STAFF REPORT
INFORMATION ONLY

Toronto Water's Infrastructure Renewal Backlog

Date:	October 8, 2008
To:	Budget Committee
From:	Lou Di Gironimo, General Manager, Toronto Water
Wards:	All
Reference Number:	P:\2008\Cluster B\TW\bc08018

SUMMARY

A detailed analysis was undertaken to update estimates of Toronto Water's water and wastewater infrastructure renewal backlog and is summarized in this report. The total backlog has been estimated to be $1.8 billion: $1.3 billion in existing sewer and watermain infrastructure and $0.55 billion for water and wastewater treatment plants and facilities.

The analysis shows that an average investment estimated at $253 million per year is required, for the next 10 years, to prevent any further growth in the infrastructure renewal backlog. Toronto Water's 2009-2018 Capital Budget Submission, includes an increase in state of good repair investment from $283 million in 2009 to more than $500 million in 2018, for a total investment of $4.2 billion over the 10 year period which will substantially clear the existing water and wastewater infrastructure renewal backlog by 2018.

Financial Impact

The financial implications arising from this report are reflected in Toronto Water's 2009 - 2018 10-Year Capital Plan and Forecast.

DECISION HISTORY

In 2001, Council accepted Toronto Water's report, entitled "Water and Wastewater Services Long-Term Sewer and Watermain Infrastructure Renewal Needs.

A copy of the Council Decision Document can be found at:
http://www.toronto.ca/legdocs/2001/minutes/council/cc011106.pdf

ISSUE BACKGROUND

The water and wastewater infrastructure renewal backlog is a recognized problem within older municipalities across North America. The construction of water and wastewater infrastructure has typically tracked the urban growth cycles; and much of this older infrastructure is now at or reaching the end of its expected service life.

In 2001, Toronto Water reported to the then Works Committee on the long-term sewer and watermain infrastructure renewal needs. This analysis has been updated in support of Toronto Water's 2009 to 2018 Capital Budget Submission and reflects current sewer and watermain system inventories and condition assessments; recent condition assessments for the City's water and wastewater treatment facilities; and current infrastructure renewal costing data.

For the purposes of this analysis, the City's stormwater management facilities, including stormwater ponds and underground storage tanks have not been included as they are relatively new infrastructure. Further, stream restoration needs to address existing erosion scars across the City; and mitigate future stream erosion are also not included in this analysis.

Watermain and Sewer System Construction History

The City's water distribution system consists of 5,850 km of pipe, ranging in size from 50 mm to 2,250 mm, with an estimated total system replacement value of $5.9 billion.

The age distribution of the system, dating back to 1858, by year of construction, is presented in Figure 1; and the cumulative percentage of system length by decade of construction is presented in Figure 2. Both figures show the growth of the system tracking the urban development growth cycles of the late 1800s, early 1900s and the major growth cycles of the 1950s, 1960s and 1970s. The average age of the system is approximately 54 years old, with 380 km (6.5%) of pipe now over 100 years of age and an additional 995 km (17%) of pipe are between 80 and 100 years of age. The most common material type is cast iron (71%), followed by ductile iron (16%).

The City's sewer system consists of 10,561 km of pipe, ranging in size from 100 mm to 5,500 mm, with an estimated total system replacement cost of approximately $13.3 billion.

The age distribution of the sewer system, dating back to 1800, by year of construction, is presented in Figure 3; and the cumulative percentage of system length by decade of construction is presented in Figure 4. The average age of the sewer pipes is approximately 48 years, with 370 km (4%) of pipes over 100 years of age. An additional 705 km (7%) of pipes are between 80 and 100 years of age. The most common material type is concrete (75%), followed by vitrified clay (15%).

Figure 1 – Watermain System Length by Year of Construction

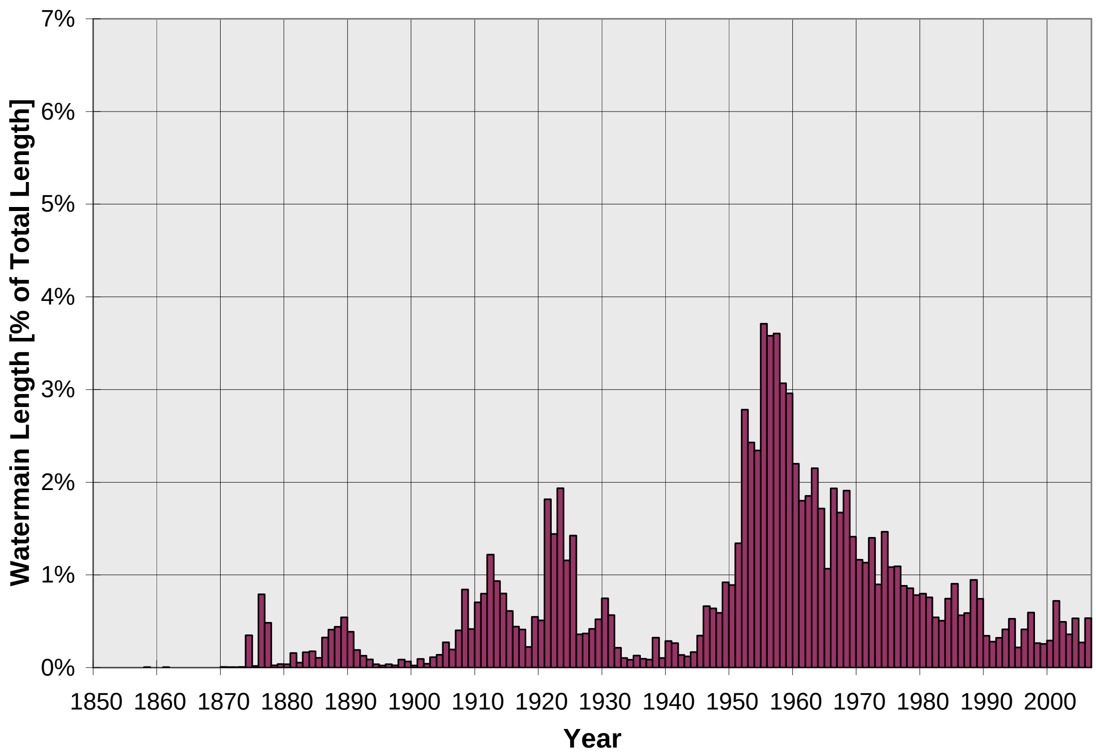


Figure 2 – Watermain System Length and Cumulative Percentage of Total System Length by Decade of Construction

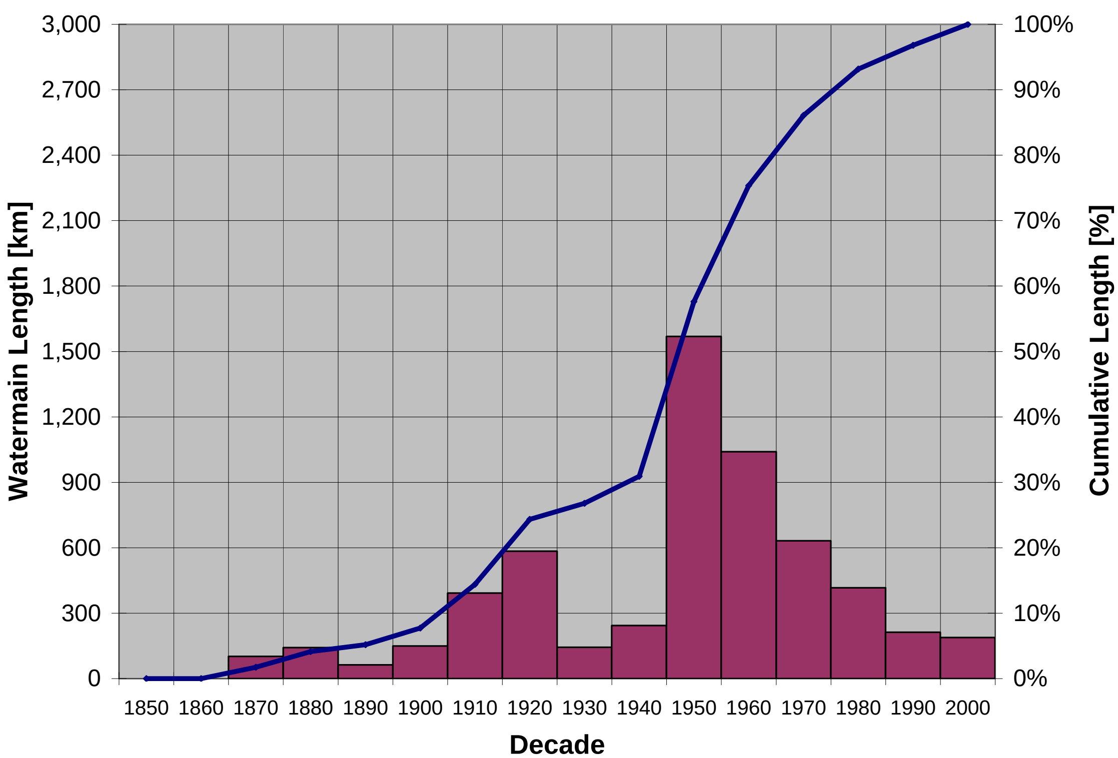


Figure 3 – Sewer System Length by Year of Construction

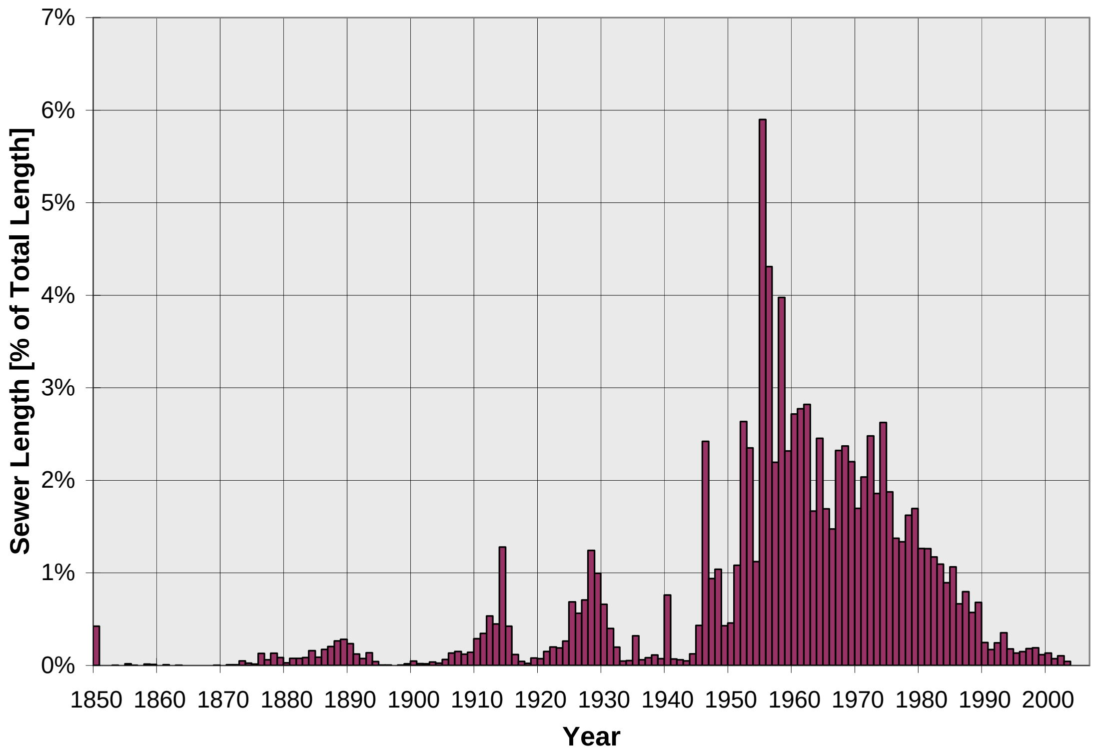
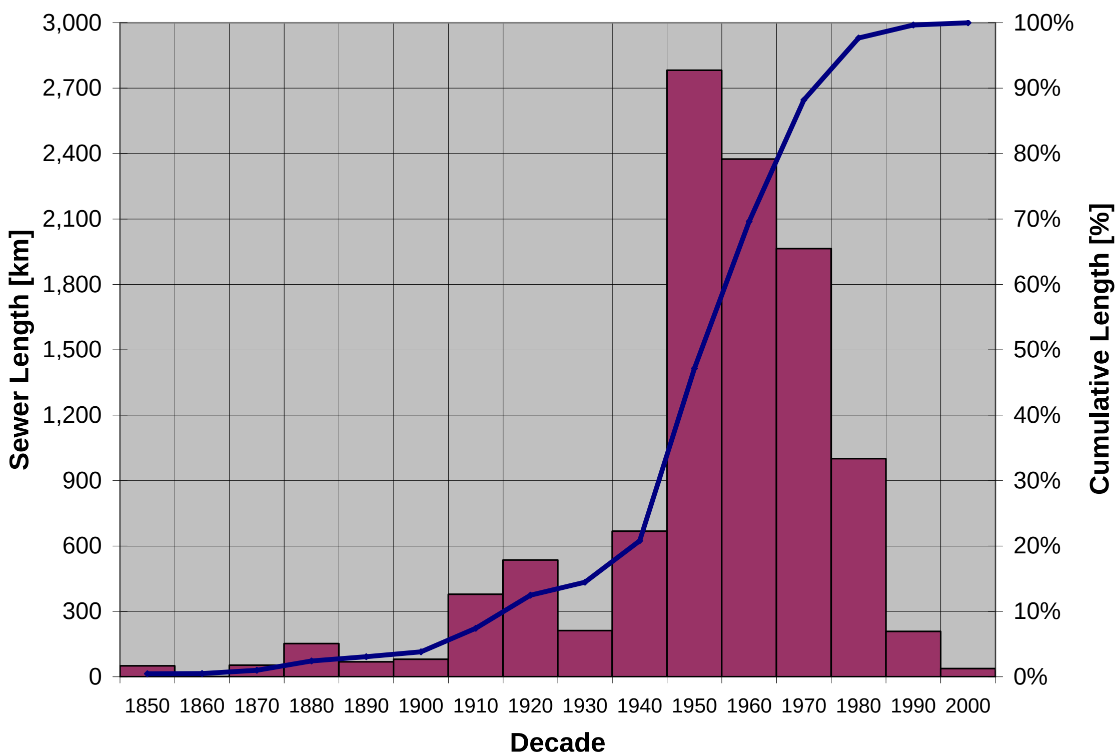


Figure 4 – Sewer System Length and Cumulative Percentage of Total System Length by Decade of Construction



Water and Wastewater Treatment Plant Construction History

Toronto Water operates four water treatment plants located across the waterfront, with a combined treatment capacity of 2.5 billion litres per day, ranging from 410 megalitres per day (MLD) at the Island Water Treatment Plant to 950 MLD at the R.C. Harris Water Treatment Plant. A summary of the operational history of the four plants is presented in Table 1. As noted in Table 1, the Island Water Treatment Plant has the oldest history of operation, dating back to 1910, however the Plant was completely rebuilt in 1977. As noted in the table, the F.J. Horgan Water Treatment Plant is the newest of the facilities, which has been operational for 29 years, while the R.C. Harris Water Treatment Plant is the oldest facility, in operation for 67 years. The R.C. Harris Water Treatment Plant was last expanded in 1958 while the R. L Clark and F.J. Horgan Water Treatment Plants have never been expanded.

Table 1 - Water Treatment Plant Capacity and Date of Operation History

Water Treatment Plant	Plant Capacity (MLD)	Operations first Commissioned (Year)
R.C. Harris	950	1941
R.L. Clark	615	1968
Island	410	1910 *rebuilt 1977*
F.J. Horgan	570	1979

Toronto Water operates four wastewater treatment plants which collect and treat the City's wastewater, with a combined treatment capacity of 1.5 billion litres per day, ranging from 36 MLD at the North Toronto Wastewater Treatment Plant to 818 MLD at the Ashbridges Bay Wastewater Treatment Plant. The three largest facilities are located along the waterfront, while the North Toronto Wastewater Treatment Plant, is located along the Don River, north of Pottery Road. A summary of the operation history of the four plants is presented in Table 2. As noted in Table 2, the Ashbridges Bay Wastewater Treatment Plant has the oldest history of operation, operating for 97 years, while the newest facility, the Humber Wastewater Treatment Plant, has been operating for 48 years. Each plant has undergone varying levels of plant expansions and major upgrades since the inception of their operations, resulting in a asset base of widely ranging ages.

Table 2 - Wastewater Treatment Plant Capacity and Operation History

Wastewater Treatment Plant	Plant Capacity (MLD)	Operations first Commissioned (Year)
Ashbridges Bay	818	1911
North Toronto	36	1929
Highland Creek	219	1956
Humber	473	1960

Toronto Water is currently completing appraisals at each of the water and wastewater treatment plants to determine asset values. These appraisals are based on a review of drawings, inventory of principal machinery and equipment assets and pertinent construction features. Replacement costs are being estimated based on the current cost to install a similar new asset, using as a basis, benchmark costs for similar design, style, construction and function, adjusted to more closely suit any site specific and specialty features.

While these appraisals are expected to be completed by the end of the year, a summary of current estimated replacement costs by asset category is presented in Table 3. At this time, the estimated cost to replace all four water treatment plants, combined with the City's 18 booster pumping stations and 11 water storage facilities is estimated to be $3.0 billion.

The cost to replace the wastewater treatment plants along with the associated 81 sewage pumping stations, within the wastewater collection system, is estimated to be $3.5 billion.

Table 3 - Water and Wastewater Facilities Replacement Costs

Facility Component	Water Facility Asset Value ($ Million)	Wastewater Facility Asset Value ($ Million)
Buildings & Structures	956	799
Machinery, Equipment & Process Units	2,034	2,692
TOTAL	**2,990**	**3,491**

System Life Expectancies

The useful service life of assets is dependent on more factors than simply age, as manufacturing technologies and materials have changed over time, as well as design standards and construction practices. In support of a planning level analysis estimating the current and projected future infrastructure renewal needs, the City's water and wastewater infrastructure assets have been grouped into asset classes; each with a corresponding projected life expectancy.

The City's watermain and sewer infrastructure was categorized based on pipe type, material, size, renewal status and age. System life expectancies were based on local historical infrastructure condition data, including pipe failure data, and input from operations staff. For new materials, such as PVC, where little local failure data available, life expectancies were based on failure statistics, and case studies from other municipalities. A summary of life expectancies and corresponding percentage of total system length, for each of the 15 watermain and 5 sewer system asset classes is presented in Tables 4 and 5, respectively.

Table 4 – Watermain Asset Classes and Life Expectancies (Small F=150mm, Large F>150mm)

Acronym	Description	Life Expectancies			Length (m)	% of Total
		100%	50%	10%		
CIPOS	Cast Iron, Pit Cast (<1950), Original, Small	60-80	80-100	100-120	623,171	10.6%
CIPOL	Cast Iron, Pit Cast (<1950), Original, large	70-90	90-110	110-130	398,567	6.8%
CIPCLS	Cast Iron, Pit Cast (<1950), Cleaned&Lined, Small	15-25	25-35	35-45	659,668	11.2%
CIPCLL	Cast Iron, Pit Cast (<1950), Cleaned&Lined, Large	25-35	35-45	45-55	115,940	2.0%
CISOS	Cast Iron, Spun Cast (>=1950), Original, Small	20-40	40-50	50-70	440,999	7.5%
CISOL	Cast Iron, Spun Cast (>=1950), Original, Large	30-50	50-70	70-90	750,035	12.8%
CISCLS	Cast Iron, Spun Cast (>=1950), Cleaned&Lined, Small	5-10	10-15	15-20	945,850	16.1%
CISCLL	Cast Iron, Spun Cast (>=1950), Cleaned&Lined, Large	10-15	15-20	20-25	221,226	3.8%
DIOS	Ductile Iron, Small	40-60	60-80	80-100	182,437	3.1%
DIOL	Ductile Iron, Large	50-70	70-90	90-110	325,062	5.5%
DICPS	Ductile Iron, Cathodically Protected, Small	15-25	25-35	35-45	190,774	3.2%
DICPL	Ductile Iron, Cathodically Protected, Large	25-35	35-45	45-55	129,164	2.2%
PVCALL	Polyvinyl Chloride, All Sizes	70-90	90-110	120-150	512,026	8.7%
MSOA	Metro Trunk and Steel, All Sizes	80-100	90-120	120-150	217,594	3.7%
OTHER	Other material (concrete, copper, AC, etc). All Sizes.	40-60	60-80	80-100	162,687	2.8%
				Total	5,875,200	100%

Table 5 – Sewer System Asset Classes and Life Expectancies

Acronym	Description	Life Expectancies			Length (m)	% of Total
		100%	50%	10%		
CS	Concrete, <=450mm	50-70	70-90	90-110	4,525,469	42.8%
CL	Concrete, >450mm	70-90	90-110	110-130	3,365,772	31.9%
BR	Brick, All Sizes	70-90	90-110	110-130	248,755	2.4%
VCS	Vitrified Clay, <=375mm	50-70	70-90	90-110	1,058,892	10.0%
VCL	Vitrified Clay, >375mm	60-80	80-100	100-120	522,519	4.9%
PVCALL	Polyvinylchloride, All Sizes	20-30	30-50	50-90	140,116	1.3%
AC	Asbestos Cement, All Sizes	80-90	90-110	110-150	590,224	5.6%
OTHER	Other material. All Sizes.	20-30	30-50	50-90	110,062	1.0%

The water and wastewater treatment plant assets have been grouped into two categories: buildings, and process equipment and machinery. Buildings at the plants are assumed to have a lifespan of 75 years, while process equipment and machinery are assumed to have an average lifespan of 54 years to account for the varying lifespans of an estimated 30 years for mechanical and electrical equipment; and 60 years for treatment processes such as filters and digesters. These assumptions are in line with the general guidelines for the Public Sector Accounting Board (PSAB) tangible capital assets reporting.

COMMENTS

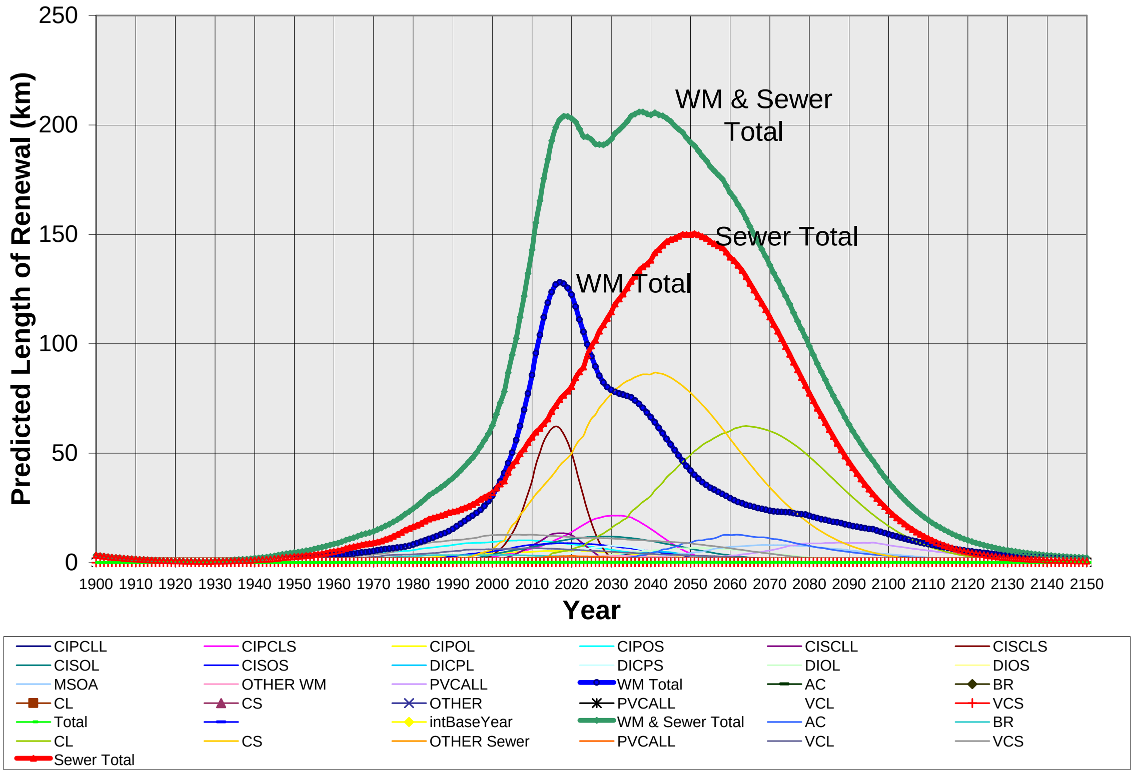
A thorough analysis quantifying the infrastructure renewal backlog for the City's water and wastewater infrastructure assets was undertaken for each of the asset classes. The approach taken in this analysis is described in detail by asset grouping in the following sections and is summarized in Table 6 that follows.

Watermain and Sewer System Infrastructure Renewal Backlog

The predictive model (KANEW), used in the 2001 staff report noted above, was developed through the American Water Works Association Research Foundation (AWWARF), and used to estimate the existing infrastructure renewal backlog and future renewal needs for the City's sewer and watermain infrastructure. The model was applied to the aggregated (City-wide) sewer and watermain infrastructure data inventory, updated to the end of 2006. The data was segregated into asset classes, based on pipe type, age and material. A life expectancy curve was generated for each asset class based on an estimate of pessimistic, optimistic and average pipe life expectancies (similar to life insurance mortality tables). The model was then used to generate annual infrastructure renewal needs, as pipe lengths, for each asset class; and the aggregate of all asset classes. A summary of the modelling results, showing annual renewal rates, in terms of system length, for watermains, sewers and the combined total linear infrastructure, respectively, is presented in Figure 5.

Based on this analysis, the estimated total infrastructure renewal backlog was computed as the sum of the predicted renewal needs to the year 2006, less any infrastructure renewal that was undertaken and not included in the original data inventory (eg. sewer relining). Using this methodology, the existing backlog of deteriorated water and sewer infrastructure is estimated to be 760 kilometres and 1,035 kilometres, respectively. Applying standard unit rates for reconstruction and assuming current levels of rehabilitation techniques such as relining, rather than reconstruction, results in a total renewal need of $1.3 billion.

Figure 5 - Predicted Annual Renewal Length by Year:
a) Watermains (WM); b) Sewers; and c) Total Watermains and Sewer



Water and Wastewater Treatment Plant Infrastructure Renewal Backlog

In 2005, a detailed assessment/survey was undertaken at each of the four water treatment plants to assess the condition of buildings, submerged structures, yard piping and process piping components, respectively. Process control and data acquisition instrumentation system components, building mechanical systems and process equipment were not included in this assessment as much of these systems had been upgraded or replaced within the last 10 years as part of upgrades to meet new Ontario Ministry of the Environment regulatory requirements.

The studies were completed in early 2007 and identified approximately $25 million of general repairs to enhance the integrity and performance of building and structural components and repair leaks in roofs, piping and valves. Subsequently, additional studies identified the need for complete refurbishment of the historical building envelope at the R.C. Harris Water Treatment Plant, replacement of aging process equipment throughout the R.L. Clark Water Treatment Plant and electrical system component replacement in many of the booster pumping stations throughout the system. This results in an estimated combined infrastructure backlog in the water treatment and supply facilities of $105 million.

Facility assessment reports were also completed for the wastewater treatment plants in 2004-2005. The reports were based on investigations of existing infrastructure at the plants through review of previous studies and drawings, staff interviews and physical inspections of buildings and services. While the backlog of renewal needs identified in these reports has corresponded well with more current estimates derived through the recent design and construction phases at the Ashbridges Bay and Humber Wastewater Treatment Plants, the Highland Creek Wastewater Treatment Plant facility forecast report has significantly under-estimated the magnitude and value of infrastructure renewal required at this facility. The estimate for infrastructure renewal needs at the Highland Creek Wastewater Treatment Plant, has therefore been adjusted, commensurate with the work identified for the Humber Wastewater Treatment Plant as the plants are of similar vintage and total asset value. The combined current backlog for the wastewater treatment plants is therefore estimated at $390 million.

In addition, recently completed assessments of 81 sewage pumping stations thoughout the City suggest that an additional $25 million is required to bring these stations to a state of good repair condition. The combined infrastructure backlog for the water and wastewater treatment facilities is therefore estimated to be $520 million.

Table 6 – Water and Wastewater Infrastructure Renewal Needs by Asset Class

Asset Class	Asset Value ($ Million)	Infrastructure Renewal Backlog ($ Million)	Annual Renewal Needs at State of Good Repair ($ Million)
Watermains	$5,900	$741	$95
Sewers	$13,300	$510	$16
Water Treatment & Supply	$3,000	$105	$63
Wastewater Treatment	$3,500	$415	$77
TOTAL:	**$25,700**	**$1,771**	**$253**

State of Good Repair Annual Renewal Needs

The previous analysis identified the total investment required to restore the system to a State of Good Repair in 2008; however, each successive year brings with it an additional renewal need as assets age and reach the end of their useful life, otherwise, the backlog will continue to grow. The determination of annual renewal needs is detailed below and summarized above in Table 6.

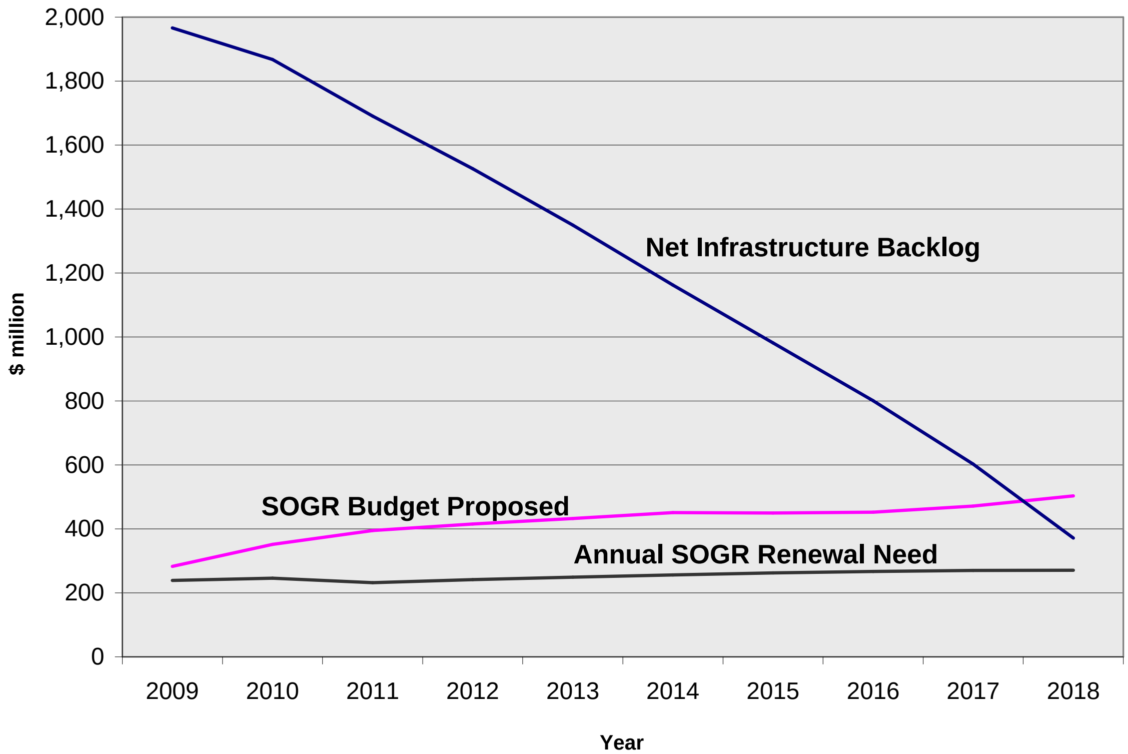
Based on the KANEW analysis of sewer and watermain renewal needs over the next 10 years shown in Figure 5, it has been estimated that annually between 70 and 130 kilometres (ie. 1.2 to 2 percent) of watermains, will be reaching the end of their service life and should be renewed to prevent a further increase in the existing infrastructure renewal backlog. Similarily, an estimated 50 to 70 kilometres (ie. 0.5 to 0.7 percent) of sewer infrastructure should be renewed annually. Combined, and based on current unit rates, this equates to an average annual investment of $112 million.

The annual funding renewal need for the water and wastewater treatment facilities can be determined based on the anticipated life expectancies of the components and the costs of replacing the facilities, established through the appraisal process, as summarized in Table 3. Assuming that the building and structures category has a lifespan of 75 years, it can be generalized that 1.3% of the asset value must be invested annually to maintain them in a state of good repair condition.

With machinery and process equipment, it is assumed that 65% of this asset category is structural such as filter and digester tankage with an average lifespan of 75 years. The remaining 35% of this asset category is largely mechanical and electrical equipment with much shorter lifespans of 30 years and 15 years respectively, resulting in a combined annual renewal rate 2.5%. Applying these factors to the asset values derived through the appraisal process results in an estimated annual renewal need of $142 million.
The combined annual renewal need to maintain Toronto Water’s assets in a state of good repair condition is therefore equal to an annual average investment of $253 million, or approximately 1% of the combined asset value, as shown in the previous Table 6.

Strategy to Address Water and Wastewater Infrastructure Renewal Backlog
Toronto Water has proposed a 10-Year Capital Plan and Forecast that reflects a significant increase in State of Good Repair Funding, that if approved will significantly deplete the backlog of deteriorated infrastructure within the 10 year planning horizon. Toronto Water’s 2009-2018 Budget Submission represents an increase of State of Good Repair investment from $283 million in 2009 to more than $500 million in 2018 for a total investment of $4.2 billion over the 10 year period. A summary of the annual combined water and wastewater program renewal needs, state of good repair renewal needs; and state of good repair budget proposed, for the period 2009-2018 is presented in Figure 6. The figure shows that if the annual investment in state of good repair is maintained, as proposed, the infrastructure renewal backlog will be substantially cleared by 2018.

Figure 6 – Summary of Annual Water and Wastewater Infrastructure Renewal Needs and State of Good Repair Investment Proposed (2009 – 2018)



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