A Guide to Sustainable Asset Management for Canadian Municipalities

(CONFERENCE EDITION)

Prepared for the
Federation of Canadian Municipalities

2nd Annual Sustainable Communities Conference

February 7, 2002

R.V. Anderson Associates Limited
consulting engineers, architects, technology managers

Federation of Canadian Municipalities

A GUIDE TO SUSTAINABLE ASSET MANAGEMENT

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… AHEAD OF THE WAVE

A few years ago the Operations Manager of a major municipality in Ontario initiated a process to develop a strategy for managing existing water and wastewater infrastructure in the community. Until that time, staff had focused on operational requirements and meeting the demands of developing new infrastructure to support growth in the community. While attention was given to system failures on an emergency basis, the Manager recognized that municipal assets were aging and needed a specific management strategy to keep them operational.

A multi-year "asset management" program was initiated with a traditional approach including detailed data gathering activities and the development of analytical tools to identify system needs and capital works programs to upgrade the existing infrastructure. However, a year into the program a major failure occurred in the system with damaging results in the community. The Manager recognized there was a more immediate response needed than the time it was taking to develop the new approach to the management of the system.

A strategic shift in the asset management program took place when the Manager proclaimed the need for results in advance of the availability of detailed information and sophisticated decision-making processes from the study. An immediate characterization of the condition of the system assets was needed so that a strategy, including an understanding of the investment needed, could be brought forward to mitigate the possibility of an even greater failure than the one just faced.

The Manager likened this situation to the helpless feeling of a swimmer in the undertow of a massive wave…where treading water accomplishes little. An immediate intervention was needed to get ahead of this wave.

The result was a new strategy, focused on developing an immediate understanding of the overall condition of the assets based upon limited available data and from which reasonable recommendations could be made. With a new approach, characterized by a "top-down" thinking process, the condition of the infrastructure was assessed at a macro level. An average annual investment was determined from this information to sustain the municipal assets over time. The concept of sustainability was incorporated into the strategic planning activities by considering the full, life-cycle demands of the assets at this high level. It became evident that this process did not circumvent, but rather complemented and enhanced the traditional asset management practices.

The immediate benefit in this simple strategic planning process is the ability to introduce sustainable and accountable practices into a municipal organization in cost-effective, manageable steps. The methods presented in this document grew from the experiences in the City of Hamilton. They evolved in an environment of creative debate and dialogue with City staff, consultant and external interactions with others seeking similar answers. The evolution is continuing, in Hamilton and other municipal settings, with new lessons and challenges regularly refining the application of the principles established in the process. While the initial development of the methodology was based on water and wastewater systems, the methodology presented in this guidebook can be used for sustainable asset management of all municipal public works assets. Applications of the process have now included road systems as well as water and wastewater systems.

This guidebook is titled *… Ahead of the Wave* to recognize the growing demands of existing municipal assets. It is rooted in the understanding that municipal assets represent a significant investment of public monies in all communities across Canada that must be protected. Furthermore, public health and safety are dependent on maintaining this infrastructure in a state of good repair, and that failure to stay ahead of this swelling wave of deteriorating facilities will have a significant impact on all Canadians. Finally, this guidebook is rooted in the recognition that a sustainable level of investment is a prerequisite to sustainable asset management, and that this is the challenge facing municipalities today.

This guidebook is written for decision-makers and asset managers to address these issues – to learn from those who have gone through the process and who continue to be challenged in developing asset management strategies that stay *"…ahead of the wave".*

Reg Andres, P.Eng.
Vice President
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TABLE OF CONTENTS

PART 1

The Management of Municipal Assets

…a changing environment

…a new approach

Municipal Assets

Changing Management Demands

Development of Canada's municipal water and wastewater infrastructure began in the middle of the nineteenth century, more than 150 years ago. Over time, as Canada's cities grew, these systems kept pace and grew in size and sophistication to address rising demands and evolving health and environmental concerns associated with increasing concentrations of human activity (e.g. typhoid epidemics and massive fires).

Figures 1-1 and 1-2 illustrate how water and wastewater infrastructure investment in Canada developed in phases according to the periods of physical growth experienced by the cities and the prevailing management issues of the day.

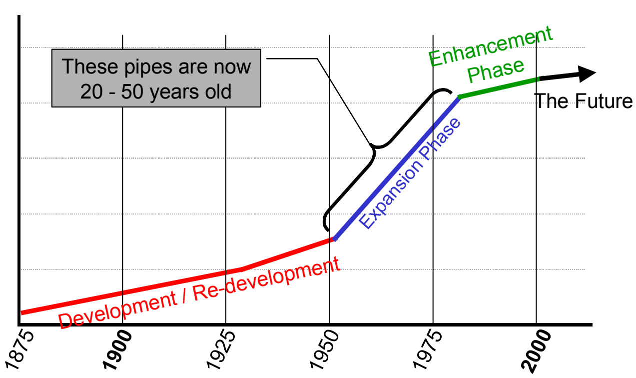


Figure 1-1
DEVELOPMENT PHASES

As these figures illustrate, today's asset managers must balance the demands of physical growth, increasingly stringent environmental protection regulations, public health protection and the realities of financial constraints facing decision-makers today. While all of these issues are important to ensure sound infrastructure management, at times they overshadow the underlying importance of the primary goal of maintaining public health and safety.

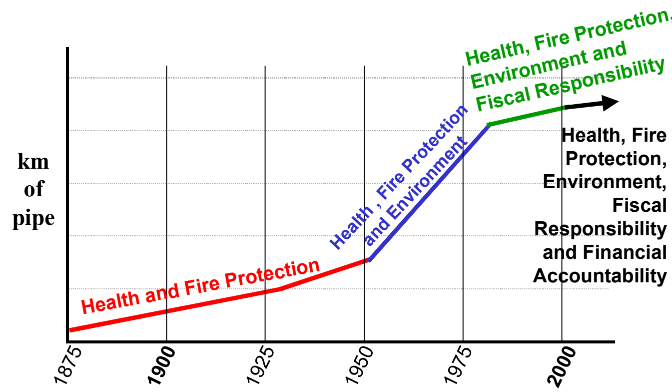


Figure 1-2
MANAGEMENT ISSUES

Projecting into the future, two (2) key factors will significantly influence the strategies for managing these assets.

Deterioration: municipalities in Canada are entering an era where a significant and growing proportion of the water and wastewater infrastructure is completing its first full life-cycle … the result of the normal process of aging. This will result in many new challenges for the asset manager.

Financial accountability: the trend for a higher level of accountability is world wide demanding transparent decision-making, demonstrating wise and effective management of public funds. This follows the need to address the pressures for reduced spending and taxes while maintaining safe and reliable municipal services.

Sustainability
A New Management Strategy

The most significant factor impacting the future management of water and wastewater assets in Canadian municipalities is the completion of the first life-cycle of existing infrastructure.

Sustaining municipal services will require a new management approach that balances a growing portfolio of aging infrastructure with increased demands arising from new growth - all within the financial means of the community. Neither stopping growth nor ignoring the problem of aging facilities is an acceptable management option.

Sustainability

The concept of sustainability has evolved in meaning and understanding over time, but is broadly understood, in terms of sustainable communities, as *"…meeting the needs of the present generation without compromising the ability of future generations to meet their own needs".*

Within the municipal sector, sustainable community development requires consideration of the following:

(i) social well-being of the community including public health and safety;
(ii) environmental integrity, including protection of natural resource values and functions; and,
(iii) financial / economic viability of the community.

Three concepts must be incorporated in a new strategy for managing municipal assets that support sustainable communities.

Asset Value: Water and sewer facilities must be managed as assets. All assets have a capital value as well as an inherent value arising from their role in achieving some greater objective. In this case, it is to sustain public health and safety and the cost of failure in terms of lives.

> ***"… manage water and sewer facilities as assets"***

Life-cycle: The management of municipal assets has traditionally included the planning, construction, operation and maintenance of the facilities providing a basic service such as the supply and distribution of potable water and the collection and treatment of sewage. The concept of sustainability implies this must be taken a step further to include a consideration of these facilities to the end of their useful life. This is generally referred to as "life-cycle" management.

> ***"… consider facilities to the end of their useful life"***

Financial and Technical Integration: Life-cycle assessments consider financial issues such as long-term investment protection, cost efficiency, cost-benefit of best approaches, priorities, and asset depreciation and replacement costs. Technical and financial evaluations must be fully integrated when establishing investment levels for capital projects, operations and maintenance, and replacement reserves to ensure adequate funding over the entire life of the asset—from inception to its ultimate replacement.

> ***"… fully integrate technical and financial evaluations"***

Framework

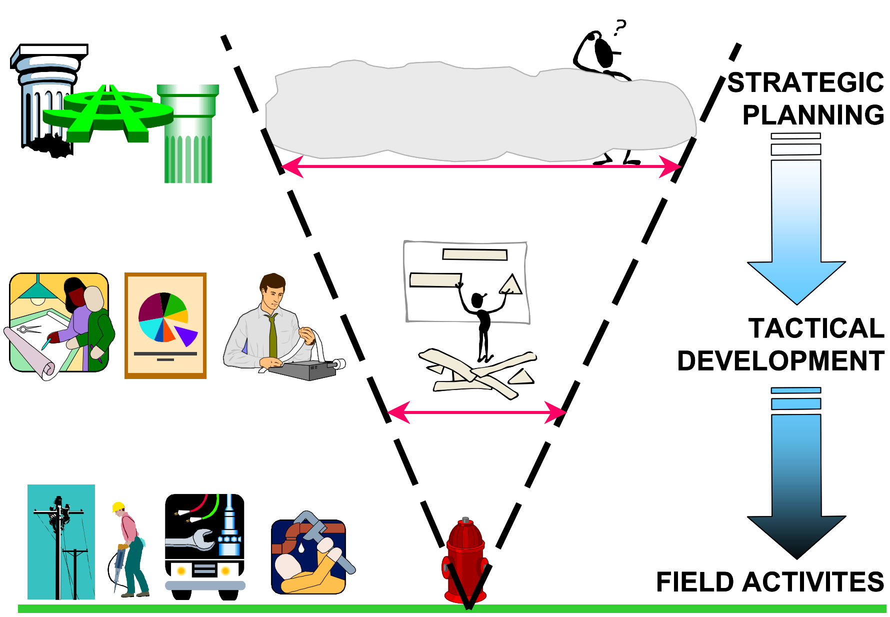
Sustainable Asset Management

Figure 1-3 illustrates three components of municipal infrastructure management including strategic planning, tactical development and field activities. The fundamental difference between current asset management practices and sustainable asset management lies at the strategic planning level. A brief review of the three levels is used to identify the sustainability gap.

Field Activities include all physical works including the collection of data used for operational and planning purposes. Maintenance Management Systems are often used to monitor and control daily work activities (e.g. work order systems) and to house system inventories (data). Also included are the programs for monitoring, cleaning, repairing and operating the system.

Tactical Development includes the preparation of capital plans that identify the projects to expand, improve and maintain the system in response to technical, public and political demands. Projects and programs developed at the tactical level are implemented at the field level. Activities include studies employing 10 to 20 year planning horizons to identify long-term infrastructure improvement, expansion and replacement projects. Projects are prioritized and funds allocated to recommended activities through the annual budget setting process. The linking of technical and financial requirements relates generally to balancing these needs in the context setting of projects priorities.

Strategic Planning is a function of broader municipal priorities. It involves the review of priority planning between



1.Sustainability model
priority planning, risk management, life-cycle costing, long-term capital planning, policy planning

2. Work Management and System Models – Long term coordination and integration, capital and financial management, system modeling, needs assessments and master planning studies

3. Data and Work Management Systems
Inventories, maintenance management, work history, condition assessment, customer service

Figure 1- 3
Sustainable Asset Management Framework

departments, policy planning, risk management, long range financial planning and life-cycle costing. A key differentiation with tactical development is capital planning on the basis of programs instead of projects. It is a level of management considering broader municipal objectives.

History has shown that the traditional approach of managing on the basis of project priorities can result in "important and necessary" infrastructure needs going unaddressed indefinitely due to budget constraints. This model often excludes provision or planning for long-term revenue generation and allocation. Consideration of the life-cycle demands of the system, technically and financially, are missing.

A "sustainable" asset management approach differs from the traditional model by identifying the annual capital works program needed to achieve the desired outcome. A sustainable approach considers the full life-cycle investment needs (i.e. sustainable funding) to develop a long term plan to balance the technical and financial needs for the infrastructure and then determines, on an annual basis, the program spending needed to sustain the level of service provided by the infrastructure over the life of the asset.

Strategic Planning:
Sustainable Asset Management

For many municipalities, size and resource limitations have dictated that asset management is confined to field activities and tactical development. Where strategic planning occurs, it is often completed in isolation of tactical and field level activities which, in them selves, are carried out by different departments (e.g. Engineering Branch and Operations Branch.) It is difficult to avoid an ultimate disconnect between the technical planners and the financial planners within organizations where these activities are managed in different departments, giving rise to the term "silo structure" - each operating in isolation of the next.

In a sustainable asset management process, these "silos" are broken down. Strategic planning activities are linked to tactical development and field activities and integrated with financial planning.

The key to implementing sustainable asset management is the strategic planning process. A "top-down" financial analysis enables achievement of the following goals and objectives:

- simple to initiate and cost effective;
- immediate results independent of complex, time consuming data collection (bottom-up) activities;
- effective in communicating results and needs to decision-makers; and
- complements or supports detailed analysis as data becomes available.

Strategic Planning Process
Developing Investment Profiles

The strategic planning component of sustainable asset management, as described in this guidebook, achieves the goals described in the previous section by answering the following questions:

1. What do we have?
2. What is it worth?
3. What condition is it in?
4. What do we need to do to it?
5. When do we have to do it?
6. How much will it cost?

The development of a sustainability model can be achieved by answering these six questions in the context of water, wastewater and road systems or and other municipal assets. The model can be used to undertake analytical evaluations, including the effectiveness of various investment strategies.

Figure1-4: *Sustainable Capital Planning*, portrays the sustainability model as an investment profile with links to financial management (i.e. capital planning) processes. What follows is a description of the six step strategic planning process of sustainable asset management.

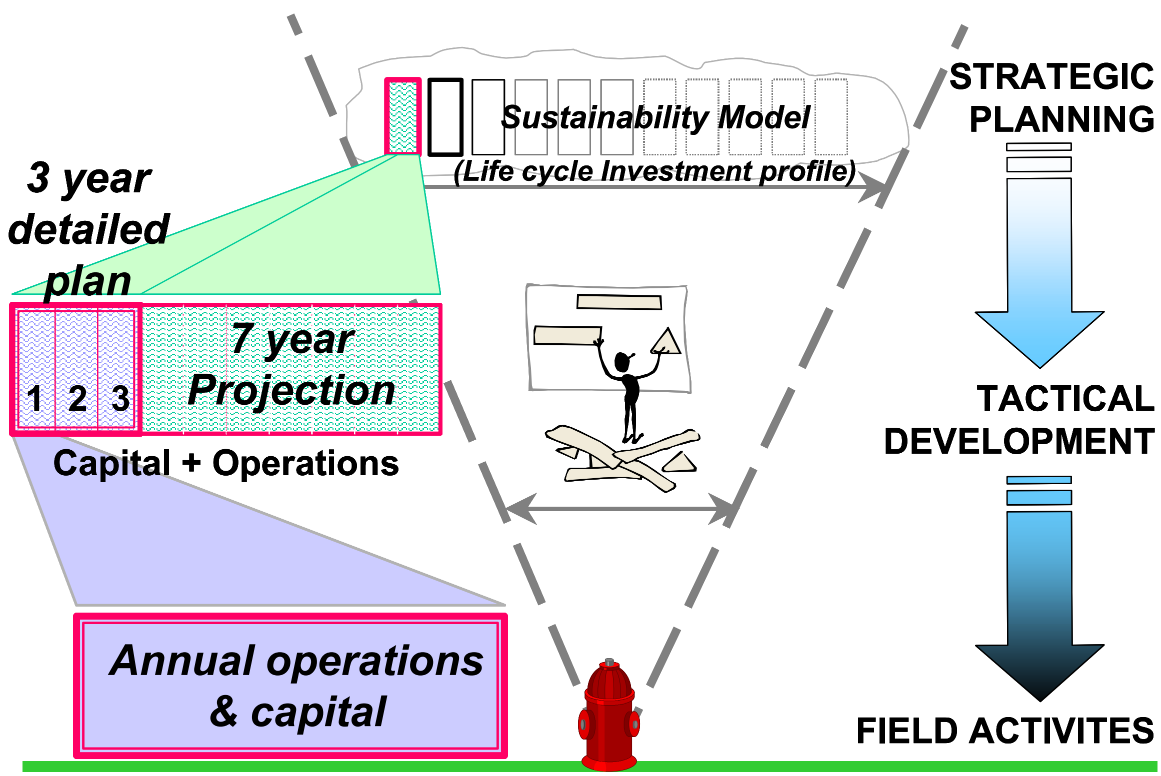


Figure 1- 4
Sustainable Capital Planning

Sustainability in Asset Management Practices

Traditional asset management activities, as practiced in many municipalities, include a component of infrastructure data management and a component of work management activities (ref. Figure 2-1: Sustainable Asset Management).

With the aid of the sustainability model (i.e. representation of the characteristics of the infrastructure systems) the asset manager can evaluate the long-term technical and financial performance of the assets. This evaluation analyzes strategies for priority planning, life-cycle profile management, long-term capital planning, risk management, corporate policy development and other issues of interest in managing municipal assets.

A sustainability model built on the basis of some broad assumptions about the assets, without the need of extensive data, has proven to be very useful in its initial application as a management tool.

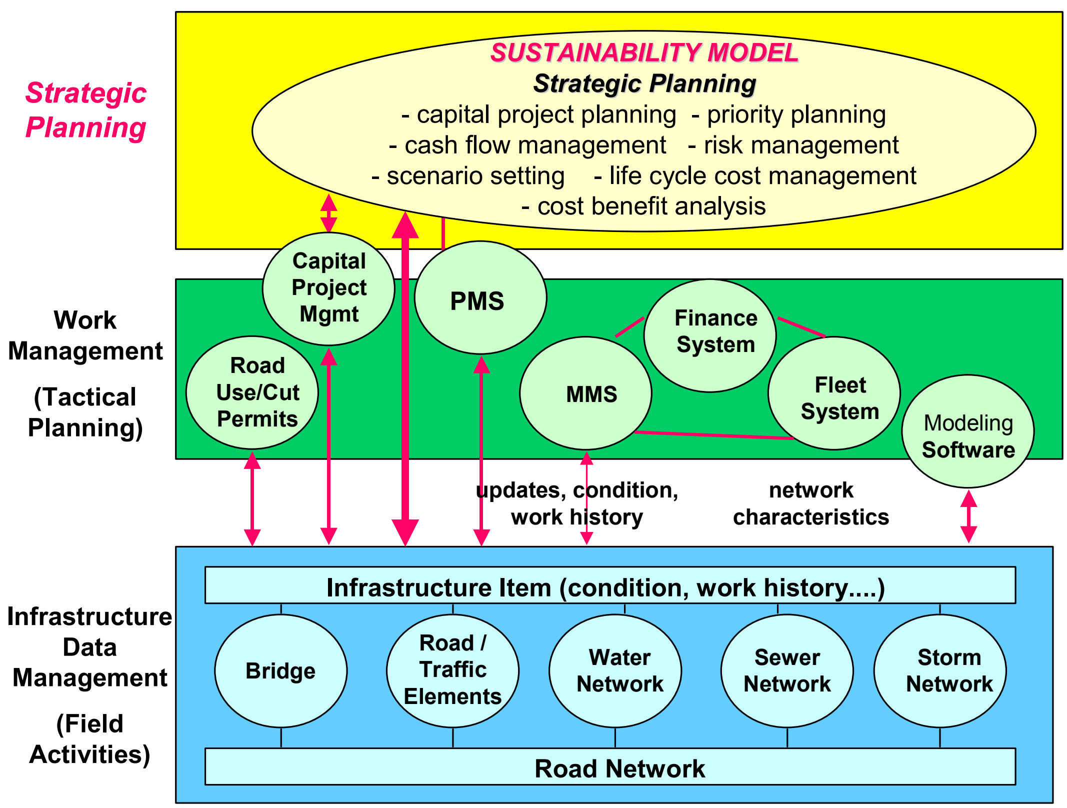


Figure 1- 5
SUSTAINABLE ASSET MANAGEMENT

PART 2

A Guide to Strategic Planning for Asset Managers

…a phased implementation process

…strategic planning process (6-steps)

Sustainable Asset Management

A Phased Implementation Process

Integrating life-cycle management practices into a municipal organization is a process of progressive steps. Each step or phase in the process introduces an increased level of detail into the sustainability model and another step closer to institutionalizing applications of the model in strategic decision-making.

The focus of this guide is how to take the first step into strategic planning.

Phase 1 - Development of Initial Sustainability Model

The first phase or introduction into sustainable asset management is intended to initiate the municipality with the concepts of building a simple model of its assets. This model is used to develop a life-cycle profile of the assets for an initial understanding of their condition and corresponding financial investment needs over a full life cycle.

The initial model does not require a detailed representation of the assets for this purpose and, therefore, is built with limited system data or best available indicators in the absence of data.

Age is a reasonable indicator of condition for many assets and if specific age data is not available, population demographics can provide a suitable age profile based on the assumption that infrastructure was constructed in a community to keep pace with the growth.

Together with cost and life expectancy information a first level life-cycle cost profile can be created with these parameters.

This guidebook is intended to enable municipalities to make this first entry into sustainable asset management by implementing the initial model with a small investment in time and resources. At the same time, it is intended to provide an initial insight into the importance and benefits of sustainable asset management.

Phase 2 – Detailed Applications of the Sustainability Model

With an initial understanding of the sustainability model, the extent to which the model can be used to assist in asset management decisions is simply an issue of the level of system detail in the model. In the case of a water system, if a single pipe length represents the initial model, it can be refined to identify the various pipe sizes and materials of construction in the model to enable a more detailed prediction of replacement and investment needs by pipe size and material. The use of specific inventory data enhances or calibrates the model and it now is capable of more accuracy in predicted life-cycle cost profiles.

Phase 3 – Integrated Organization

The municipality will ultimately be fully integrated with life-cycle management as an institutionalized practice. It will be evidenced by on-going calibration and use of the model, documented policies, programs and procedures that address issues of sustainability and, finally, possible structural changes to the organization to better coordinate and manage these processes.

Strategic Planning – 6 Steps

Step 1 – What do we have?
Building the Sustainability Model

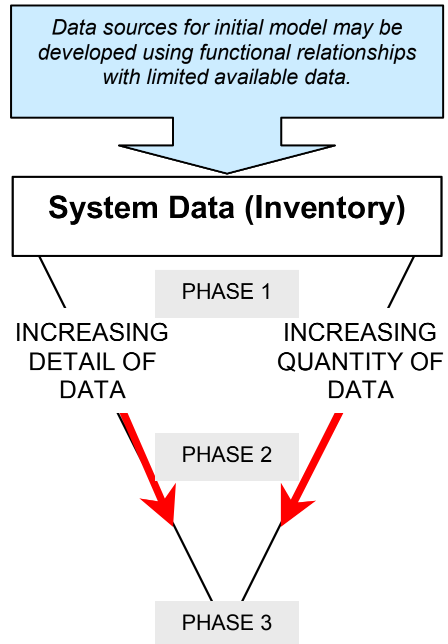
The first step in building the sustainability model is to define the system components. This is a basic inventory of the infrastructure assets. The initial model should be limited in the level of definition detail.

The concept for the form of the data is that of a "tree" structure. A serviced population could define a water system, providing an initial sense of the overall size of the system.

The next level of detail could define the system as pipes and above grade structures (plants, pumping stations, reservoirs). In the absence of actual inventory data, it is appropriate to estimate this data using functional relationships (e.g. pipe length can be estimated from population data by assuming 1 km of pipe per 250 serviced population or treatment plant sizes can be estimated by similar population data).

As the model is refined or calibrated, it is simply broken into more detail. The next level of detail for the pipes could include size and materials. Ultimately pipes could be identified down to street-by-street definition, if this level of detail was necessary for detailed evaluations.

It is important to note that the lack of detailed inventory is not a barrier to the development of an initial model or representation of the system. Although the inventory will be needed at some point, it is entirely appropriate to build the initial model with limited data.



Maximum Level of Detail for Phase 1 Inventory

Water Systems

- Watermains– length & size
- Hydrants – number (may be a function of WM length)
- Valves – number (may be a function of WM length)
- Other broad grouping of assets

Wastewater Systems

- Sewer pipes– length & size
- Manholes – number (may be a function of sewer length)
- Pumping stations- number & capacity
- Treatment plants- number & capacity
- Storage tanks- number & capacity
- Other broad grouping of assets

Road Systems

- Road types or sections:
  - Urban – overall length
  - Semi-Urban – overall length
  - Rural – overall length
- Road classes:
  - Arterials – overall length
  - Collectors – overall length
  - Local – overall length

Strategic Planning – 6 Steps

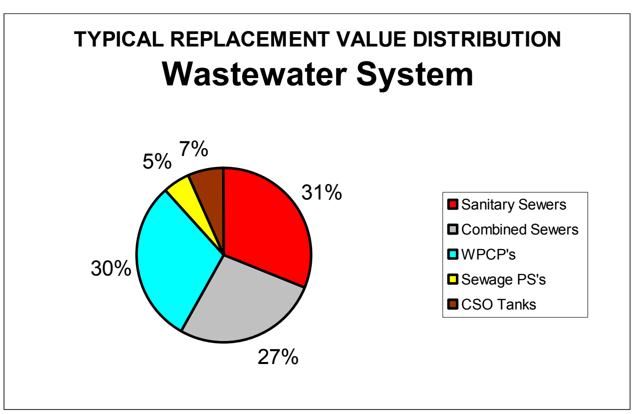
Step 2 – What is it worth?
Building the Sustainability Model

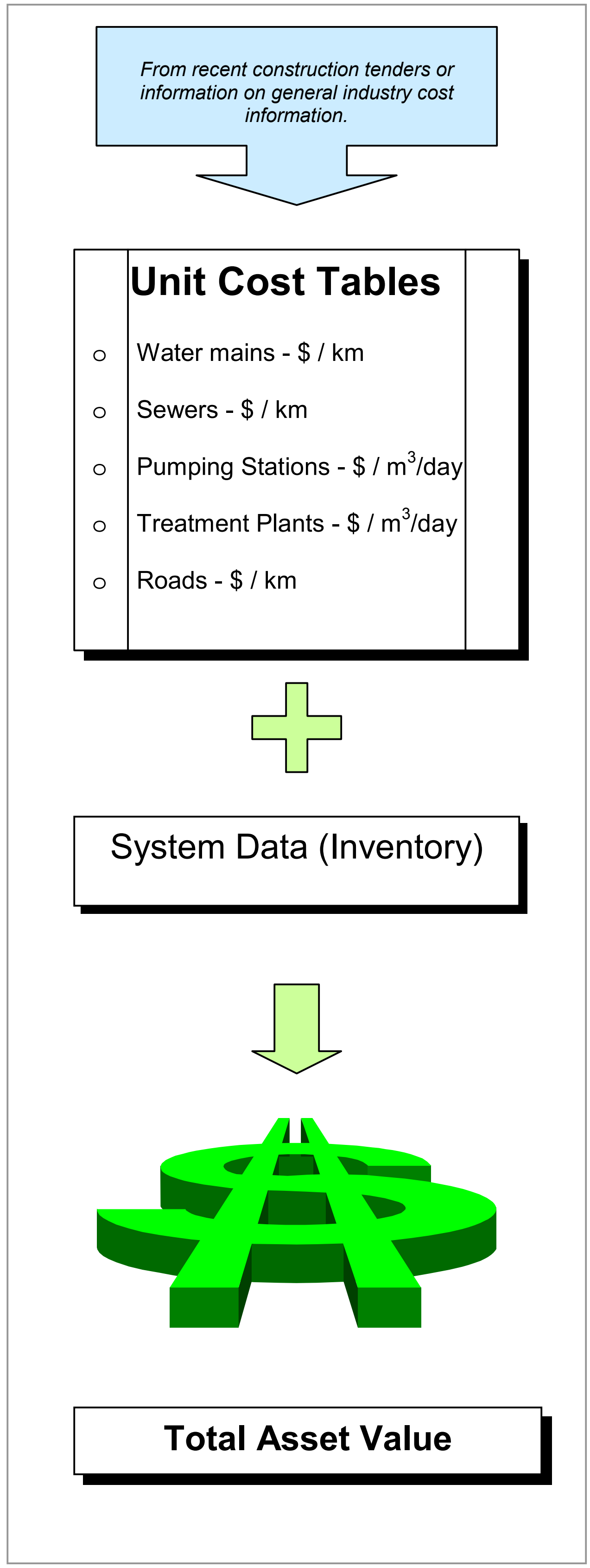
This is the next logical step to the inventory of the assets. It involves the application of current construction cost estimates to available system data to determine the replacement value of existing assets. As with Step 1, this activity can be straightforward when kept at a macro level using available data.

There are other methods of valuation other than current replacement costs for assets. For purposes of this model, the method provides a suitable basis for the types of evaluation carried out.

Calibrating the model is a case of upgrading the unit cost tables to reflect local conditions that affect construction costs (e.g. – soil conditions, bedrock depth, isolated areas, etc).

The representation of the asset values in graphical form provides early insights into the nature of the asset and relative importance of individual components. (e.g. typically, the value of assets buried underground exceed above grade structure build assets).





Strategic Planning – 6 Steps

Step 3 – What condition is it in?
Building the Sustainability Model

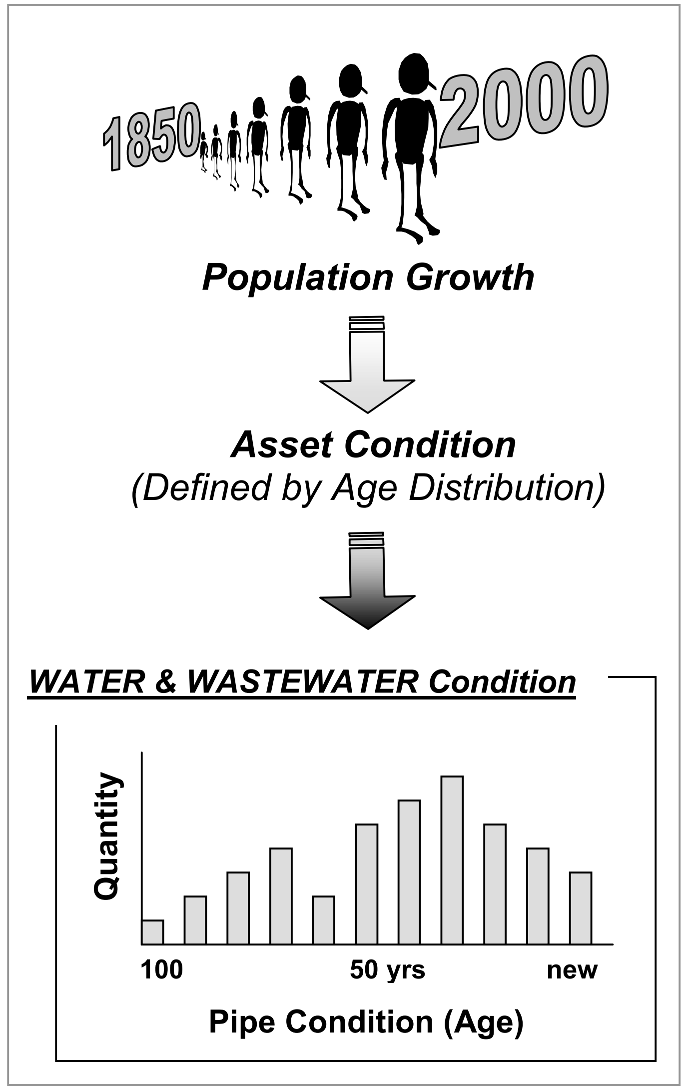
The objective of this step is to obtain an understanding of the general condition of the entire asset base to enable assessment of future demands for minor and major repairs, rehabilitation and replacement.

Use condition indicators that can be measured over time. In most situations, age is an appropriate indicator of asset condition for the initial assessments. Where the age of assets is unknown, it is reasonable to assume they were built to keep pace with population growth. In this case, use census data and historic mapping to determine the growth of infrastructure in different time periods.

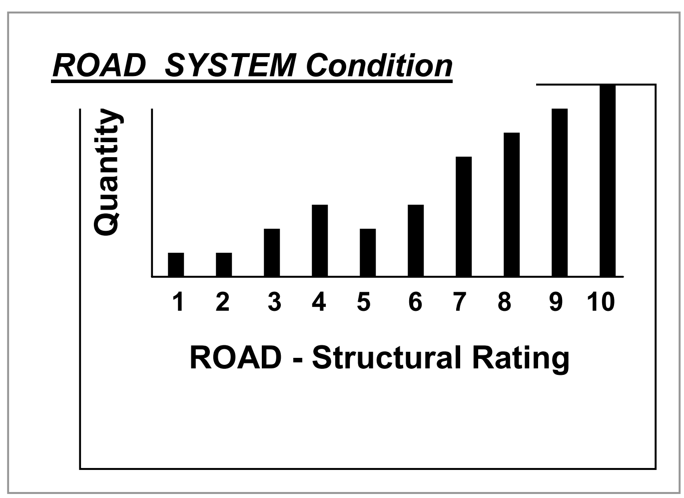
While other factors can be used, assessing infrastructure condition as a function of age enables simple characterization of the overall asset. This is particularly the case for water and sewer assets.

In the case of roads, typical structural adequacy ratings from Road Needs Studies are good condition-rating indicators.

> It is important to avoid the tendency to embark on a major data collection exercise at this stage to determine and assign a condition for each component of the asset base.



Asset Condition
(Defined by Structural Rating)



Strategic Planning – 6 Steps

Step 4 – What do we need to do to it?

Building the Sustainability Model

The purpose of this step is to identify the type of investments required during the life-cycle of each group of assets.

Four (4) general categories are used to group the different investment activities required over the life of the assets:

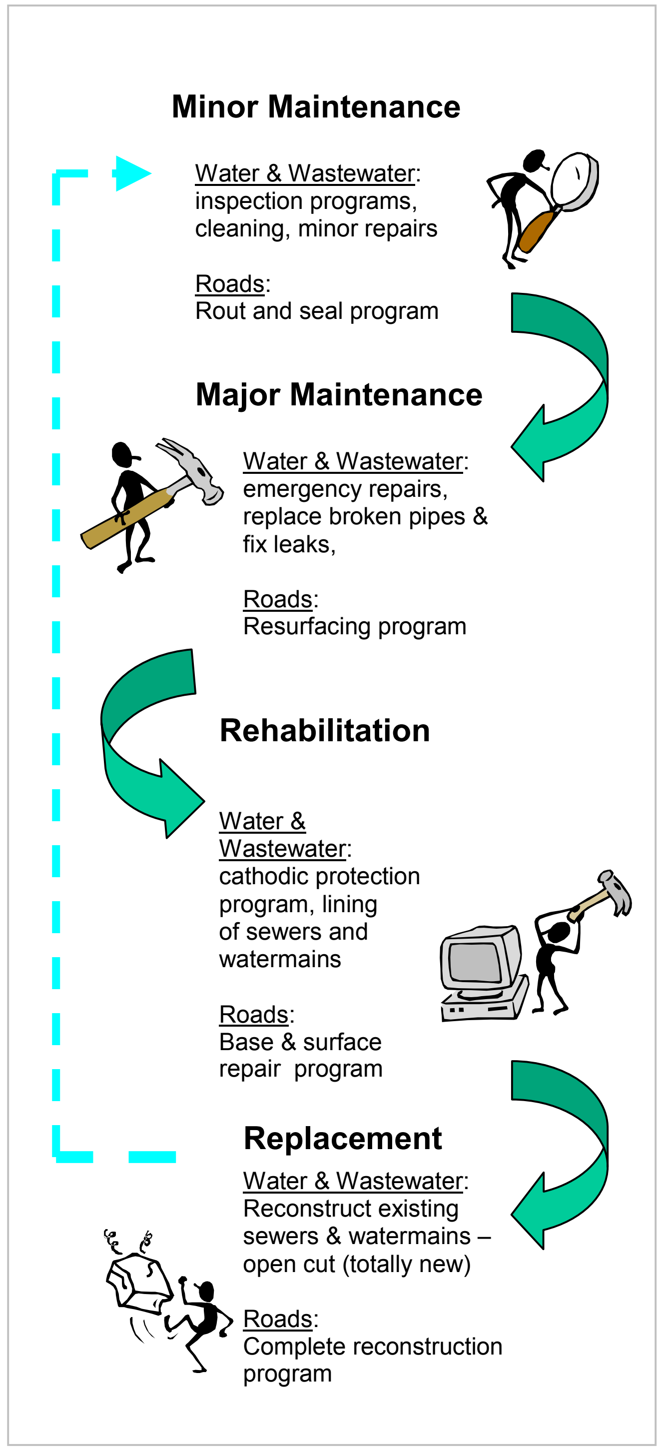
- minor maintenance,
- major maintenance,
- rehabilitation, and;
- replacement.

Minor maintenance includes all regularly scheduled maintenance activities such as inspection programs, cleaning, lubricating and minor repairs for water and wastewater systems. In road systems, a rout and seal program is typically identified. These would be modified to adapt to specific practices of the municipality.

Major maintenance typically includes activities such as repairing broken mains, replacing motors or pumps, and similar unscheduled or unplanned emergency type activities carried out to maintain service for water and wastewater systems or resurfacing programs for road systems. Again, these would address specific municipal practices.

Rehabilitation is generally a one-time event designed to extend the life of the asset, such as lining a sewer or installing cathodic protection in a water system. This is a base and surface repair program for road systems.

Replacement is the unavoidable event that occurs at the end of the service life of all assets. For water and wastewater systems, these are usually open-cut installations. For roads, a complete reconstruction takes place.



Strategic Planning – 6 Steps

Step 5 – When do we need to do it?

Building the Sustainability Model

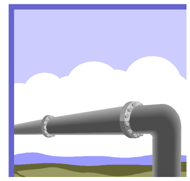
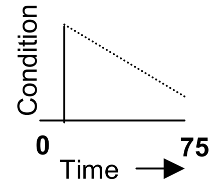
Having determined the full range of investment activities required over the life of an asset, the greater challenge is to predict when it will reach the end of its service life and how quickly its condition will deteriorate. This is not an exact science, and for the purposes of the sustainability model assumptions are necessary.

The objective of this step is to generate a life cycle investment profile for each asset component by assigning a time interval for the cost events identified in step four. For example, minor maintenance costs are annual cost events incurred every year of the asset's life. Major maintenance costs would be treated in a similar fashion but may increase over time.

The timing of rehabilitation events are assigned on the basis of industry information and estimated in relation to the life of the asset.

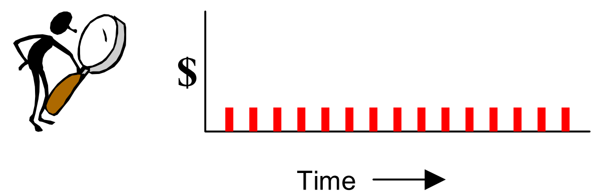
The replacement cost is a single cost event that takes place at the end of the expected service life of the asset.

Estimates can be refined over time through tactical and field activities that target collection of relevant data (e.g. the age of pipes replaced, and frequency of meter repairs and pump breakdown).

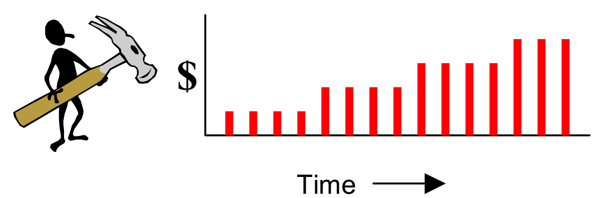
ASSET	Life Expectancy	Rate of Deterioration
	75 YEARS	

Component Life Cycle Profile

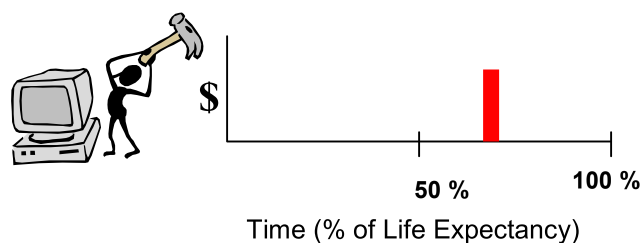
Minor Maintenance (annual cost events)



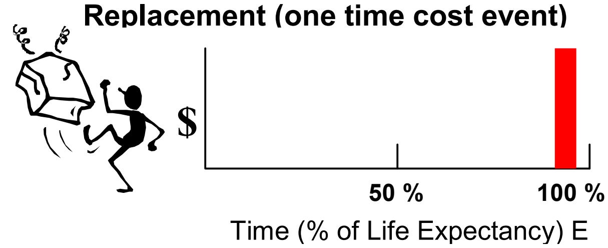
Major Maintenance (annual cost events)



Rehabilitation (one time cost event)



Replacement (one time cost event)



Strategic Planning – 6 Steps

Step 6 – How much will it cost?

Building the Sustainability Model

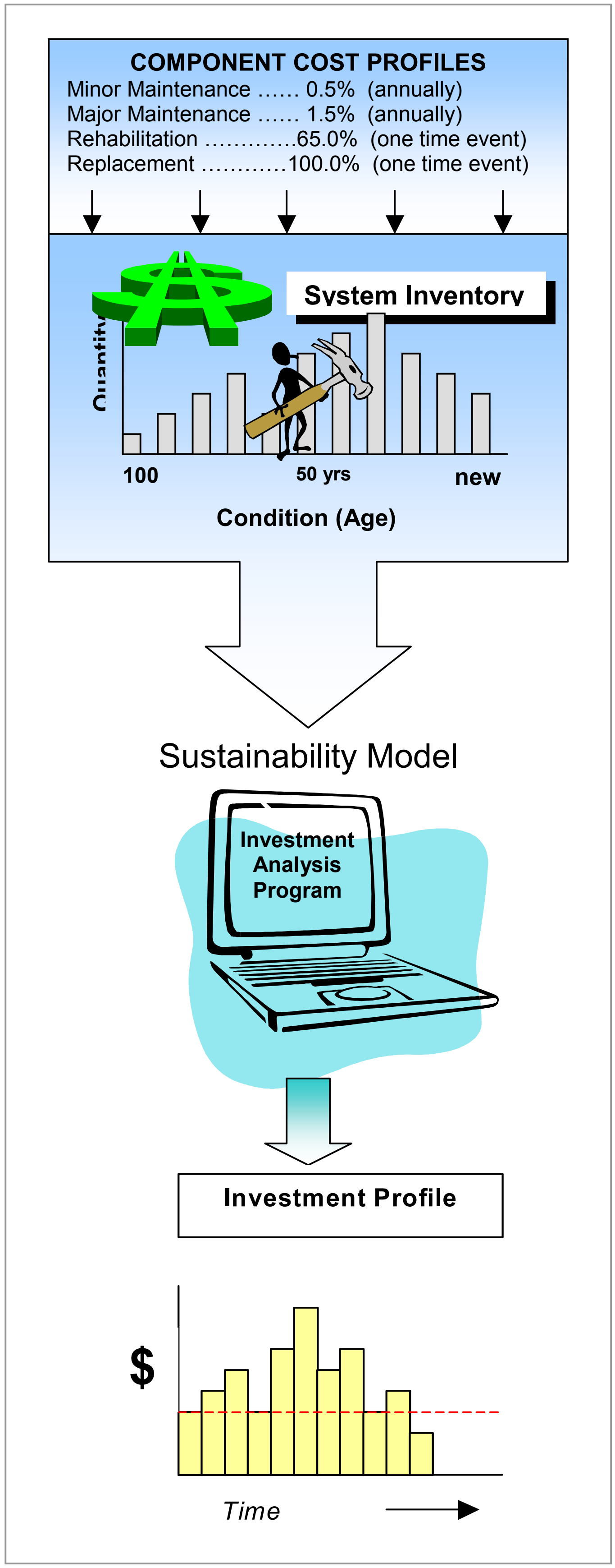
The final step in building the sustainability model is to estimate the cost of each investment event as a percentage of the total asset value (i.e. replacement cost).

Rehabilitation costs, as a percent of total asset value, are estimated from general industry knowledge for this type of work. Maintenance costs may be obtained from industry benchmarking exercises, research studies or estimated from the municipality's own budgets.

Combining the timing information from Step 5 with the costs determined in Step 6 results in individual component life-cycle profiles for the assets, which, in conjunction with all the related data and information, is the "sustainability model".

Using computer tools to manage and manipulate the model, specific evaluations can be made to assist management decisions. One of the elemental analysis routines is to determine long-term investments that need to be funded. Any number of funding scenarios, cost modifying activities, etc can be analyzed for making sustainable asset management decisions.

The advantage of using a sustainability model is its ability to provide dynamic representation of the assets over time, and to manage data to analyze specific aspects of the assets (e.g. the impact of changing major maintenance practices on the overall life of the asset).



Sustainable Asset Management
Tools, Applications, Implications

Tools: Computer Programs

Reference to building a sustainability model in this document is not a reference to a computer model. It is a representation of an asset in a combination of inventory databases, cost tables, age profiles (tables), and related assembly of information in tabular, database or graphical form that characterizes an asset. While the sustainability model is not a computer program, it does require this technology to store, retrieve, assemble, analyze and report the information that makes up the sustainability model.

The nature of the analytical evaluation and data manipulations can become complex. Spreadsheet programs can be used in the initial analysis. Building a sustainability model with a spreadsheet program, however, has limitations and at some point a more sophisticated database management program will be required.

At the present time, few database management programs, specifically designed for strategic planning analysis in the context of sustainable asset management, exist on the market. It is anticipated that this will change. The emergence of these types of analytical needs will result in the development of such models.

To illustrate the application of an investment valuation computer model, the following is a brief summary of the desired functionality of such a program.

An asset management program needs to use an advanced object-oriented design to support three primary functions in conjunction with sustainable asset management.

Data Management: Information needs to be received from different databases allowing users to configure how the value and condition of the infrastructure is determined and how detailed the valuation and maintenance model should be.

Analysis: The model should support complex formulas for sourcing, calculating and estimating the numbers needed to perform long-range planning. Computing these financial algorithms should be able to be done simply with any aggregation of the data to perform and demonstrate results for comparative analysis. Support for multiple management strategies would allow an organization to test different policies for preserving their assets. Changing the strategies in the model would allow for a determination of effect on condition and budget implications.

Reporting: An important aspect of analyzing different strategies and management scenarios is the ability to present and view the results in effective and communicative pictorials. The program needs to provide for viewing of the information in easy-to-read charts and graphs. Users need to navigate between graphs and trail the formula and components used to calculate a number.

Applications

This guide document outlines the development of a sustainability model for the purpose of strategic planning in the context of sustainable asset management. The applications for the model are as diverse as the challenges that asset managers meet in the course of delivering the municipal services for which they are responsible. A variety of operational planning, financial, policy and related decisions need to be made on a regular basis. The following is a sampling of some of the management applications for the sustainability model.

Full Cost Accounting
One of the elemental applications for the model is its ability to determine life-cycle costs for operations, maintenance, rehabilitation and replacement capital to sustain an asset over its full life. This provides the basis for long-term financial planning to ensure revenues are adequate (i.e. rates).

Policy Development
The model is an effective tool to identify policies that support cost effective management strategies, to test the effects of current policies or to identify the impacts of contemplated policies.

Program Planning
Understanding the dynamic of an asset in terms of the types of investment needs it will require over time allows the asset manager to develop sustainable maintenance, rehabilitation and replacement program budgets and responding program activities over time.

Design Standards
Specific design standards as they relate to issues of durability, longevity and associated costs, can be reviewed. By example, the cost effectiveness of the design standard for a specific road base can be compared with a standard that may cost more but would last longer.

Budget Planning Process
During the budget planning process municipal staff are often challenged with identifying the impacts of contemplated revisions, inclusions or exclusions of activities in a budget. The sustainability model offers a tool that can quickly analyze impacts and provide for more informed decisions in the budget planning process.

Implications

Implementing sustainable asset management practices has some potential implications for changes to traditional institutionalized practices in a municipal organization. These may include:

- Decision-making, with respect to the investment / budget plan for an asset, must consider the needs of the infrastructure systems over the full service life of the assets.
- Investment plans for an asset must be defined in terms of programs as opposed to projects.
- Revenue streams need to be approved on the basis of long-term program needs.
- Policies and programs supporting sustainability need to be identified and approved.
- Organizational structure may need to change to support new management approaches and responsibilities.

PART 3

Case Study in Strategic Planning

…Water and Wastewater
City of Hamilton, Ontario

A Case Study

Water and Wastewater Assets
City of Hamilton

Hamilton is a municipality, located on the westerly shore of Lake Ontario with an approximate population of 470,000. In 1997 the City embarked on a multi-year asset management program designed to assist in the development of a management strategy to address the needs of the municipality's existing, aging infrastructure. The program began with a typical approach of detailed data collection and program development. During this process the need for more immediate outcomes from the program resulted in a strategic shift in the program. A top-down approach was initiated and in 2000, the City of Hamilton became the first municipality to implement the sustainable asset management system and in particular, the strategic planning activity, described in this guide. At the time of the asset management study, Hamilton was a Regional jurisdiction with 7 area municipalities. The Region was responsible for the entire water and wastewater (collection and distribution, treatment, etc) systems.

The following is a summary of the development of the 6 Steps and the outcomes and analytical results of the sustainability model.

Step 1 – What do we have?

During the 1990's, Hamilton implemented an advanced maintenance management system to track and support their operations and maintenance activities. Over a period of several years the water and wastewater systems were inventoried and the data was loaded into the maintenance management system.

For purposes of this study, the inventory was reasonably complete except for age data. The detail selected to aggregate the data and the source of the data is presented below:

SYSTEM COMPONENTS	DESCRIPTION OF INVENTORY DATA	BASIS OF DETERMINATION
Water System		
1. Pipes	Lengths for individual pipe diameters from 100 mm diameter to 2,250 mm diameter, by community	MMS data base
2. Water services	Number by community	Water billings
3. Hydrants	Number by community	MMS data base
4. Valves	Number by community	MMS database
5. Treatment Plants	Number	MMS data base
6. Pumping Stations	Number	MMS database
7. Reservoirs	Number	MMS database
Sewer System		
1. Pipes	Lengths in size groupings (>300mm, 350-600 mm dia., 625-900 mm dia., 975-1200 mm dia., 1350-3000 mm dia., by community	MMS data base
2. Sanitary laterals	Number by community	Water billings
3. Manholes	Number by community	MMS data base
4. Treatment Plants	Number	MMS data base
5. Pumping stations	Number	MMS database
6. CSO tanks	Number	MMS database

Step 2 – What is it worth?

For each of the system components a cost table was developed from industry figures, averaging costs for 'lumped' components like pumping stations and reservoirs. The results were reported in a simple table as follows:

WATER MAINS

Less than 200mm …	$ 417,505,000
250 – 300mm …..…	$ 197,069,000
400 – 500mm ……..	$ 149,764,000
600 – 750mm ……..	$ 67,955,000
Greater than 750mm..	$ 144,508,000
TOTAL	***$ 976,801,000***

WATER SERVICES
124,315 services at
~$2000 per service

$ 248,630,000

HYDRANTS
11,232 hydrants at
~$5,000 each

$ 56,160,000

VALVES
14,097 valves at
~$3,000 each

Cost included in estimate for water mains

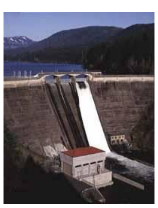
$ 42,291,000

PUMPING STATIONS
24 stations at
~ $1.5 million each — $ 36,000,000

$ 36,000,000

TREATMENT PLANT
Woodward Ave WTP — $ 375,000,000

$ 375,000,000



STORAGE RESERVOIR
16 water storage
reservoirs at $4.5M each — $ 72,000,000

$ 72,000,000

TOTAL ESTIMATED VALUE (Water) $1,806,882,000

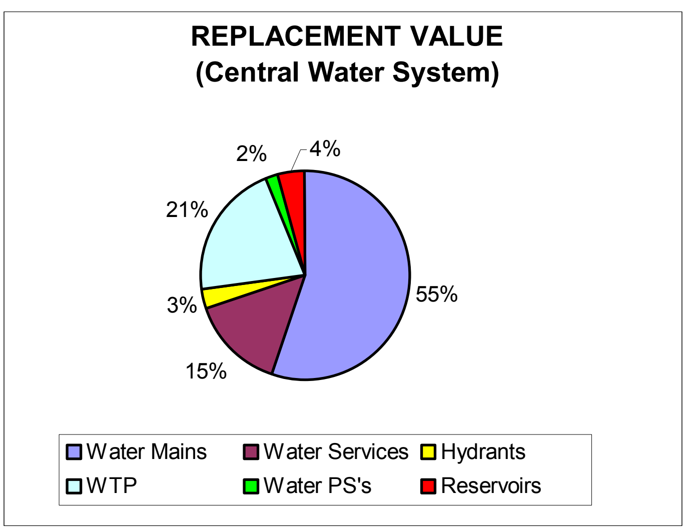
SEWER MAINS	
Sanitary sewers	$ 446,235,178
Combined sewers	$ 389,089,838
TOTAL	***$ 835,325,016***
MANHOLES	*Cost included in estimate for sewer mains*
34, 463 manholes at $5,000 each	
	$ 172,315,000

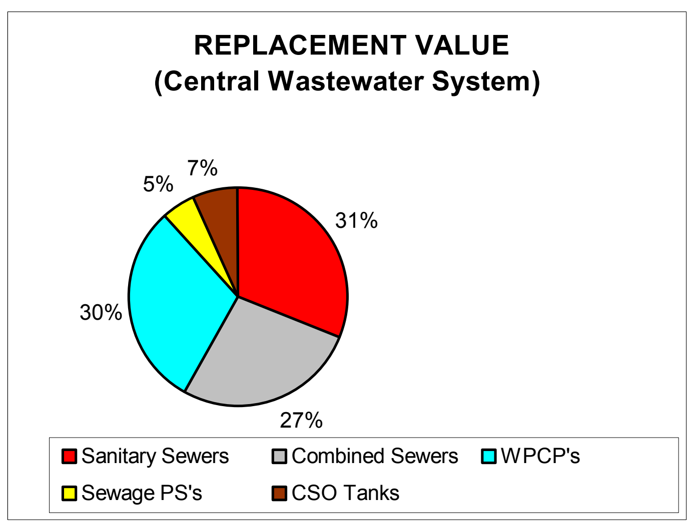
SEWAGE PUMPING STATIONS	
65 stations at ~$1,050,000 each	$ 68,250,000
	$ 68,250,000
WASTEWATER TREATMENT PLANTS	
Woodward Ave WPCP	$ 400,000,000
Dundas WPCP	$ 30,000,000
Waterdown WPCP	$ 6,000,000
	$ 436,000,000

CSO STORAGE TANKS	
5 CSO tanks at $19.5 million each	$ 97,600,000
	$ 97,600,000

TOTAL ESTIMATED VALUE (Wastewater) $1,437,175,016

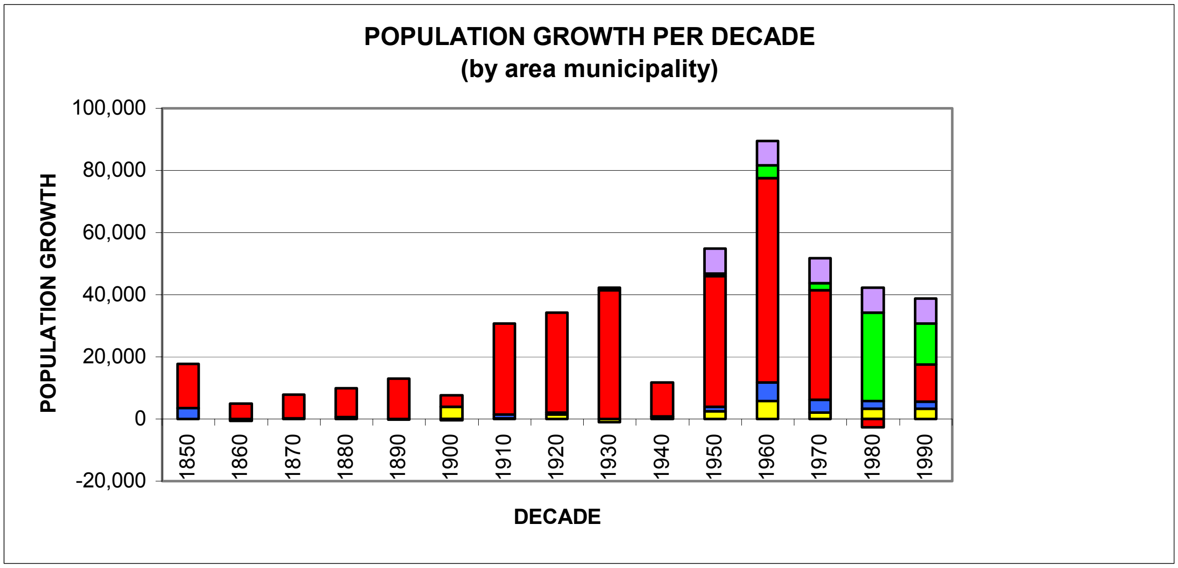
The combined assets of water and wastewater systems totaled more than $3.2 billion. This fact alone was revealing for the asset managers and corporate decision-makers in terms of the responsibility they had for a significant municipal investment. The representation in the "pie charts", below demonstrated another fact – that over two-thirds of these assets are buried under ground.





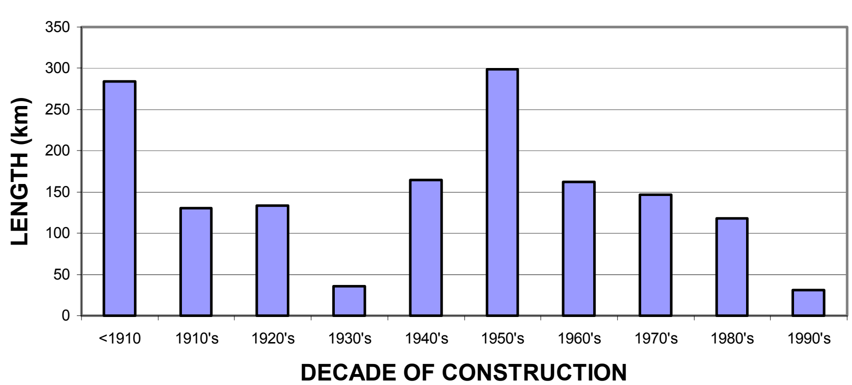
Step 3 – What condition is it in?

Development of a condition assessment or characterization of the overall condition of the water and sewer assets was accomplished based on using age as an indicator. The City has and continues with an extensive CCTV inspection of its sewers. The reports include a pipe-by-pipe condition assessment. This was deemed too detailed for the initial assessment in this study. As a result, it was decided to find a simpler method of characterizing the condition of the system as a whole. Age was selected as this general indicator. Since age of infrastructure was not in the database, population growth was used as an indicator of age with the assumption that as the community grew the infrastructure grew in proportion.



The population distribution over the past 150 years is represented in a bar chart and when the proportionate growth per decade is translated into sewer pipe lengths per decade, the age distribution of the sewer system is presented on a similar looking graph. The assumption is made that anything over 100 years old is in the first decade as a backlog of aging pipes over 100 years old. The fact that some of these pipes may have already been replaced is not significant enough to change the basic picture of the age distribution of the piped sewer system. The water system would be similar since the same population profile is used as the indicator.

AGE DISTRIBUTION OF SEWERS



Step 4 – What do we need to do to it?

Over the life of the water and wastewater assets, the four (4) primary cost events were identified, including minor maintenance, major maintenance, rehabilitation and replacement.

Minor Maintenance generally includes planned events such as inspections, monitoring, cleaning and flushing, hydrant flushing, pressure tests, CCTV inspections and visual inspections

Major Maintenance includes maintenance and repair activities, generally unplanned, but over the course of a year can be anticipated in a general way. This would include such events as repairing watermain and sewer breaks, repairing valves, replacing individual sections of pipe and sealing.

Rehabilitation includes that one point in the life of an asset where a major activity is required to upgrade or rehabilitate system component such that it can continue to provide service for an additional period of time. In the Hamilton water system, the major activity was cleaning and lining. In the sewer system, this included a sewer re-lining program.

Replacement is the one event in the life of all assets that will eventually come. When the useful service life of an asset is reached, it must be replaced. Some components of an asset will last longer than others, but they will always come to the end of their life at some point in time.

Step 5 – When do we need to do it?

Estimates were made regarding the service life of the various asset components. Using the actual performance of the municipal assets and research information, the following service life estimates were used in the sustainability model:

COMPONENTS		**EXPECTED SERVICE LIFE**
Central Water Supply System		
Water mains		100 years
Water Services		100 years
Hydrants		100 years
Valves		100 years
Water treatment plant, pumping stations	Structural components (concrete structures, buildings, etc) 70% of total	75 years
	Mechanical / electrical systems 30% of total	25 years
Reservoirs	Structural components	75 years
	Repainting (towers)	15 years
Central Wastewater System		
Sewers		100 years
Manholes		100 years
Water treatment plant, pumping stations	Structural components (concrete structures, buildings, etc) 70% of total	75 years
	Mechanical / electrical systems 30% of total	25 years
CSO Storage Tanks	Structural components (concrete structures, buildings, etc) 70% of total	75 years
	Mechanical / electrical systems 30% of total	25 years

Step 6 – How much will it cost?

Based on the service life estimates, life-cycle cost profiles were developed for each system component by mapping the service life estimates and the four (4) primary cost events identified below:

Minor Maintenance is an annual cost event. Hamilton budgeted for this on a regular basis at the rate of approximately 0.5% of the value of the assets. This was compared to empirical formulae established by AWWA in a recent study and found to be comparable.

Major Maintenance is an annual cost event. The AWWA empirical formulae were applied to Hamilton's water system yielding an investment level of 2.4% of the replacement value of the water system. Sewers were estimated to be slightly above that of water and as a result, a combined O&M estimate of 2.5% of the total water and wastewater inventory value was identified for the model. This figure combined the minor and major maintenance costs. Since the minor maintenance was determined to be 0.5%, the major maintenance cost event, on an annual basis, was the balance of the overall O&M estimate. This was 2% of asset value.

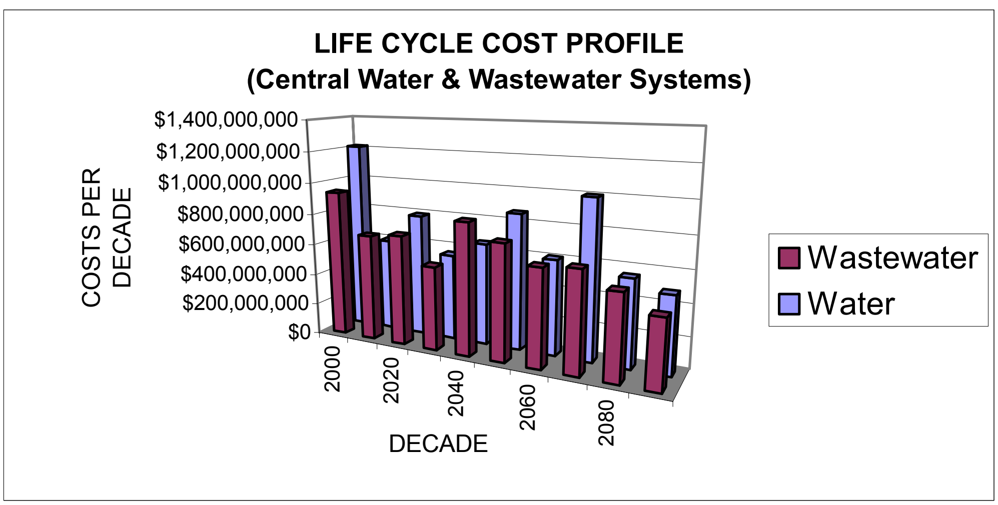
Rehabilitation estimates, for purposes of the study were determined, as a one time cost event as a percentage of asset value (or replacement value) as follows:

- Water system rehabilitation investment of 60% of the water system replacement value occurring at two-thirds of the full life expectancy.
- Sewer system rehabilitation investment of 75% of the sewer system replacement value occurring at three-quarters of the full service life.

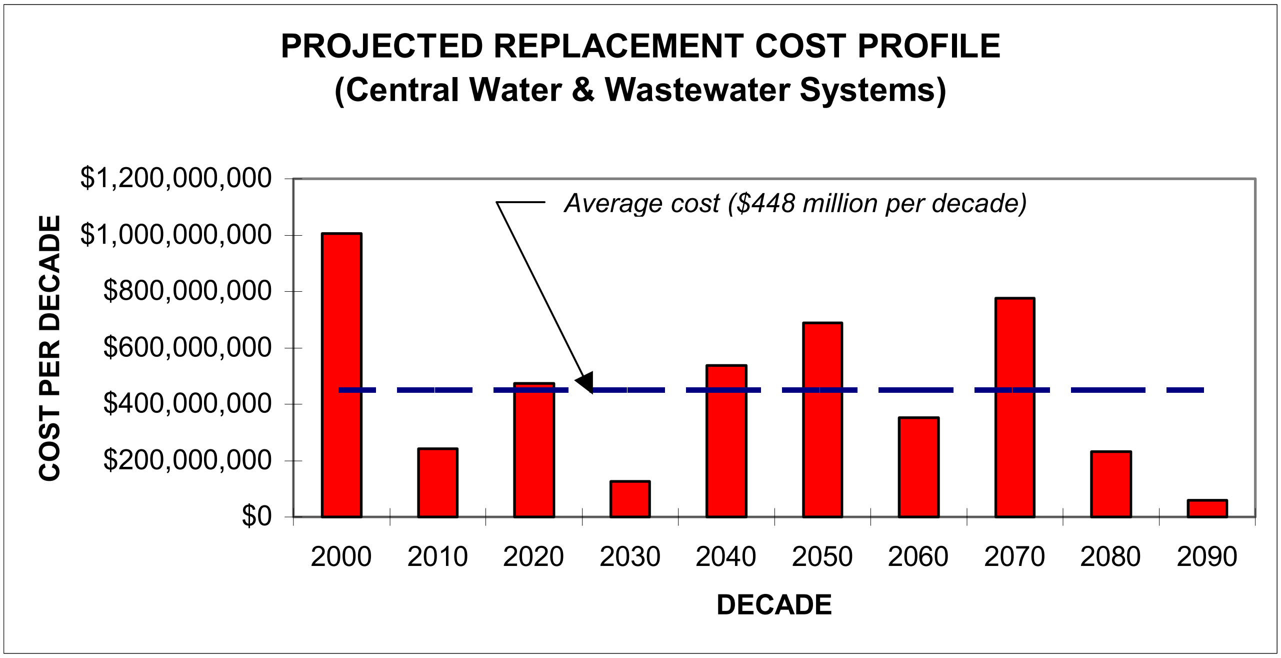
Replacement costs are equal to100% of the asset value, assuming current construction dollars.

When the individual component cost events were combined, a life-cycle cost profile was developed for the overall system. This cost profile was representative of the inherent characteristics of the water and wastewater systems. It can be presented in a variety of ways, providing a different perspective or representation of the asset for purposes of financial planning, design and program decisions, policy development, and related strategic planning activities.

The chart below is the life cycle profile representing Hamilton's water and wastewater systems individually on the same chart for comparison purposes.



The same information can be shown individually, combined and in any format that helps understand the investment needs and financial planning required to sustain the systems. Below is a chart showing only the "replacement" component of the combined water and wastewater systems. This is an informative representation indicating that the existing water and sewer systems, apart from new or growth related investments, requires an annual average investment in the replacement program of approximately $448 million per decade over the next 100 years.



This chart reflects the fact that Hamilton's water and wastewater infrastructure is a mature system, having been in existence since the mid-1800's and has expanded over the years. This is reflecting high replacement costs in the first decade (i.e. backlog in the replacement program). Lower values in the second and fourth decades probably reflect the impact of the first and second world wars and subsequent decades highlight the post-war boom. As a result of this assessment, the average annual investment required over a 100-year life cycle to meet Hamilton's replacement program needs is estimated to be $44.8 million. Even in those periods when the system demands are less than this average, a strategy of building reserves can be planned to ensure financial resources are in place when demand exceeds the average. This is the start of sustainable strategic planning that will minimize significant financial problems in years to come.

The City of Hamilton's asset management strategy is based on an aggressive, coordinated re-investment strategy where the right dollars are invested at the right time and on the right piece of infrastructure. The sustainable asset management process is an essential tool in successfully implementing this program and achieving these goals.