IS OUR INFRASTRUCTURE

CRUMBLING?

By Allen Lucas, P.Eng.

With cutbacks, government program downloading and sins of past management practices, are the utilities of today faced with a critical situation?

Toronto could have become little more than a quaint tourist resort area, nestled on the shores of Lake Ontario between the Don and Humber Rivers. Infrastructure development, however, enabled the city to grow into a large urban centre. Many of Canada's cities, towns and villages owe their well-being to the installation of pipes to provide fire protection, pipes for domestic water, sewers of various shapes, sizes and types, and myriad roads for transportation. The municipal infrastructure systems in use today were installed in order to service growth of urban centres.

Early installations of fire protection systems were important to ensure that wooden structures, constructed close together, were adequately protected. The developing communities led to the need for improved sanitation. Provision of adequate supplies of fresh water helped to reduce epidemics of diseases such as cholera. Interestingly enough, at a time when the need to construct sewers to take waste away was increasing, treatment of sewage was given less attention. The natural processes of sewage treatment and dilution were relied on. Over time, science became more sophisticated, enabling improvements. Significant growth of cities happened at key points, and the desire by citizens for improvements, and government regulation, have shaped the municipal landscape.

Today we are faced with managing these critical infrastructure components to ensure that society as we know it can be sustainable into the future. Consider for a moment what it would cost for your municipality to replace all the water pipes, fire hydrants, water treatment plants, pumping stations, sewage pipes, sewage treatment plants, roads, curbs, sidewalks, traffic signals, street lights and all other municipal infrastructure. The bill would be staggering.

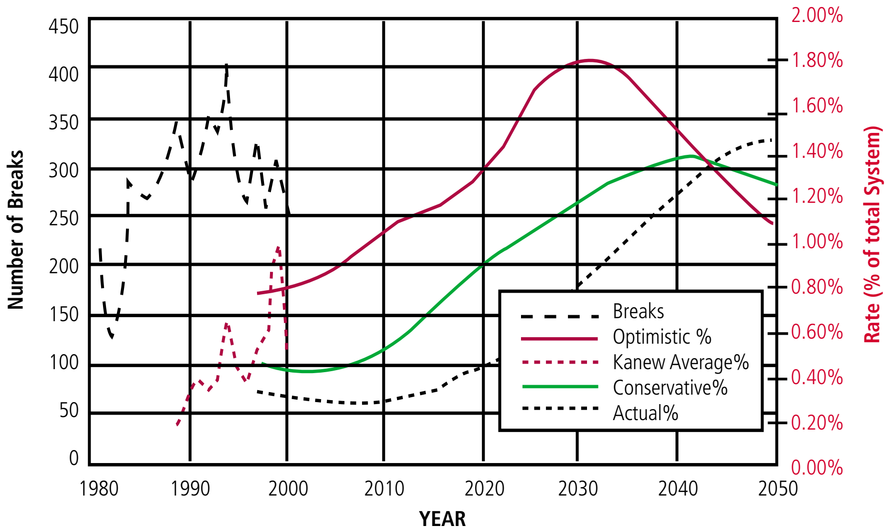
Cost is the first consideration of infrastructure management. Considering the cost and the importance of these various infrastructure systems for all Canadians' well-being, the need to ensure optimum life is engineered into them becomes evident. The value of the design and initial installation, while regarded by some as sunk capital cost, is perhaps the most important component of the infrastructure. Due regard must be given to these to ensure quality and value for society. Engineers play a critical role to ensure that designs are not merely functional, but that the infrastructure will provide valuable service for decades, without excess capital expenditure up front.

The second important component of infrastructure management is a well-run maintenance and replacement program. These are essential for realizing the most life from the infrastructure components, while minimizing life-cycle costs. There are a number of tools available for the engineer or manager to do this, from simple card systems to sophisticated data hungry computer models. Each will provide a level of service to ensure the most life is gained from the infrastructure.

However, with government cutbacks, program downloading and sins of past management practices, are the utilities of

Figure 1

Nessie Type Curve—Predicted Replacement % Rates—Kanew Model—(1998 Data) vs Actual % Replacement Rates



today faced with a critical situation? The public looks at the increasing constraints and demands on finances and there appears to be a gloomy outlook. Rate increases affecting users get media attention. In order to examine this more closely consider just one of the many utilities, the water utility.

Work on water

Jack W. Hoffbuhr, executive director of American Water Works Association (AWWA) said, "First the infrastructure problem is not easy to define and, second, it is even less easy to solve. Depending upon whom you listen to, either we are in the midst of a crumbling infrastructure crisis or we have nothing to fear because routine replacement and rehabilitation will be adequate."[1] Many studies have been conducted to assess where the water industry is at in terms of infrastructure condition and benchmarking. From these exercises an interesting picture can be seen.

Within the water distribution systems, there are a number of factors that affect practically every municipality in Canada and all of North America. Some of the recent studies conducted by AWWA Research Foundation have identified key boom eras following each of the World Wars and the boom of the mid 1960s. Another interesting component in the study of the infrastructure problem is that changes in pipe manufacturing techniques have seen the average pipe life drop from 120 years for the oldest cast iron pipes to 75 years for those installed post World War II. This results in a convergence of wear out times[2]. Researchers looking at replacement rates have plotted this data and have described the shape as a Nessie Curve. This is partly because of the serpentine characteristic of the curve, not unlike the mythical creature from Loch Ness, as well as the comparison that we currently see only the head of the monster.

The City of Ottawa has participated in much of the AWWA Research. Data from the City of Ottawa is the basis for the Nessie Curve plotted in Figure 1[3]. Historical operation and installation data were used to develop the predicted curves with the computer model "KANEW." The key step in understanding the required maintenance program and in being able to develop a comprehensive, cost-effective replacement strategy is to gather and analyze actual data. The dotted black line, showing the number of actual watermain breaks, is just one of the input parameters which over time can also be used to monitor the effectiveness of replacement programs. Overlaid on this Ottawa model is the 1989 to 2000 actual watermain replacement data. This can be compared with the three predicted model replacement requirements from 1996 onward as a benchmark. As shown, the City of Ottawa responded to the model information by increasing replacements in recent years, which may be reflected in the trends toward fewer watermain breaks. These will be key performance indicators in the future in terms of assessing quantity of main replacements as well as performance, something all municipalities will have to face.

The current level of replacement, somewhere between the conservative and average requirements, at 0.6 per cent of the total system length must be steadily increased over the next 30 years to between two and three times the current levels in order to simply maintain the infrastructure. The engineering challenge will be to learn to manage this replacement boom in light of the demands placed on competing financial interests and physically replacing the infrastructure. Further examination of the Kanew computer model for Ottawa, beyond 2050 (not shown), indicates there are two additional higher peaks before the year 2100. The challenge continues. These results are typical across the utilities that have developed the models.

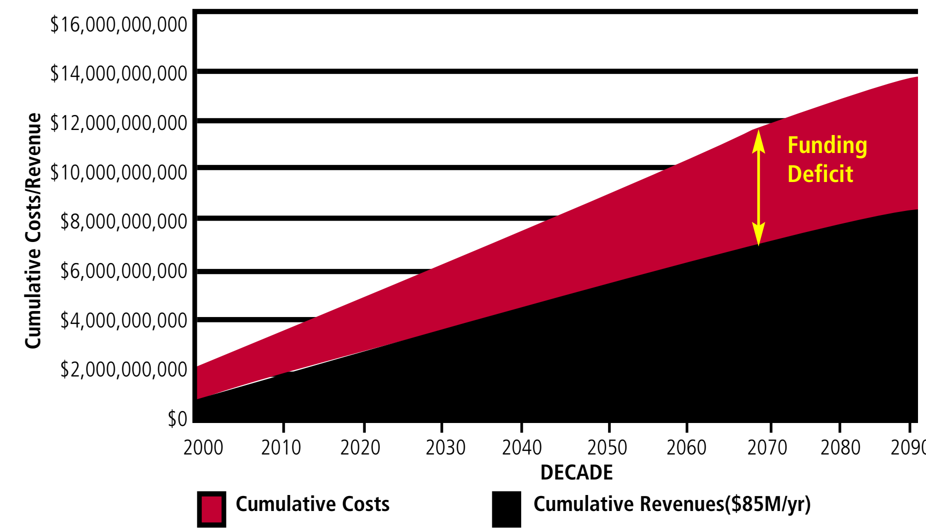
Another example, shown in Figure 2[4], provided by R.V. Anderson Associates Limited, shows the cumulative costs and revenues for the City of Hamilton water and wastewater systems. The graph depicts the funding deficit or funding gap that could result should current infrastructure spending be maintained. This is based upon constant average costs and revenues. What is not shown, nor easily predicted, is at what point in time does the degradation of the system start to increase because of the gap in replacement. On Figure 3[4], the detailed analysis, by increments of 10 years, shows spikes in required expenditures to coincide with replacement of infrastructure from high growth periods of the past and convergence of material wear out.

A detailed analysis was completed within the study to assess where the critical time periods would be for expenditure. Ten-year time frames were used to examine the effects of historical growth periods, trends in material wear out and the effects of changes in materials used for construction. As shown on Figure 3, the expenditures required will vary above and below the average. These variances are partially a result of the cumulative effect of changes in materials and respective shorter life spans, as well as past high growth times.

These examples illustrate what every municipality faces in the coming years, not simply in water distribution, but in all municipal infrastructure. As the AWWA study clearly shows, however, municipalities have not been asleep at the switch: "Water utilities have been making the right investments so far, but the need is going to rise steadily and significantly over the coming decades as the pipes and other components wear out."[5] Municipalities are also just beginning to recognize the need not only to replace existing infrastructure but also to expand it (i.e. make a more substantial reinvestment in infrastructure over the next 30 years than simply replacement cost), due to population growth. Combined with the replacement need is also the need to upgrade plants for compliance with new regulations and the fact that wastewater infrastructure and compliance needs are also on the horizon.

Figure 2

City of Hamilton—Current Cumulative Costs & Revenues (Central Water and Wastewater Systems)

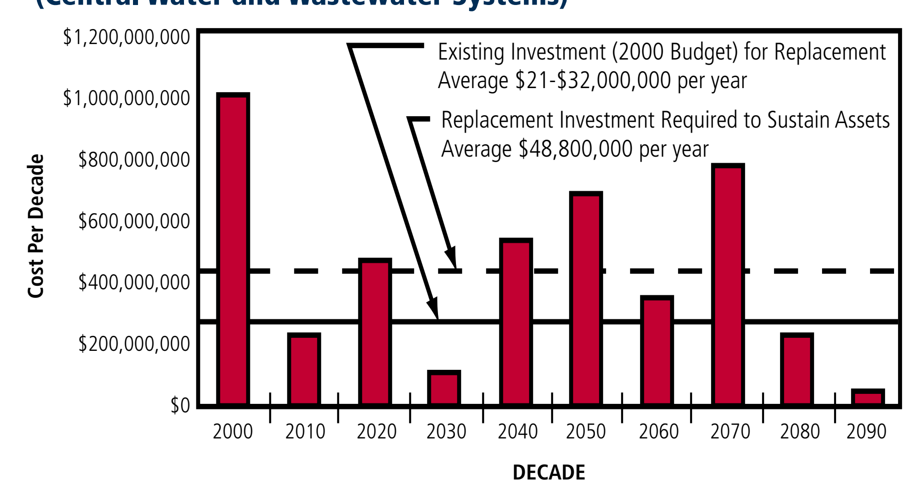


The engineer's role

This coming era of infrastructure reinvestment will be important for engineers. Sound engineering judgment at the design stage will be essential for safety, on the one hand, and good return on investment on the other. An efficient maintenance and replacement program contributes to safety and cost-efficiency. Advances in construction techniques and design tools will assist in minimizing impacts of replacement while adding value to the vital infrastructure society has come to rely on.

Figure 3

City of Hamilton—Projected Replacement Cost Profile (Central Water and Wastewater Systems)



Engineers have assisted in several areas, computer aided design and drafting (CADD) is one such example. The designer can analyze a number of alternatives quickly and easily, develop cost scenarios, and assess operational impacts in order to select the optimum design. Development of "no-dig technology" has enabled efficient repairs and upgrading in order to extend the life of existing facilities or to replace infrastructure in a timely, cost-effective manner in difficult situations.

A particular challenge faces system managers. Politicians need to be prepared to allot sufficient money for infrastructure redevelopment, which will mean convincing consumers to pay more. System managers have the knowledge and the information to help the public understand the factors at play. System managers are the key to ensuring that education of all parties is completed in a timely fashion to ensure that finances are available in order for the work needed to be completed.

This nation's infrastructure is not in ruin. However, we are approaching "the dawn of the replacement era." Timely investments have been made in the past while maintaining reasonable rates. The challenge will be to find innovative ways to manage future cost impacts and set appropriate rate structures to ensure that the demographic wave does not swamp us. Communication with consumers is critical to ensure that they are included in the dialogue about the challenges because rates will have to increase, in order to narrow the funding gap. A quote from a recent paper delivered by Dr. Janice A. Beecher at the 2001 AWWA Infrastructure Conference may say it all: "There is little doubt that the restoration of the nation's water systems will require a significant infusion of capital, along with expertise in management of long-life assets. In reality, whatever the final need estimate, the cost and rate impacts will be significant. But the idea of a funding gap combines myth with reality. The funding gap exists due to the persistent unwillingness to pay, but not necessarily to an underlying inability to pay."[6] ◆

References:

1. HOFFBUHR, Jack W., "Waterscape- an executive perspective" *American Water Works Association Journal*, July 2001, p. 6
2. SCHARFENAKER, Mark A., "Reg Watch," *American Water Works Association Journal*, July 2001, pp. 20-32
3. TOBALT, Mike, *City of Ottawa*
4. ANDRES, Reg, R.V. Anderson Associates Limited
5. SCHARFENAKER, Mark A., "Reg Watch," *American Water Works Association Journal*, July 2001, pp. 20-32
6. BEECHER, Dr. Janice A. "The Infrastructure Gap: Myth, Reality and Strategies," *2001 AWWA Infrastructure Conference Proceedings*, March 11-14, 2001.