Canadian Water and Wastewater Association

Municipal Water and Wastewater Infrastructure:

Estimated Investment Needs 1997 to 2012

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TABLE OF CONTENTS

Executive Summary iii

Introduction 1

Methodology 3

Base Municipal Populations and Services 4

Projected Needs 17

Summary of Investment Needs 26

Alternative Methods 28

Financial Aspects 31

Conclusions 32

References 33

Disclaimer 34

LIST OF TABLES

Executive Summary

Table A - Summary of Investment Needs by Area of Investment ($ millions) iv
Table B - Summary of Municipal Infrastructure Investment Need Estimates - 1997 to 2012 v

Discussion Paper

Table 1 - Populations and Levels of Water and Wastewater Servicing by Province, 1994 4
Table 2 - Populations with Different Levels of Wastewater Treatment Services, 1994 7
Table 3 - Number of Kilometres of Water Mains 10
Table 4 - Number of Kilometres of Sewers for Wastewater Collection Systems 11
Table 5 - Number of Existing and Additional Storage Tanks Required 12
Table 6 - Populations Served by Water Supply Systems and Level of Service Needed 13
Table 7 - Populations with Different Levels of Wastewater Treatment Service and Needed Upgrades 14
Table 8 - Estimated Wastewater Collection Systems Requiring Stormwater Separation 15
Table 9 - Serviced Population Requiring Meters, by Degree of Metering 16
Table 10 - Underground Water Distribution System Investment Needs 18
Table 11 - Additional Storage Tanks Investment Needs 19
Table 12 - Underground Sewage Collection System Investment Needs 20
Table 13 - Water Supply Treatment Systems Investment Needs 21
Table 14 - Estimated Investments Needed for Populations with Different Levels of Wastewater Treatment Service Upgrades 23
Table 15 - Estimated Investment Needs for Sewer Separations 24
Table 16 - Number of Water Meters Required and the Estimated Costs of Installation 25
Table 17 - Summary of Investment Needs by Purpose and by Province 27

EXECUTIVE SUMMARY[1]

Questions are often posed as to the investment needed for the renewal and enhancement for municipal water and wastewater infrastructure in Canada. Reasons for posing these questions vary from **political** to **managerial** to **commercial**, and there is also the perspective of **infrastructure research and development**.

Several estimates have been made in recent years and there is a wide variance amongst them. The variance is no doubt caused by several factors, not the least of which is the possibility, indeed probability, of differing "end points" for the investment, e.g., renewal and enhancement to "what standard of service". There is of course, also the general paucity of data on which to base any estimate, and the likelihood that different unit cost and growth assumptions have made.

This paper attempts to report on these various estimates, to consolidate them where possible and in any case to compare them with an estimate made by the Association itself.

The "end points" of the CWWA estimate are that all "urban" residents of municipalities should be connected to public water and wastewater systems; that water supplies should meet the *Canadian Drinking Water Guidelines*; that storm and sanitary sewer systems should be separate; and that wastewaters would be treated to Level III wastewater treatment standards. Also included as an endpoint, although this does not relate to the quality of treated water or wastewater, is the objective that all water customers should be metered in order to provide a uniformly imposed system of water pricing that reflects the full costs of service, thereby providing an opportunity for water demand management using the pricing mechanism.

In reviewing this document, the reader should be aware that there is very little information available on which to base **any** estimates, and what information there is, is very fragmentary. The best we can do is to set out the methodology employed, the data used, and the assumptions made so that any disagreements with the resulting estimates might be reduced by modifying the methodology or revising the analysis that led to the estimates (i.e., revising the data or changing the assumptions). It is also hoped, from the macro-economic standpoint, that some of the errors on the micro-economic level will cancel each other out. Thus, on a national level, the estimate will have a lesser degree of error than, say, on a provincial basis, and even less than any attempt to provide estimates on a sub-provincial basis.

There is a further, very significant assumption - that the end points will be achieved through the application of currently available and traditional technology. Technological innovations are available that almost

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[1] The methodology was developed by CWWA staff and tested conceptually with a number of engineering and economic consultants who are members of CWWA and who provided data referenced above. However the end result, good or bad, is solely the responsibility of CWWA.

certainly could reduce the investments need to meet the endpoints - however, the implementation of the technology will require changes in management attitude and probably changes in the regulatory framework within which the water and wastewater industry operates.

The report shows that using a crude but simple methodology to estimate future demands for water and wastewater services on a broad regional and national basis and by applying crude cost factors to these needs, the estimated **annual investment** would be to spend $6.03 billions over the next 15 years ($1.84 billion on water systems, $4.09 billions on wastewater systems) leading to a **total investment** of $89.0 billions in the period 1997-2012 ($27.6 billions on water and $61.4 billions on wastewater). In addition some $1.5 billions would be required to complete the metering of all water customers.

These figures are shown in summary in Table A below:

Table A - Summary of Investment Needs by Area of Investment ($ billions)

Water	Mains	Storage Tanks	Treatment Plants	Total
	12.5	1.2	13.9	27.6
Wastewater	Sewers	Combined Sewer Separations	Treatment Plants	Total
	11.7	36.5	13.2	61.4
Metering				1.5
Total				90.5

Table A indicates there is more than twice as much investment required on the wastewater side as on the water side ($61.4 billions to $27.6 billions), but in terms of the nature of the work, there is much more to be done in underground services (water mains, sewer systems and sewer separations) than in above ground systems (plants) $50.7 billions to $28.3 billions.

Having made this estimate, other questions can logically be posed: what happens at the end of this 15 year period? Is there no further investment required? Is it just a question of maintaining the system from here on in? Well the answer to that is that further investments will be required to meet continuing expansion of the populations to be served, and to meet new and more stringent water and wastewater quality standards. What the level of these investments might be is entirely speculative, but it should be noted that investment in improving then nation's water and wastewater infrastructure is a continuing process and requirement.

The CWWA estimate is also shown below in Table B with the other estimates that have been identified and which can be used as possible benchmarks.

Table B - Summary of Municipal Infrastructure Investment Need Estimates - 1997 to 2012

Estimate	Annual Investment Need ($ billions)		Total Investment Need ($ billions)	
	Low	High	Low	High
FCM - McGill	1.40		21.00	
Winnipeg as a ”model”	4.35		62.25	
National Round Table - (George Powell/Delphi Group)	4.70		70.50	
National Round Table - (Environment Canada/Peat Marwick)	4.67	6.00	70.00	90.00
CWWA - water and wastewater system expansions and upgrades	**5.93**		**89.00**	
CWWA - metering	**0.10**		**1.50**	
CWWA - total	**6.03**		**90.50**	

INTRODUCTION

There has been considerable speculation, discussion and estimation over the last several years on and of the future investment needs for the municipal water and wastewater treatment infrastructure in Canada. Articles and reports have been prepared, and commentary has been included in various documents dealing with municipal infrastructure renewal needs, impacts of new drinking water quality standards, impacts of more stringent wastewater effluent standards, and the discussion has entered topical magazines and reviews on environmental and engineering matters.

The reasons for making these estimates vary from **political** (e.g., should the senior levels of government be asked to help fund municipal infrastructure programs?), to **managerial** (e.g., what capital investment plans should I be making as a system manager?), and to **commercial** (e.g., should the construction industry be gearing up to deal with particular areas of future infrastructure investment?). There is also the perspective of **infrastructure research and** development, e.g., where are the big investments needed? and what are the opportunities to focus research and development on means to reduce this need? That is to say, if we have to spend $80 billions over the next 15 years, maybe it is worth spending 0.1% of that, or $80 millions, on R&D to reduce the needed investment.

The discussion paper represents a fairly straight-forward approach of predicting on a macro-economic scale these investment needs.

The Canada Mortgage and Housing Corporation (CMHC) conducts research on the manner in which housing design and urban development can impact on municipal infrastructures and the financial and other needs of municipalities as a result of these factors. Housing design and municipal development create along with economic benefits to the community and Canada at large, burdens that also have to be supported through municipal revenue generation, whether this is through taxes, development fees, or user charges.

CMHC asked the Canadian Water and Wastewater Association (CWWA) to examine the area of infrastructure needs and to prepare a report on future investment needs for the municipal water and wastewater industry over the next 15 years. The need to prepare that report catalysed the production of this discussion paper.

This paper represents a fairly straight-forward approach at predicting on a macro-economic scale, these investment needs.

The estimates developed arise from four categories of investment needs:

a. maintenance of the current infrastructure in a good operating condition (since a large portion of Canada's population is adequately served by the current infrastructure),
b. expansion of the current infrastructure to urban Canadians who currently do not receive complete services (e.g., some are connected only to water services and not to wastewater services),
c. improvement in the current infrastructure (some portions of the current infrastructure are of a rudimentary level of service), and

d. growth of the current infrastructure to meet extraordinary population pressures (some areas of Canada are forecast to be subject to exceptional growth in population over the next 15 years).

Finding data on which to base these estimates is difficult - Canada has little data readily available on municipal infrastructure. Provincial data exists, but it is largely not available. Federal data is reasonably good where it exists, but the coverage is incomplete. Industry data is sometimes relevant, but its reliability and applicability is moot. Nevertheless, estimates are required and would be useful for macro-economic planning purposes.

The paper sets out the methodology, the assumptions and the data used in arriving at these estimates. It does so in the belief that they are reasonable, but like any other process of estimating macro-economic figures, can be subject to error or to difference of opinion. At least, with the methodology set out and described, improvements can be made to the estimates by adjusting any of the or their analytical components.

For comparative purposes, other estimates of infrastructure needs studies that have been made by various organizations have been collected and included as benchmarks - when you are exploring the unknown, it is sometimes comforting to find sign posts along the way!

It is hoped that the paper will stimulate further investigations and a refinement of the investment needs.

METHODOLOGY

The methodology followed is to take the best available aggregated statistics on the size of the water and wastewater industry based on populations served (available nationally and by province for several years) and the levels of service provided, and then to formulate estimates of current and future capital investment, replacement capital needs and expansion or enhancement capital needs by applying to those population based data, aggregated investment, cost and other factors derived from various sources. Where appropriate the data have been converted to standardized units (e.g., population served per km of water main, cost of a treatment plant per capita served) to facilitate the process of estimation.

The advantage of this is fundamental simplicity and perhaps a minimization of overall error by the use of aggregated statistics and factors.

The disadvantage is that the level of accuracy on a province-by-province basis may be high since the expansion factors are aggregated nationally, and may not, indeed will not reflect regional variations. Thus the value of the estimates diminishes as the level of dis-aggregation increases.

BASE MUNICIPAL POPULATIONS AND SERVICES

Environment Canada conducts a survey of municipal water and wastewater systems twice every five years. The following table, combined with population data from Statistics Canada, sets out on a province-by-province basis, population and level of service data.

Table 1 - Populations and Levels of Water and Wastewater Servicing by Province, 1994.

Prov.	Total Population (Statistics Canada estimate) (TOT)	Total Surveyed Population (TSP)	TSP as a % of TOT	Water Supply		Sewage Collection		Sewage Treatment	
				Popul'n. Served	% of TSP	Popul'n. Served	% of TSP	Popul'n. Served	% of TSP
NF	581200	402143	69.2	370552	92.1	345931	86.0	58271	14.5
PE	134600	70736	52.6	38807	54.9	55678	78.7	55678	78.7
NS	933900	615236	65.9	466058	75.8	460491	74.8	136747	22.2
NB	757700	495343	65.4	340862	68.8	377274	76.2	338974	68.4
QC	7288100	5941932	81.5	5537251	93.2	5283886	88.9	4444600	74.8
ON	10937100	9279718	84.8	8534258	92.0	8317703	89.6	8316997	89.6
MB	1129500	845440	74.9	793847	93.9	808822	95.7	809099	95.7
SK	1012200	665450	65.7	638449	95.9	639388	96.1	637703	95.8
AB	2715600	2223663	81.9	2106173	94.7	2084640	93.7	2083548	93.7
BC	3670800	3174505	86.5	2785527	87.7	2658766	83.8	2591975	81.6
YT & NWT	94900	68329	72.0	61584	90.1	61534	90.1	58719	85.9
CAN.	29255600	23782495	81.3	21673368	91.1	21094113	88.7	19532311	82.1

The Statistics Canada estimates of total population by Province or Territory (column 2) are for July 1, 1994. They are drawn from the *1997 Canadian Source Book*, page 5-2.

The Environment Canada data (columns 3 to 10) is drawn from an as yet unpublished report on *Municipal Water Rates in Canada, Current Practice and Prices* for the 1994 survey, which is expected to be published shortly along with the 1996 survey data and results. This survey is of all municipalities having a population greater than 1000 persons.

Given the nature of the Environment Canada survey data, it appears that more than 81% of Canadians are

residents of municipalities which were surveyed and which responded to the survey. It is likely that the actual number of Canadians resident in some form of municipality is closer to 85% although for the purposes of this paper, the 3 - 4% potential difference is not significant.

An examination of Table 1 provides insights into the relative portion and numbers of Canadians connected to some sort of municipal water and wastewater infrastructure, and those not connected. The examination also provides the basis for estimating the expansion of service which would be needed to ensure that all urbanized populations are provided with a common degree of service, at the current level of service. (See the next section of the paper - Projected Needs and the corresponding tables.)

Municipalized Populations

Column 4 of Table 1 shows that Quebec, Ontario, Alberta and British Columbia all have more than 81% of their populations living in municipal areas greater than 1000 people. Perhaps surprisingly, the Territories have a greater municipalized population (72%) than the Maritime Provinces and Saskatchewan, all of whom have less than 70% of their populations in municipalities. Prince Edward Island is the least municipalized province (less than 53% in municipalities greater than 1000).

There is some inaccuracy in the figures derived from this source. There are municipalities with a population of less than 1000 persons which may provide municipal water and wastewater services through a central infrastructure which should be counted, although the extent of this is not known. There are some municipalities that did not respond to the survey. It is not reasonable to impugn reasons for this non-response - is it because the level of service provided is not high, and there was a reluctance to report it? or is it because the municipality just did not get around to responding? It is also likely that some of those resident in municipalities who are reported as not being connected to the municipal systems may not reasonably be connected (i.e., economically) due to their location in areas of very low density. The combined effects of these possibilities is not considered great, but could in total be to the order of a 5% under-estimation of the level of service overall.

Municipal Water Services

For those Canadians who do live in municipalities greater than 1000 persons, more than 91% are provided with a municipal water service. Prince Edward Island has the least served with water (55%) and Saskatchewan the most (96%). Aside from PEI, Nova Scotia and New Brunswick (55% to 76%), the rest of the provinces range from 88% to 96%. Overall, 91% of Canadians who live in a municipal area with more than 1000 persons, have a municipally provided water service.

The implication is that there is an investment need to extend the provision of municipal water services in those areas where this service level is lower than the national average. (See also the caveat above regarding low density populations.)

Municipal Sewer Collection Services

For those Canadians who live in municipalities greater than 1000 persons (regardless of the provision of water services) 88.7% have a municipal sewer collection service of some type. With the exception of Prince Edward Island, it is likely that the provision of a sewer collection service is related to the provision of water services, but (PEI excepted) not all those with water services also have a sewer collection service. Prince Edward Island is the clear exception: more of its municipal residents are connected to a sewer service than to a water service. For the other provinces, the percentage of residents having sewer collection services has less variability than for water services. Nova Scotia and New Brunswick have the lowest level of sewer connections (75% and 76% respectively), Alberta, Saskatchewan and Manitoba have the highest levels (94% to 96%), and the rest of the provinces range from 79% to 90%. Overall, 88.7% of Canadians who live in a municipal area with more than 1000 persons, have a municipally provided sewage collection services.

As with the provision of municipal water services, the implication is that there is an investment need to extend the provision of municipal sewer collection services in those areas where this service level is lower than the national average. (See also the caveat above regarding low density populations.)

Municipal Sewage Treatment Services

For those Canadians who do live in municipalities greater than 1000 persons, a lesser portion 82% have a sewage treatment service than have a sewage collection service (89%). That is to say, more than 6% have a waste collection service, but do not have a sewage treatment service, i.e., the sewage is collected but not treated prior to discharge. There is a great deal of variability in this proportion across the country, with Newfoundland and Nova Scotia providing this service to 14.5% and 22.2% of their populations respectively. New Brunswick is the next lowest, but significantly greater at 68%, followed by Quebec at 75%, Prince Edward Island at 79% and BC at 82%. The remaining provinces range from 86% to 96% having sewage treatment services.

As with the provision of municipal water services and sewer collection services, the implication is that there is an investment need to extend the provision of municipal sewer treatment services in those areas where this service level is not provided. (See also the caveat above regarding low density populations.)

The situation is more complicated than the variability described above shows. There is the 11% of municipal residents who have no sewage collection service at all. There is the 18% whose sewage is not subject to any form of treatment prior to discharge. Of the remaining 71% for whom some level of wastewater treatment is claimed, many may be or are inadequately treated. Sewage treatment services are normally graded at three levels: primary treatment, secondary and tertiary treatment. The data above only distinguishes between those who have no treatment services and those who have some level of treatment services. It does not indicate the proportion of populations served who are currently served with primary, secondary or tertiary levels of treatment.

Table 2, below, is drawn from draft statistics to be included in the next State of the Environment Report, indicates the population connected to a sewer collection system, as served by the various levels of treatment (please note, the population data given do not correspond exactly with the data shown in Table 1 - no explanation for this variance has been given, and the variation is not considered sufficient to invalidate the methodology at this time).

Table 2 - Populations with Different Levels of Wastewater Treatment Services, 1994

Province	Total	None	Primary	Secondary	Tertiary
NF *(See Note 1)*	345931	287660	30271	28000	-
PE *(See Note 1)*	55678	-	19678	36000	-
NS *(See Note 1)*	458791	322044	90128	41919	4700
NB *(See Note 1)*	394648	38300	38974	317374	-
QC	5304713	837786	2156784	1783551	526592
ON	8320103	706	529110	1348152	6442135
MB *(See Note 2)*	808822	1500	100000	307322	400000
SK *(See Note 2)*	638703	1000	104758	412945	120000
AB *(See Note 2)*	2098911	0	50000	1562603	486308
BC	2662958	66791	1779065	609348	207754
YT/NWT	63134	800	1050	61284	0
CANADA	21152392	1556587	4899818	6508498	8187489

Notes:

1. The individual provincial figures are estimated using ratios from Table 1, from data that was consolidated to show the four Atlantic Provinces combined, when the official figures are available on a provincial basis, this Table will be corrected.

2. The individual provincial figures are estimated using ratios from Table 1, from data that was consolidated to show the three Prairie Provinces combined, when the official figures are available on a provincial basis, this Table will be corrected.

PROJECTED NEEDS

Projected needs for municipal water and wastewater services fall into a number of categories, within which they can be expressed in the form of a series of questions:

Water distribution system:

a. How many kilometres of water main need to be replaced annually?
b. How many kilometres of water main need to be added annually?
c. How many kilometres of water main need to be added to bring unserved populations to service?
d. How many additional [surface] storage tanks are needed?

Wastewater collection system:

e. How many kilometres of sewer need to be replaced annually?
f. How many kilometres of sewer need to be added annually?
g. How many kilometres of sewer need to be added to bring unserved populations to service?

Water treatment plants:

h. What investment is needed in water treatment plant expansions?
i. What investment is needed in water treatment plant upgrades?

Wastewater treatment plants:

j. What investment is needed in wastewater treatment plant expansions?
k. What investment is needed in wastewater treatment plant upgrades (from non-treatment to primary, from primary to secondary, from secondary to tertiary)?

Combined sewer separations:

l. What investment is needed to separate sanitary and storm sewer systems?

Water demand management/metering:

m. What investment is needed to provide for universal water metering of customers?

In each of these areas of projected need, no account has been taken of potential water demand reductions or wastewater generation reductions and the consequent impacts on the investment needs for distribution or collection or treatment infrastructures that could be occasioned by significant water conservation or wastewater re-use programs. Many municipalities are currently implementing water conservation programs as a means of postponing investment in expanded infrastructures. A concerted national program of water demand management has been advocated by Environment Canada, the Canadian Council of Ministers of the Environment, and the Association, amongst others, that could have profound affects on the projected needs for infrastructure. The following projected needs are therefore made on the *ceteris paribus* basis of "all other things being equal".

Water distribution and wastewater collection systems

It is essential for the methodology to estimate the total length of municipal water and wastewater systems (the underground infrastructure) in order to provide an estimate of capital costs for rehabilitation of the existing network, for its expansion to meet currently un-serviced population needs and for expansion to meet expected growths in populations.

This can be done by taking advantage of a statistic found in the 1995 AWWA Canadian Water Utility Data base, that on average there are 193 persons served per kilometre of water main (taking the 50% range, the range is a low of 143 to a high of 247). A refinement to the model might be to use the upper and lower statistics for different parts - i.e., expansion to meet un-serviced demands would be estimated at the 143 persons per kilometre on the basis that this is likely to be a lower population density area, while rehabilitating existing lines could be at the higher end of the range, reflecting the more dense levels of the existing urbanized populations..

It is assumed that the same ratio of 193 persons connected per kilometre of line would apply to wastewater collection systems.

Population Growth

Statistics Canada has indicated in its population forecasts that the growth in population is likely to be significantly focussed in a number of regional, urbanized areas of the country - namely: the Halifax-Dartmouth region in the Atlantic Provinces, the Golden Triangle area of southern Ontario, and the Lower Mainland area of BC, with modest or little growth in other areas and provinces. For the purposes of this paper though, which is dealing with urbanized populations, even in provinces or areas where little population growth is expected overall, it is presumed that the trend of migrating to urbanized areas will continue and that urbanized communities will continue to expand by encompassing adjacent rural municipalities leading to an expanded demand for traditionally supplied urban services. These population growth factors appear in Tables 3, 4 and 5.

Table 3 - Number of Kilometres of Water Mains

Prov.	Total Population *(1)*	Surveyed Population *(2)*	Existing Water Supply		Expanded Water Supply		Growth in Water Supply		
			Population. Served *(3)*	kms *(4)*	Population to be served *(5)*	kms *(6)*	Population Increase to 2012		kms *(8)*
							%	Number *(7)*	
NF	581200	402143	370552	1920	31591	164	10	40214	208
PE	134600	70736	38807	201	31929	165	10	7074	37
NS	933900	615236	466058	2415	149178	773	20	123047	638
NB	757700	495343	340862	1766	154481	800	10	49534	257
QC	7288100	5941932	5537251	28690	404681	2097	10	594193	3079
ON	10937100	9279718	8534258	44219	745460	3862	30	2783915	14424
MB	1129500	845440	793847	4113	51593	267	15	126816	657
SK	1012200	665450	638449	3308	27001	140	10	66545	345
AB	2715600	2223663	2106173	10913	117490	609	20	444733	2304
BC	3670800	3174505	2785527	14433	388978	2015	30	952352	4934
YT & NWT	94900	68329	61584	319	6745	35	15	10249	53
CAN.	29255600	23782495	21673368	112297	2109127	10928		5198672	26936

Notes: Columns (1) to (4) are taken from Table 1; column (5) is derived by subtracting column (3) from column (2); column (7) is derived by multiplying column (2) by the % population forecast; columns (4), (6) and (8) are columns (3) (5) and (7) respectively divided by the factor of 193 persons/km.

Table 4 - Number of Kilometres of Sewers for Wastewater Collection System

Prov.	Total Population *(1)*	Surveyed Population *(2)*	Existing Sewage Collection		Expanded Sewage Collection		Growth in Sewage Collection		
			Population Served *(3)*	km *(4)*	Population to be served *(5)*	kms *(6)*	Population increase to 2012		kms *(8)*
							%	Number *(7)*	
NF	581200	402143	345931	1792	56212	291	10	40214	208
PE	134600	70736	55678	288	15058	78	10	7074	37
NS	933900	615236	460491	2386	154745	802	20	123047	638
NB	757700	495343	377274	1955	118069	612	10	49534	257
QC	7288100	5941932	5283886	27378	658046	3410	10	594193	3079
ON	10937100	9279718	8317703	43097	962015	4985	30	2783915	14424
MB	1129500	845440	808822	4191	36618	190	15	126816	657
SK	1012200	665450	639388	3313	26062	135	10	66545	345
AB	2715600	2223663	2084640	10801	139023	720	20	444733	2304
BC	3670800	3174505	2658766	13776	515739	2672	30	952352	4934
YT & NWT	94900	68329	61534	319	6795	35	15	10249	53
CAN.	29255600	23782495	21094113	109296	2688382	13929		5198672	26936

Notes: Columns (1) to (3) are taken from Table 1; column (5) is derived by subtracting column (3) from column (2); column (7) is column (2) multiplied by the percentage growth forecast; and columns (4), (6) and (8) are the respective preceding columns divided by the factor of 193 persons/km.

Water Storage Tanks

Many water distribution systems have in-system storage tanks, either above-ground or in-ground. As a system expands, the system may require additional storage tanks or the expansion of the existing storage tanks' capacities.

The 1995 AWWA survey indicated, for the surveyed utilities that there were 684 tanks for the 42,869 km of water mains. Although the situation will vary from place to place, for the purposes of estimating the number of new tanks that might be needed as the water distribution systems expand, a ratio of 1 tank to every 63 km of water main has been used. On this basis, the following table applies:

Table 5 - Number of Existing and Additional Storage Tanks Required

Prov.	Existing		Expanded		Growth		Total	
	kms	Tanks	kms	Tanks	kms	Tanks	kms	Tanks
NF	1920	30	164	3	208	3	2292	36
PE	201	3	165	3	37	1	403	6
NS	2415	38	773	12	638	10	3826	61
NB	1766	28	800	13	257	4	2823	45
QC	28690	455	2097	33	3079	49	33866	538
ON	44219	702	3862	61	14424	229	62505	992
MB	4113	65	267	4	657	10	5037	80
SK	3308	53	140	2	345	5	3793	60
AB	10913	173	609	10	2304	37	13826	219
BC	14433	229	2015	32	4934	78	21382	339
YT & NWT	319	5	35	1	53	1	407	6
CAN.	112297	1782	10927	173	26936	428	150160	2383

Water Treatment Plant Upgrades

It is very difficult to assess the need of the water treatment plant upgrades that might be needed due to a lack of overall information on the characteristics of the existing treatment plants' water supply qualities and the plants' characteristics and capabilities. However some broad assumptions are set out regarding the

proportion of populations served by plants likely to need upgrade by the installation of filtration systems (identified as base upgrades and largely applicable to smaller systems), and improvements to treatment systems (identified as major upgrades/new systems and largely but not exclusively applicable to small and mid-sized systems). The following table sets out some base subjectively derived assumptions for such actions.

Table 6 - Populations Served by Water Supply Systems and Level of Service Needed

Prov.	1994 Population served	Base Upgrade		Major Upgrade/New System		New Population (Increase to 2012)	
		%	Population	%	Population	%	Population
NF	370552	20	74110	40	148221	10	37055
PE	38807	20	7761	40	15523	10	3881
NS	466058	25	116515	50	233029	20	93212
NB	340862	25	85216	50	170431	10	34086
QC	5537251	20	1107450	40	2214900	10	553725
ON	8534258	15	1280139	30	2560277	30	2560277
MB	793847	20	158769	40	317539	15	119077
SK	638449	25	159612	50	319225	10	63845
AB	2106173	20	421235	40	842469	20	421235
BC	2785527	20	557105	40	1114211	30	835658
YT & NWT	61584	20	12317	40	24634	15	9238
CAN.	21673368		3980229		7960458		4731288

Wastewater Treatment Plants Upgrades

The Environment Canada data does supply information on current levels of wastewater treatment services (see Table 2 above) which can be modified to identify or project needs for upgraded service levels. Table 7 below sets out the upgrades needed to serve current populations and projects expansions needed to meet population growths.

Table 7 - Populations with Different Levels of Wastewater Treatment Service and Needed Upgrades

Province	Total	None - Tertiary Needed	Primary - Upgrade to Tertiary	Secondary - Upgrade to Tertiary	Tertiary - No upgrades needed	Population Growth Factor	Population generating need for expansion
NF (See Note 1)	345931	287660	30271	28000	-	10	34593
PE (See Note 1)	55678	-	19678	36000	-	10	5568
NS (See Note 1)	458791	322044	90128	41919	4700	20	91758
NB (See Note 1)	394648	38300	38974	317374	-	10	39465
QC	5304713	837786	2156784	1783551	526592	10	530471
ON	8320103	706	529110	1348152	6442135	30	2496031
MB (See Note 2)	808822	1500	100000	307322	400000	15	121323
SK (See Note 2)	638703	1000	104758	412945	120000	10	63870
AB (See Note 2)	2098911	0	50000	1562603	486308	20	419782
BC	2662958	66791	1779065	609348	207754	30	798887
YT/NWT	63134	800	1050	61284	0	15	9470
CANADA	21152392	1556587	4899818	6508498	8187489		4611219

Notes:

1. The individual provincial figures are estimated using ratios from Table 1, from data that was consolidated to show the four Atlantic Provinces combined, when the official figures are available on a provincial basis, this Table will be corrected.

2. The individual provincial figures are estimated using ratios from Table 1, from data that was consolidated to show the three Prairie Provinces combined, when the official figures are available on a provincial basis, this Table will be corrected.

Combined Sewer Separations

The final major investment need is to separate the sanitary and storm sewer systems across the country. Again some fairly broad estimates are needed to identify the likely amount of separations that would be needed. It is assumed that any expansion or growth in the system will be built with separated systems, **therefore the separation problem applies only to the existing system**. The following table sets out the assumptions.

Table 8 - Estimated Wastewater Collection Systems Requiring Stormwater Separation

Prov	Existing Sewer Length	Expanded Sewer Length	Growth in Sewer Length	Total Sewer Length	Percentage requiring Separation	New Separate Sewer lines to be constructed
NF	1792	291	208	2291	60	1075.2
PE	288	78	37	403	60	172.8
NS	2386	802	638	3826	60	1431.6
NB	1955	612	257	2824	60	1173
QC	27378	3410	3079	33867	60	16426.8
ON	43097	4985	14424	62506	40	17238.8
MB	4191	190	657	5038	40	1676.4
SK	3313	135	345	3793	40	1325.2
AB	10801	720	1204	12725	30	3240.3
BC	13776	2672	4934	21382	60	8265.6
YT & NWT	319	35	53	407	50	159.5
CANADA	109296	13930	25836	149062		52185.2

Water demand management/metering

A fundamental factor in the ability of water and wastewater system managers to control or influence demand is the pricing of water and wastewater services. Pricing should be related in some manner to water consumption and wastewater generation. Without water meters, it is not possible to control or influence

water demand by way of the pricing mechanism.

Table 9 below, drawn from the Environment Canada's 1994 survey data indicates that there 9,918,000 Canadians who are served by un-metered water lines. It also shows that the problem of un-metered service is greater in the smaller communities, although there are significant numbers of unmetered services provided in some of the larger municipalities.

Table 9 - Serviced Population Requiring Meters, by Degree of Metering

Province	Serviced Population in 000's Requiring Meters, by degree of Metering					Total Serviced Population	% of Population Requiring Meters
	0%	0.1 - 10.0%	10.1 - 90.0%	90.1 - 99.9%	Total not metered		
NF	365	8	1	0	374	375	99.7%
PE	37	1	0	0	38	39	97.4%
NS	41	19	21	1	82	466	17.6%
NB	80	11	124	1	216	341	63.3%
QC	4,220	488	91	1	4,800	5,537	86.7%
ON	551	773	300	23	1,647	8,534	19.3%
MB	27	10	0	0	37	794	4.7%
SK	8	0	1	0	9	638	1.4%
AB	55	19	475	1	550	2,106	26.1%
BC	946	1,155	38	2	2,141	2,786	76.8%
YT & NWT	1	21	2	0	24	62	38.7%
CANADA	6,331	2,505	1,053	29	9,918	21,678	45.8%
Population Size Groups							
0 - 5	998	66	22	2	1,088	1,519	71.6%
5 - 10	594	110	22	2	728	1,239	58.8%
10 - 50	2,070	284	257	5	2,616	4,830	54.2%
50 - 100	964	509	103	0	1,576	3,406	46.3%

100 +	1,706	1,536	648	21	3,911	10,684	36.6%
CANADA	6,332	2,505	1,052	30	9,919	21,678	45.8%

PROJECTED NEEDS

The projected costs of meeting the forecast needs can now be calculated.

Investment in the underground water distribution system

Table 10 on page 18 sets out the estimated investments required to meet the:

- annual maintenance of the existing system over the period (it is estimated that 0.6% of the existing system is replaced each year),
- expansion of the existing system to serve all current residents of the municipalities, and the
- growth of the system to meet the expected growth in population.

To simplify the calculations the maintenance needs are calculated as being 15 years times 0.6% or that 9% of the current network will be replaced in the period. That all the expansion and growth needs will be met in the period.

Costs of replacement, expansion and growth are different. Replacement involves opening (assuming that trenchless technology is not used) the opening of existing surface infrastructures such as roads and sidewalks and their replacement as would the expansion of existing systems - the cost of this is estimated at $300 per metre or $300,000 per km. Installation costs for new systems (growth) is presumed to take place prior or during the construction of surface structures, thus it is cheaper. This cost has been estimated at $200 per metre or $200,000 per km.

Investment in the above ground water distribution system

Table 11 on page 18 sets out the estimated investment needed for aboveground water distribution system expansions. The costs of constructing above ground storage tanks are of course proportional to the size of the storage unit being constructed, however the assumption made here is that as these are additional tanks they will be in the range of the smaller tanks (300,000 m^3) and would be priced at approximately $600,000 per tank (based on an adaptation of US EPA figures). This estimated cost includes ancillary pumping equipment. This figure has been applied to the estimate number of tanks needed to meet the expansion of the current system to meet the currently un-serviced populations and also to the expansion needed to meet the growth in the population. Capital costs needed to maintain the current stock of such tanks is taken at the probable cost of depreciation over an estimated 20 year lifetime i.e., 5% of the estimated average replacement cost of $600,000 or, over the 15 year period 75% of $600,000 or $450,000 per tank.

Investment in the underground sewer collection system

Table 12 on page 19 sets out the estimated investments required in a similar manner as that for the underground water distribution systems. The same set of parameters have been applied in terms of

costs/metre.

Table 10 - Underground Water Distribution System Investment Needs

Prov.	Existing		Expanded	Existing and Expanded		Growth		Total Investment ($millions)
	3 kms	Rep. kms	kms	3 kms	Cost ($millions)	kms	Cost ($millions)	
NF	1,792	161	291	452	135.7	208	41.6	177.3
PE	288	26	78	104	31.2	37	7.4	38.6
NS	2,386	215	802	1,017	305.0	638	127.6	432.6
NB	1,955	176	612	788	236.4	257	51.4	287.8
QC	27,378	2,464	3,410	5,874	1,762.2	3,079	615.8	2,378.0
ON	43,097	3,879	4,985	8,864	2,659.1	14,424	2,884.8	5,543.9
MB	4,191	377	190	567	170.2	657	131.4	301.6
SK	3,313	298	135	433	130.0	345	69.0	199.0
AB	10,801	972	720	1,692	507.6	2,304	460.8	968.4
BC	13,776	1,240	2,672	3,912	1,173.6	4,934	986.8	2,160.4
YT & NWT	319	29	35	64	19.1	53	10.6	29.7
CAN.	109,296	9,837	13,930	23,767	7,130.0	26,936	5,387.2	12,517.2

Table 11 - Additional Storage Tanks Investment Needs

Prov.	Existing		Expanded		Growth		Total	
	Tanks	$ millions	Tanks	$ millions	Tanks	$ millions	Tanks	$ millions
NF	30	13.5	3	1.8	3	1.8	36	17.1
PE	3	1.4	3	1.8	1	0.6	7	3.8
NS	38	17.1	12	7.2	10	6.0	60	30.3
NB	28	12.6	13	7.8	4	2.4	45	22.8
QC	455	204.8	33	19.8	49	29.4	537	254.0
ON	702	315.9	61	36.6	229	137.4	992	489.9
MB	65	29.3	4	2.4	10	6.0	79	37.7
SK	53	23.9	2	1.2	5	3.0	60	28.1
AB	173	77.9	10	6.0	37	22.2	220	106.1
BC	229	103.1	32	19.2	78	46.8	339	169.1
YT & NWT	5	2.3	1	0.6	1	0.6	7	3.5
CAN.	1781	801.5	174	104.4	427	256.2	2382	1162.1

Table 12 - Underground Sewage Collection System Investment Needs

Prov.	Existing		Expanded	Existing and Expanded		Growth		Total Investment ($millions)
	3 kms	Rep. kms	kms	3 kms	Cost ($millions)	kms	Cost ($millions)	
NF	1,920	173	164	337	101.0	208	41.6	142.6
PE	201	18	165	183	54.9	37	7.4	62.3
NS	2,415	217	773	990	297.1	638	127.6	424.7
NB	1,766	159	800	959	287.7	257	51.4	339.1
QC	28,690	2,582	2,097	4,679	1,403.7	3,079	615.8	2,019.5
ON	44,219	3,980	3,862	7,842	2,352.5	14,424	2,884.8	5,237.3
MB	4,113	370	267	637	191.2	657	131.4	322.6
SK	3,308	298	140	438	131.3	345	69.0	200.3
AB	10,913	982	609	1,591	477.4	2,304	460.8	938.2
BC	14,433	1,299	2,015	3,314	994.2	4,934	986.8	1,981.0
YT & NWT	319	29	35	64	19.1	53	10.6	29.7
CAN.	112,297	10,107	10,927	21,034	6,310.1	26,936	5,387.2	11,697.3

Water Supply Investment Needs

Water supply systems will need some upgrading over the period and for the sake of simplicity as well as the lack of data, a base upgrade has been set at a per capita cost of $300, which is considered to apply to a relatively small proportion of the populations served, a major upgrade is set at a per capita cost of $400, which would apply to a larger portion of the population served (basically twice that of the base upgrade portion), and finally there is a group that represent new populations - for these the per capita investment has been set at $2000 on the basis that they require a complete new systems and this is the estimated cost of such. These per capita costs were drawn subjectively from information supplied by consultants serving the water and wastewater industry in southern Ontario.

Table 13 - Water Supply Treatment Systems' Investment Needs

Prov.	Base Upgrade		Major Upgrade/New System		New Population (Increase to 2012)		Total Investment Needed ($millions)
	Population	Cost ($ 'ms)	Population	Cost ($ 'ms)	Population	Cost ($ 'ms)	
NF	74110	22.2	148221	59.3	37055	74.1	155.6
PE	7761	2.3	15523	6.2	3881	7.8	16.3
NS	116515	35.0	233029	93.2	93212	186.4	314.6
NB	85216	25.6	170431	68.2	34086	68.2	161.9
QC	1107450	332.2	2214900	886.0	553725	1,107.5	2,325.6
ON	1280139	384.0	2560277	1,024.1	2560277	5,120.6	6,528.7
MB	158769	47.6	317539	127.0	119077	238.2	412.8
SK	159612	47.9	319225	127.7	63845	127.7	303.3
AB	421235	126.4	842469	337.0	421235	842.5	1,305.8
BC	557105	167.1	1114211	445.7	835658	1,671.3	2,284.1
YT & NWT	12317	3.7	24634	9.9	9238	18.5	32.0
CAN.	3980229	1,194.1	7960459	3,184.2	4731289	9,462.6	13,840.8

Wastewater System Upgrades

Some 13 million Canadians are connected to a wastewater treatment system which needs an upgrade ranging from a minor level (from secondary to tertiary levels) to a major upgrade (from primary to tertiary) or which needs a treatment system to be built.

The following table estimates the populations which need upgrades and the costs of doing so. The cost estimates are as follows on a per capita basis: to install a tertiary treatment plant where there is none - $2,000 per person, to upgrade a primary treatment plant to a tertiary level plant - $1,200 per capita, to upgrade a secondary treatment plant to a tertiary level plant - $400 per capita.

In addition there is an estimated growth for the urbanized populations, which growth will incur an expansion cost for the plants (all assumed to be already at a tertiary level) of $350 per capita.

These per capita costs were drawn subjectively from information supplied by consultants serving the water and wastewater industry in southern Ontario.

Table 14 - Estimated Investments for Populations with different levels of Wastewater Treatment Service Upgrades

Province	None - Tertiary Needed		Primary - Upgrade to Tertiary		Secondary - Upgrade to Tertiary		Population Growth		Total Cost
	Pop'n	Cost	Pop'n.	Cost	Pop'n.	Cost	Pop'n.	Cost	
NF (est)	287,660	575.3	30,271	36.3	28,000	11.2	34,593	12.1	635.0
PE (est)	-	0.0	19,678	23.6	36,000	14.4	5,568	1.9	40.0
NS (est)	322,044	644.1	90,128	108.2	41,919	16.8	91,758	32.1	801.1
NB (est)	38,300	76.6	38,974	46.8	317,374	127.0	39,465	13.8	264.1
QC	837,786	1,675.6	2,156,784	2,588.1	1,783,551	713.4	530,471	185.7	5,162.8
ON	706	1.4	529,110	634.9	1,348,152	539.3	2,496,031	873.6	2,049.2
MB (est)	1,500	3.0	100,000	120.0	307,322	122.9	121,323	42.5	288.4
SK (est)	1,000	2.0	104,758	125.7	412,945	165.2	63,870	22.4	315.2
AB (est)	0	0.0	50,000	60.0	1,562,603	625.0	419,782	146.9	832.0
BC	66,791	133.6	1,779,065	2,134.9	609,348	243.7	798,887	279.6	2,791.8
YT/NWT	800	1.6	1,050	1.3	61,284	24.5	9,470	3.3	30.7
CANADA	1,556,587	3,113.2	4,899,818	5,879.8	6,508,498	2,603.4	4,611,218	1,613.9	13,210.3

Combined Sewer Separations

The following table, drawn from the data in Table 8 above, sets out the presumed needs to reconstruct existing sewer systems to separate the storm and the sanitary lines on the basis of $700 per metre. This is considerably higher than the cost of replacing a single main, but is founded on the assessment of the additional complexity of excavation, disconnecting and reconnecting to new sewer lines.

Table 15 - Estimated Investment for Sewer Separations

Province	Sewer Length to be reconstructed	Estimated Investment ($ millions)
NF	1,075.0	752.5
PE	172.8	121.0
NS	1,431.6	1,002.1
NB	1,173.0	821.1
QC	16,426.8	11,498.8
ON	17,238.8	12,067.2
MB	1,676.4	1,173.5
SK	1,325.2	927.6
AB	3,240.3	2,268.2
BC	8,265.6	5,785.9
YT & NWT	159.5	111.7
CANADA	52,185.0	36,529.5

Water demand management/metering

Table 9 on page 16 above, indicates that in 1994 there were 9,918,000 Canadians served by un-metered water lines. In a report done by that Department in respect to the 1991 data, the ratio of 3 residents for every water connection was used to estimate the number of meters that would need to be installed to achieve complete metering. This same ratio is used in Table 16 below to estimate the number of meters that would have to be installed to complete the metering of all water services.

The Greater Vancouver Regional District has recently completed a study of the cost of metering in the

GVRD and they estimate that some 450,000 meters will be needed to completely meter the District. Estimates are that the costs of doing so vary between $210 per connection if the meter is installed inside the building to $450 per meter installed at the property line. Table 16 shows the application of these two alternatives to the estimated number of meters required.

Table 16 - Number of Water Meters Required and the Estimated Costs of Installation

Province	Total Population not metered	Number of Meters Required (000's)	Low Cost of Metering ($ millions)	High Cost of Metering ($ millions)
NF	374	125	$ 26.2	$ 56.1
PE	38	13	$ 2.7	$ 5.7
NS	82	27	$ 5.7	$ 12.3
NB	216	72	$ 15.1	$ 32.4
QC	4,800	1,600	$ 336.0	$ 720.0
ON	1,647	549	$ 115.3	$ 247.1
MB	37	12	$ 2.6	$ 5.6
SK	9	3	$ 0.6	$ 1.4
AB	550	183	$ 38.5	$ 82.5
BC	2,141	714	$ 149.9	$ 321.2
YT & NWT	24	8	$ 1.7	$ 3.6
CANADA	9,918	3,306	$ 694.3	$ 1,487.7

SUMMARY OF INVESTMENT NEEDS

The following table summarizes by province, the investment needs found under the present methodology, by province.

Where there may have been a range in estimated investment, e.g., water metering, the higher cost has been included.

Table 16 - Investment Needs by Purpose and by Province
($ millions)

Province	Water Mains	Water Tanks	Water Treatment	Subtotal - Water	Sewers	Combined Sewers	Wastewater Treatment	Subtotal Wastewater	Water meters	Grand Total
NF	177.3	17.1	155.6	350.0	142.6	752.5	635.0	1,530.1	56.1	1,936.2
PE	38.6	3.8	16.3	58.7	62.3	121.0	40.0	223.3	5.7	287.7
NS	432.6	30.3	314.6	777.5	424.7	1,002.1	801.1	2,227.9	12.3	3,017.7
NB	287.8	22.8	161.9	472.5	339.1	821.1	264.1	1,424.3	32.4	1,929.2
QC	2,378.0	254.0	2,325.6	4,957.6	2,019.5	11,498.8	5,162.8	18,681.1	720.0	24,358.7
ON	5,543.9	489.9	6,528.7	12,562.5	5,237.3	12,067.2	2,049.2	19,353.7	247.1	32,163.3
MB	301.6	37.7	412.8	752.1	322.6	1,173.5	288.4	1,784.5	5.6	2,542.2
SK	199.0	28.1	303.3	530.4	200.3	927.6	315.2	1,443.1	1.4	1,974.9
AB	968.4	106.1	1,305.8	2,380.3	938.2	2,268.2	832.0	4,038.4	82.5	6,501.2
BC	2,160.4	169.1	2,284.1	4,613.6	1,981.0	5,785.9	2,791.8	10,558.7	321.2	15,493.5
YT & NWT	29.7	3.5	32.0	65.2	29.7	111.7	30.7	172.1	3.6	240.9
CANADA	12,517.3	1,162.4	13,840.7	27,520.4	11,697.3	36,529.6	13,210.3	61,437.2	1,487.9	90,445.5

ALTERNATIVE METHODS

There may be other ways of checking the magnitude of the estimates arrived at by the selected methodology.

National Round Table Estimates

The National Round Table on the Environment and the Economy recently published a report on Municipal Water and Wastewater Infrastructure needs. In it they cited various sources of information.

First approach:

The first source comprised a two part estimate of independent maintenance and expansion costs. The maintenance part was based on an estimate of current annual capital investment based on 1992 figures for Ontario (George Powell in Environmental Science and Engineering) and adjusted for inflation to an estimated 1994 figure (+ 10% for inflation) and expanded to provide a national picture (Ontario assumed to be 40% of the Canada). On this basis, it was estimated that the current replacement costs were $2.3 billions per year.

Added to this was an estimate by the Delphi Group for new capital expenditures (not replacement) represented $2.4 billions per year.

This lead to a combined figure of $4.7 billions per year, which on a 15 year profile would result in an investment need of $70.5 billions..

Second approach:

Like the first approach the second approach relied on combining two figures together to derive a total estimated annual investment need.

The first based on an Environment Canada report for un-met water and wastewater infrastructure needs ranging from $38 - $49 billions to ensure that the current capital stock and services is maintained.

The second is derived from a Peat Marwick paper presented to a national Conference on Public Private Partnerships in 1994. This paper estimated that $41 billions of new capital will be needed to upgrade the infrastructure to take into account future demands on water and wastewater quality.

The combined figures of maintaining and upgrading infrastructure thus range from $70 to $90 billions over the next 15 years.

It is not sure the extent to which either of these estimates reflect needs to meet population growth or changes in water or wastewater treatment qualities.

Federation of Canadian Municipalities - McGill University

The Federation of Canadian Municipalities engaged McGill University' Faculty of Engineering to provide estimates of the infrastructure needs of the country's municipalities. The report gives interesting detail on costs per capita to bring the infrastructure up to an "acceptable level" by different population groupings for the municipalities. Details of what an "acceptable" level may be are not given.

The following table excerpts the estimates related to water and wastewater infrastructures.

Facilities	Average Cost/Capita to bring to acceptable level					Pop'n (millions)	Total Cost (billions)
	<10,000	10,001 - 100,000	100,001- 400,00	>400,001	All groups		
Water distribution	$431	$195	$183	$202	$202	29.6	$6.0
Sewage	$583	$261	$376	$1	$152	29.6	$4.5
Sanitary & Combined Sewers	$563	$248	$206	$93	$146	29.6	$4.3
Water Supply	$596	$133	$395	$37	$106	29.6	$3.1
Storm	$430	$127	$96	$87	$103	29.6	$3.0
Total	$2,603	$964	$1,256	$420	$709	29.6	$21.0

City of Winnipeg as a Model

The City of Winnipeg recently completed a capital needs study for the 10 - 15 year period 1995 to 2010. Winnipeg is perhaps a typical city in respect to its age and its inventory of infrastructure, although it might be seen to be ahead of those cities not equipped with wastewater treatment facilities (such as Halifax, Saint John, or Victoria). The commentary in its Task Force report is enlightening - "Like most cities through North America, the City of Winnipeg is facing a serious situation with regard to infrastructure. Much of the City's aging infrastructure needs to be repaired, upgraded or replaced. Conditions are getting worse and at an accelerating pace. City streets, alleys, bridges, sidewalks, water, wastewater and land drainage systems, civic buildings and leisure facilities are all part of this growing concern." It estimates that the gap between what has been invested for infrastructure and what is required, will approach $750 millions. In addition new infrastructure projects may include the first four items below:

City of Winnipeg Investment Plans
($ millions)

Aqueduct rehabilitation	$	50.00
Supplementary potable water supply	$	85.00
Water treatment plant	$	204.00
Combined sewer overflow mitigation	$	1,000.00
One fifth portion of infrastructure deficit	$	125.00
Total	**$**	**1,464.00**

The City of Winnipeg comprises approximately 650,000 residents, which would indicate that a 15 year investment plan per capita would be approximately $2,250.

Given that the **urban** population of Canada is currently to the order of 29,000,000, the national forecast would be $62.250 billions and the annual investment needs over the 15 years would be $4.350 billions.

FINANCIAL ASPECTS

Given an estimated median population over the period of 32 millions, the per capita investment needed to generate $90.5 billions is $2,828 for the period, or $189 per year, or $0.52 per day

In broad terms, and there are difficulties with the following assessment (since some capital costs are already included in current water rates including sewer surcharges), water rates range between $0.83 and $0.96 per day per household and the average household uses about 1 cubic metre of water per day. Assuming an average of 3 persons per household, this amounts to a daily per capita cost of $0.28 or $0.32 for water and sewer services. To raise sufficient funds to meet the investment needs, the daily water rates would have to be increased from $0.30 to $0.82 per person, and the daily water (and sewage) bill per household would have to be increased from $0.90 per day to $2.46.

CONCLUSIONS

A number of conclusions can be drawn from this approach to estimating the Canada-wide investment needs for municipal water and wastewater infrastructure on the assumptions that

a. the methodology, the data and the per capita and other parameters are reasonably accurate,
b. the end points are to:
   - connect all residents of urbanized municipalities to centrally provided water and wastewater services,
   - ensure that all water supplies meet the *Canadian Drinking Water Guidelines*,
   - all wastewaters are treated to a level III treatment process, and that
   - all water customers are metered,
c. traditional technology continues to be applied throughout the 15 year period, and that
d. the end points do not change.

These conclusions include:

a. approximately $90.5 billions of dollars could be spent over the next 15 years or approximately $6.0 billions per year,
b. more than twice the amount needs to be spent on the wastewater side as compared to the water side ($61.4 billions vs $27.5 billions),
c. approximately equal amounts need to be spent on water and wastewater treatment plants ($13.8 and $13.2 billions respectively),
d. investment in underground infrastructure improvements ($60.7 billions) is more than twice the amount required on treatment plants ($28.3 billions),
e. given an estimated median population over the period of 32 millions, the per capita investment needed is $2,828 for the period, or $189 per year, or $0.52 per day, and
f. the funds needed to meet this investment could be provided if the average cost of water and sewer services as currently charged through water rates were to be increased.

REFERENCES

The following materials or sources were used in the construction of this estimate:

1. Population statistics from Statistics Canada.
2. Unpublished data from the Environment Canada Municipal Water Use Survey of 1994.
3. The Report on Municipal Infrastructure prepared by McGill University for the Federation of Canadian Municipalities, in 1996.
4. Canadian Utility Profiles, prepared by the American Water Works Association from a survey of its Canadian water utility members, in 1995.
5. Information received from the City Of Winnipeg.
6. Information received from various engineering and economic consultants to the water and wastewater industry in southern Ontario.

DISCLAIMER

The methodology was developed by CWWA staff and tested conceptually with a number of engineering and economic consultants who are members of CWWA and who provided data referenced above. However the end result, good or bad, is solely the responsibility of CWWA.