations are grouped into the following three broad categories.

ASSET MANAGEMENT

- Develop an accurate inventory of underground assets and their condition over time. This inventory should provide a basis for risk assessments and investment plans.
- Establish clear standards for asset quality and the steps and investments required to raise the quality to a specified target.
- Quantify the infrastructure deficit and set priorities and targets to eliminate it over a specified time period.

The above-ground assets are primarily water and wastewater treatment facilities. Most municipalities have a clear picture of the condition of treatment facilities, performance standards, management plans, upgrading requirements, and required investments. These assets link very directly to public safety and public health and are carefully managed. However, municipalities typically have less information or poorer quality information regarding the underground networks that distribute water or gather wastewater. More complete and accurate inventories provide better opportunities to identify and manage risks and costs. In most municipal water systems, line breaks present a significant problem and a cost item. A careful asset inventory not only enables more timely replacement of aging pipes, it also provides evidence to counter pressures to defer capital investment in the interest of short-term cost control.

Similarly, it is one thing to talk of an infrastructure deficit, yet quite another to have an accurate picture of the specific investments that must be made to close the gap. A long-term investment plan should include the funds that will be required to raise the quality of assets from today's standard toward the longer term target. An asset inventory can also help to ensure that infrastructure does not become overbuilt and that investments are made according to a set of priorities.

PRICE AND COST RECOVERY

- Universal metering should be immediately implemented.
- Cost studies should be undertaken to ensure that all costs of providing water and wastewater services are identified and allocated among user categories.
- Social and environmental costs should be identified and quantified. A plan should be developed to incorporate these costs into customer charges over time, and to review these costs on a regular basis.

Our recommendations around pricing and cost recovery may appear simple and self-evident. They are. Unfortunately they have not yet been implemented across the country. Consumers must pay for every unit of water they consume, and the price paid must reflect the supply cost. Water charges based on the value of property, or any other fixed measure that is not directly related to water consumption, cannot provide clear price signals. Many Canadian municipalities have recognized this and have created separate water corporations whose funding comes entirely from water charges. Unfortunately, not all municipalities have taken this basic step.

The current situation for water pricing and metering is in sharp contrast to essential energy services. These services are most often provided by corporations owned by the municipalities or by private companies. Provincial regulators continue to play a role in market structure, market design, and pricing policies. Although we did not explore the topic directly, there are likely lessons to be learned from examining the contrast between retail electricity in Ontario and retail water. Electricity consumers will soon have universal smart meters and a rate structure that accommodates time-of-use rates. Water consumers in some locations have meters.

Identifying the direct costs of providing water services provides information necessary for efficient pricing. When the direct costs are fully and properly quantified, it then becomes possible to allocate them among functions or among customer groups. With accurate information, appropriate charges can be designed—for example, development fees, connection fees, monthly fixed charges, or volumetric rates. Cost identification, cost allocation, and rate design principles can be very complex. But there is a great deal of available experience, whether in water services or other retail utility services.

Finally, with respect to pricing, there is a gap between what is currently considered to be full cost recovery and what is required to ensure long-term sustainability. Ontario's move toward source water protection is a current example of efforts to identify and close this gap. Because water allocation decisions and many environmental protection measures are provincial duties, the role of municipal water and wastewater systems in meeting these objectives is a multi-stakeholder exercise. The complexity of the problem does not excuse lack of progress. Growing human pressure on the environment creates an imperative for action and underscores the importance of the precautionary principle.

CONSERVATION AND DEMAND MANAGEMENT

- Rates should provide customers with a clear indication of the cost of providing the service and clear incentives to reduce consumption.
- Targets should be established for each measure intended to reduce consumption.
- Conservation programs should include investments to reduce losses due to leaky mains or line failures.
- Retail consumers should be clearly informed of programs or grants available to improve their water efficiency. The grants should result in an attractive payout to the consumer for any investment that will reduce water consumption.
- Water service providers should review public education programs regularly to ensure that they are effective. These programs identify actions that consumers can take for free, but the impact needs to be assessed. Websites and mail-outs are only effective if consumers are aware of their options and change their behaviour.

One of the clear messages in water management is that the most sustainable incremental water supply is water that does not need to be provided. Several municipalities have programs to reduce per capita water consumption or to manage total water abstractions. Fewer municipalities show clear evidence that the conservation incentives, subsidy programs, or demand management measures are each part of an integrated plan to be effective stewards of a scarce resource.

CONCLUSIONS

Our review of water infrastructure management and investment practices has identified some encouraging trends and many remaining challenges. The move toward universal metering is encouraging, as is the observation that some municipalities have always had universal metering. The remaining challenge is to accelerate the pace of progress. With universal metering, an encouraging shift toward volumetric pricing has emerged. However, the prices charged don't often fully recover the direct cost of providing service, and only rarely include any provision for the cost of ecosystem protection.

With regard to infrastructure investment, important first steps are to understand the state of existing assets and to identify the investment required. Many Canadian municipalities still struggle with these issues. Once the state of the assets is understood, incremental effort can be made to set the right priorities to improve assets, and the costs can be identified. A cultural shift away from relying on the tax base toward relying on those who use the service still seems to be required in many instances. A similar cultural shift from below-cost pricing to full cost pricing appears to be necessary to close the infrastructure gap, establish clear and correct price signals, and shift the focus from short-term cost savings to long-term service quality.

APPENDIX

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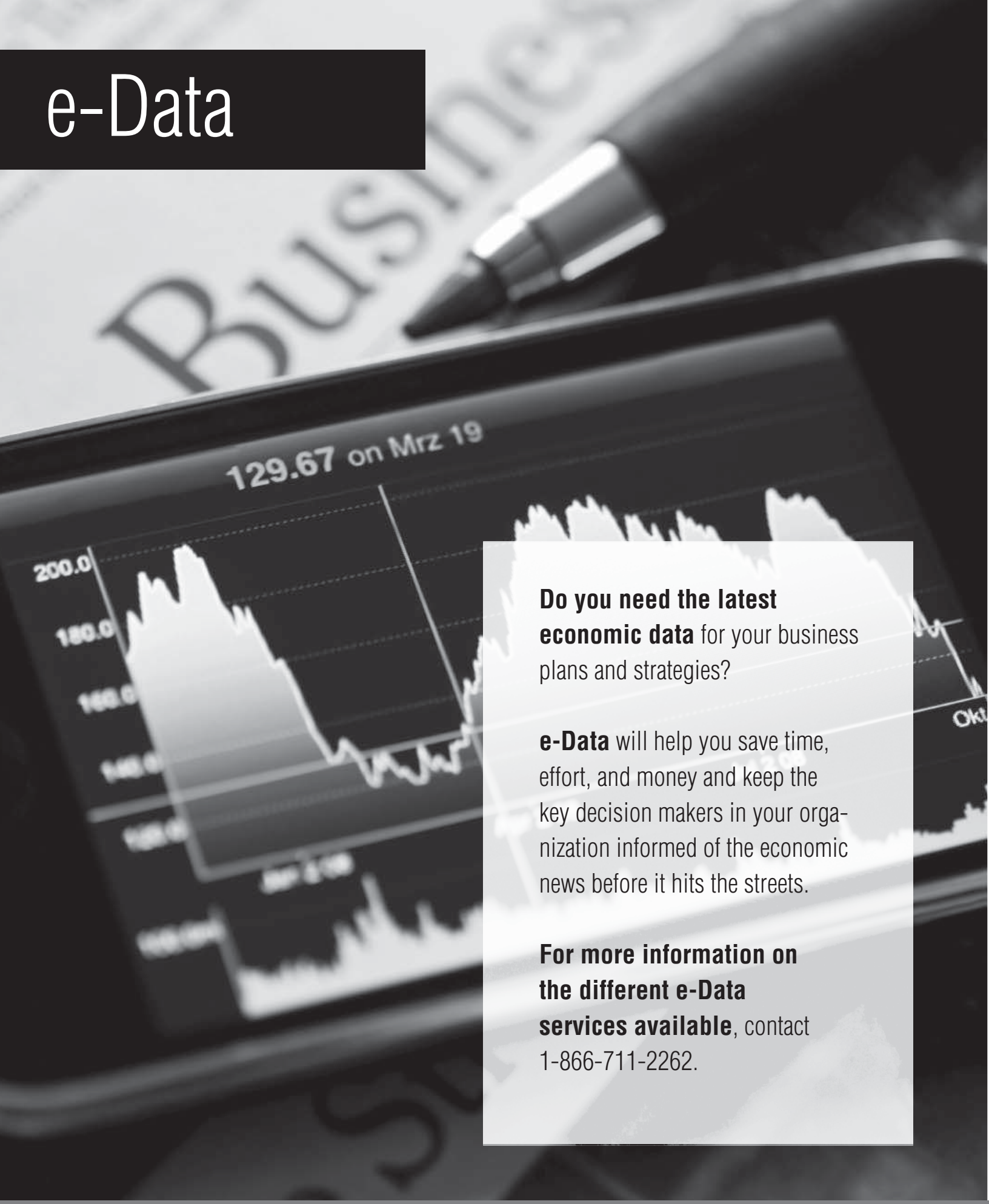

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