RESIDENTIAL AND
CIVIL
CONSTRUCTION
ALLIANCE OF
ONTARIO

RCCAO

Constructing Ontario's Future

Water and wastewater asset management in the GTA

Challenges and opportunities

Tamer E. El-Diraby, PhD.
Associate Professor, University of Toronto
July 2007

The Residential and Civil Construction Alliance of Ontario has commissioned two complementary reports related to water and sewer infrastructure:

1. Water and wastewater asset management in the GTA: Challenges and opportunities by Tamer E. El-Diraby, University of Toronto, Department of Civil Engineering

2. Financing Water and Sewer Systems in the Greater Toronto Area: What Should be Done? by Harry Kitchen, Trent University, Department of Economics

It is our hope that these reports will stimulate debate on ways to increase investment in vital water and sewer infrastructure not only in the GTA but across Ontario.

The RCCAO is an alliance composed of management and labour groups that represent all facets of the construction industry. Its stakeholders stem from the residential and civil sectors of the construction industry, creating one unified voice. The RCCAO's goal is to work in cooperation with governments and related stakeholders to offer realistic solutions to a variety of challenges facing the construction industry.

RCCAO members and contributors are:

- Metro Toronto Apartment Builders Association
- Toronto Residential Construction Labour Bureau
- Heavy Construction Association of Toronto
- Greater Toronto Sewer and Watermain Contractors Association
- Residential Low-rise Forming Contractors Association of Metro Toronto & Vicinity
- LIUNA Local 183
- Residential Carpentry Contractors Association
- Carpenters' Union
- Ontario Concrete & Drain Contractors Association
- Toronto and Area Road Builders Association

For more information, visit www.rccao.com

Executive Summary

The health of our water and wastewater assets are integral to human safety and health. These are not just major infrastructures systems; they are our civil "lifelines". Fortunately, water and wastewater assets (WWA) are no longer viewed as just physical facilities supporting public health and economic activity; they are now viewed as a critical part of the global market of environmental goods with major impacts on sustainability. Consequently, WWA span three major spheres: public services, industrial commodities and ecological management. The management of WWA has to assure the delivery of the public service, recognize the commodity potential, and promote sustainability.

Having been historically controlled by governments, WWA domain has the potential to be marred by politics at the expense of public policy. The result is an imperfect industry characterized by: deteriorating systems (due to years of deferred maintenance), ad hoc finance, lack of long-term plans, technical and administrative inefficiencies, layers of bureaucracies, and overlapping, if not conflicting, regulations, weak or no competitiveness, limited and scattered R&D, incoherent data models and performance measures, and almost complete disassociation from customers and their needs.

In managing WWA, municipalities are facing demands for higher costs due to increased urbanization, historically deferred maintenance, land use and urban development styles. At the same time, income is not slated to increase due to anticipated conservation and the limitation on full cost pricing. The utilization of asset management practices and technologies is a must to deal with such challenges. This includes using better standards for design, long-term planning, embracing life cycle costing and effective use of performance measures (including collection and management of performance data). However, technology and information systems alone are not enough. What is really needed is a government-led initiative to promote a reliable and effective industry structure for WWA. This can be accomplished with the following tools:

3. National policy for WWA: defining national goals, benchmarks, and standards for managing WWA.

4. Effective governance scheme: assuring accountability, transparency, coordinated planning and close alliance with all stakeholders.

5. Sustainable funding mechanisms: clearly identifying funding sources in a stable long-term fashion and aligning funding with service levels and sustainability performance.

6. Advanced asset management and information systems: collection, analysis and use of performance data, and integrating sustainability and life cycle costing in design, operation and maintenance practices.

Main Findings and Recommendations

1. **Asset management culture**: Several aspects of asset management practices are being implemented in water and wastewater systems in the GTA. However, such efforts lack the required depth and coherence proportional to the problem at hand. Asset management is not just a valuation of assets, estimation of deficit, or the establishment of inventory databases. The true implementation of asset management includes a cultural change that promotes a proactive organization-wide system for life cycle management of assets to deliver services to the customers and optimize their engineering, economic and environmental performance. The realization of asset management as a cultural change is at the early awareness stage in the GTA.

2. **National asset management policies**: A major reason for the lack of adequate asset management culture and practices in the GTA is that the domain of infrastructure management, especially governance and funding, is marred with politics and very little policy. There is a need for the establishment of long-term sustainable national and provincial policies to preserve and manage our assets. Such policies should be developed based on best practices and thorough consultation with the public and professionals to shield them from the short-term orientation of local and national politics.

3. **Accountability and transparency**: The governance of assets should remain local. However, it should be accountable and transparent. Municipalities have to be held to a clear set of standards and contribute minimum levels of performance in regards to the management and planning of their assets.

4. **Collaborative sharing of knowledge**: While legislation is the cornerstone of any accountable/sustainable asset management policy, it is not enough and could have negative impacts if it is not combined with a concerted effort to embed asset management knowledge into the organizational culture of municipalities. Any legislation should be limited to identifying the major performance measures and the responsibilities for achieving them. Governments should complement any legislation by leading a collaborative effort to develop and share knowledge about asset management. This is needed given that asset management is a cultural issue before being a technical one; the gap is relatively large and municipalities need support in this regard. Given that asset management practices and systems are almost identical in all municipalities, it makes sense that senior governments should lead municipalities to pool resources in establishing and sharing asset management systems. This may include common data standards, common deterioration models and a knowledge base for cases and decision making practices.

5. **Grants and public funding**: government grants have been recently criticized due to the belief that they replace (not increase) municipal investments and the perceived inefficiency that they may promote. Consequently, government funding should be tied to agreed performance achievements at the local level and the existence of long term and adequate plans for asset management. Capital spending is not believed to realize/achieve adequate return on investments. Some of the best areas for government funding include: R&D, development of common asset management software systems and best practices, training and education, support for the development of long term plans, audits and evaluation assessment, public communication and engagement initiatives.

6. **Municipalities should lead**: While federal and provincial governments are required to foster the spread of asset management culture and policies, a fundamental change is required at the municipal level. GTA municipalities should lead the drive for an asset management culture by pooling their expertise and resources in a local initiative that benchmarks the best practices and establishes a clear vision for the future of WWA. This should include holding themselves to clear and relevant performance measures, identifying goals in terms of governance, accountability, transparency, responsibility, environmental and engineering standards and customer rights and service levels. They should, consequently, define the role and resources federal and provincial governments have to provide.

7. **Private sector**: the responsibility for asset management is not limited to the public sector. Private sector, especially the construction industry, has a major role to play. This includes acquiring expertise and knowledge in asset management, development and use of best practices to build more resilient and sustainable infrastructure systems, adaptation of advanced information technology systems to document and communicate initial data about assets in a more accurate manner.

Contents

Introduction

Asset management relates to the efficient, long-term management of civil infrastructure systems to optimize their performance from engineering, economic and environmental perspectives. Asset management is a sustained systematic process of designing, operating and maintaining assets/facilities effectively. It streamlines decision making through the life cycle of an asset to provide the best value to system users and an optimum budget performance. The practice of asset management gained momentum in the last two decades in the realization of the pressing need to preserve our infrastructure, which is deteriorating at an increasing rate. Asset management is tied to a "best value" and "service delivery" model which encompasses the following paradigms (Victoria Dept. of Treasury and Finance, 2000):

- Service delivery: addressing the social, environmental, and economic needs.
- Life cycle approach: assessing the operating and maintenance requirements, and the implications of eventual replacement or retirement of assets.
- Integrated approach: coordinating the management and service delivery, across all assets and all governmental departments and agencies. This looks beyond stewardship of individual assets and examines the total asset base during decision making.
- Accountability for asset investment: Requiring greater transparency and quality in reporting arrangements.

Efficient long-term planning is the starting point of asset management. This includes assuring that, on a regional scale, any new infrastructure is adequately scoped to fit in the existing and planned socio-economic fabric of the local community. This includes consideration of environmental, social and economic aspects of any new infrastructure. In addition, this also includes analysis of the best means to design, construct and operate the new facility. This normally includes selecting designs that minimize not only direct cost but also operation and maintenance costs.

Asset management is based on the use of performance indicators to make decisions about the operation, maintenance and rehabilitation of existing assets. This includes a complex decision making process which involves the following tasks:

1. Determination of deterioration levels: using statistical or simulation based systems to assess the status of infrastructure including the risks associated with current and future status.
2. Cost estimation: estimation of rehabilitation or replacement costs and comparing them with costs associated with the risks.
3. Decision optimization: allocating traditionally limited budgets to assets based on their needs and based on an integrated analysis of the interrelationship of assets and the overall impacts on their performance, sustainability and service levels.

Asset management is not about data collection or software systems only. It's an organizational culture.
The major barriers for establishing such culture are human attitudes, complacency with status quo, and lack of leadership.

While asset management covers the whole life cycle of an infrastructure, the real challenge of asset management exists during the operation stage of the life of a facility. Municipalities have to keep consistent data about the location and status of existing assets. The management of such data is challenging due to various reasons, including:

4. The nature of infrastructure systems: much of the infrastructure systems are buried underground which makes it hard to assess their status.
5. Nature of data: in many cases, there is no agreement about which data to collect, the relevance of certain data to measuring performance, and the subjectivity of data in some cases.
6. Costs: in many cases, establishing a sound system for data collection and performance measurements could be expensive, especially in large agencies or where there has been no history of consistent collection of such data.
7. Training and human factor: qualified personnel are the cornerstone of any effective asset management program. Shortages of such staff could be a major deterrent to effective asset management implementation.

An Asset Management system should include:

- Strategic goals
- Inventory of assets (physical and human resources)
- Valuation of assets
- Quantitative condition and performance measures
- Measures of how well strategic goals are being met
- Usage information
- Performance-prediction capabilities
- Relational databases to integrate individual management systems
- Consideration of qualitative issues
- Links to the budget process
- Engineering and economic analysis tools
- Useful outputs, effectively presented
- Continuous feedback procedures

Source: FHWA (2003).

Study objectives

The study stems from the understanding that collaboration between public agencies, private enterprises, NGOs and researchers is the hallmark of modern policy making. The study is carried with an independent, open-minded attitude and with a spirit of collaboration. The aim is to develop an understanding of current status of water and wastewater asset management practices, challenges and opportunities in GTA.

It is important to point out here that this study starts from the recognition that Canadian municipalities (and in particular municipalities in the GTA) have had extensive expertise and achievements in the domain of this study. Some of this work is being benchmarked by other countries and is on the leading edge of innovative and effective practices in the domain. Within this scope, the study aims at reviewing and documenting current practices, as well as exploring further opportunities for progress in order to use the expertise and existing systems to further support a sustainable and effective management of GTA infrastructure. The study focuses on two main thrusts that are essential to proper management of WWA:

1. Governance: the governance scheme of municipal infrastructure is the backbone for effective decision making and planning for asset management. Governance schemes define decision powers, decision criteria, accountability and transparency guidelines, and influence the speed and efficiency of the decision making and management processes.
2. Asset Management Practices: while governance deals with decision making and leadership aspects of infrastructure management, this thrust focuses on the actual technical and managerial practices for managing the assets including business processes, personnel, and software systems engaged in the design, operation and maintenance of assets.

In both thrusts, the study attempted to deliver the following:

1. Assessment of current status: this includes identification of systems currently used, challenges, best practices and opportunities for capitalizing on the progress made so far.
2. Benchmarking best practices: analysis of best practices from other countries and jurisdictions that could help enhance asset management practices in GTA.
3. Development of general policy options: development of relevant suggestions for policy/implementation options that could have positive impacts on the management of water and wastewater assets in GTA.

Asset management issues

Effective asset management in GTA is faced with several challenges. These include:

Physical Situation:

It is a known fact that some of the worst levels of decline in the Canadian infrastructure systems have been reported in water and wastewater systems (Infrastructure Canada 2004). A survey by McGill University established that 59% of the water distribution networks and 43% of the water supply systems were in unsatisfactory condition in 1995. It is believed that the condi-

tions of such systems in major/older urban areas (such as Toronto) are even worse. For example, 20% of all water mains in Toronto are more than 80 years old.

Consequently, the rate of leaks has more than doubled over the last three decades. Traditionally, leaks have been portrayed negatively due to their impact on revenue. The impacts go even further, including energy waste (bumps have to work harder to deliver services), associated green house gas emissions, engineering implications (in terms of maintenance timing), and capacity extension impacts due to lost revenues and increased operational costs (Colombo and Karney 2002). However, an increasingly important impact is the interruption to traffic and business activities.

The overall investments in infrastructure reached about $11 billion in the late eighties. Eighty percent of this was used for new construction. Only 20% was allocated to the rehabilitation of deteriorated infrastructure. This lack of attention by all levels of government has led to the current unacceptable deteriorated state of Canada's infrastructure (Mirza and Haider 2003). New investments in public infrastructure have not kept pace with economic growth: from 1971-2000 public infrastructure capital per capita grew at 0.9%, about half the rate of the productivity of public infrastructure capital (GDP per unit of public infrastructure), therefore population growth and economic growth are combining to increasingly overburden Canada's stock of public capital infrastructure (Infrastructure Canada 2004).

Demographic Situation:

Large cities are faced with ever increasing budget pressures to meet the demands of developing and maintaining adequate physical and social infrastructure. This is mainly due to the rising value of human resources in new economy production; the growing concentration of these resources in urban centres; the increasing diversity (socio-economically, racially, culturally and religiously) of these urban populations; and the fact that responsibility for accommodating and welcoming this diversity have fallen largely to local governments (Clutterbuck and Novick 2003).

Two-thirds of Canada's population, employment, and real output are located in 27 Metropolitan Areas. The GTA is one of the fastest growing regions in North America. GTA is the largest housing market in Canada, representing 55% of new home sales in Ontario and 25% of new home sales in Canada (TD 2003). The increased urbanization means that most of our infrastructure will be rehabilitated in heavily congested areas. This has major impacts on the direct and indirect costs of projects. Construction activities have to be weaved in congested neighbourhoods to mitigate impacts on already gridlocked traffic and local businesses.

In general, the average national rate of urbanization in Canada has not changed significantly in the past half century, but the rate of suburbanization has changed substantially and is changing Canadian cities into city-region states (TD 2003). In many cases this has shifted population from downtowns into the suburbs, with a substantial increase in infrastructure budgets. However, Toronto represents a unique situation, where, due to increased concentration of new immigrants, both the downtown and the suburbs are seeing significant growth.

The price of water in Canada is one of the lowest in the developed world (Infrastructure Canada, 2004b). However, the ability to increase prices is limited. Canada's population is aging at higher rates. A good proportion of this segment of society is living on fixed income with a high sensitivity to rate increases. Additionally, immigration is on the rise and many of the new comers also have high sensitivity to rate increases.

Sustainability Concerns

Society is becoming more savvy regarding environmental and health issues. In general, the public recognizes the linkage between additional investments necessary to mitigate or reduce environmental impacts. On the other hand, a segment of the population demonstrates major resistance to new projects, which makes the community consultation and EA assessment lengthy and expensive. Although this tension exists, the public is increasingly demanding higher quality water for consumption.

There is also a social and political push for conservation. Currently, the per-capita water consumption in Canada is one of the highest in the world, second only to the US (Infrastructure Canada 2004b).

Infrastructure Interdependency

Recent events such as the blackout of 2003 have highlighted the interdependency between infrastructure systems. Events like those that took place in Walkerton are raising the bar on assuring safe, secure and reliable performance of infrastructure systems. This is adding significant costs to the operation budgets of many municipalities. This is slated to even increase further given the deterioration of infrastructure systems.

Budget Situation:

Urban centres are slated to face even further budget pressures due to a set of factors:

- Increasing costs: infrastructure development/ rehabilitation costs are going up because of urbanization, deferred maintenance, and the increasing demands for enhancing the environmental and health aspects of water and wastewater.
- Dedicating funds to metering: to achieve fair pricing and to encourage conservation, municipalities have to increase the rate of water metering. Installing such meters will require dedicating budgets.
- Decreasing income: even though Canada has one of the lowest water prices, the ability to increase prices is limited due to the demographics and the anticipated decrease in total sale due to the impacts of full cost pricing. As conservation efforts continue, municipalities will sell less water. The implementation of full cost pricing is poised to lower consumption too. For example, in New South Wales, Australia, the move to a pay-for-use regime in 1982 has resulted in a sustained reduction in overall water consumption, around 24% (WRIC 2006).

In the mean time, land use policies have traditionally favored a low-density style of development, which inherently costs more money.

In short, municipalities are facing demands for higher costs due to increased urbanization, historical deferred maintenance and land use and urban development styles. At the same time, income is not slated to increase due to anticipated conservation and the limitation/impacts of full cost pricing.

While the need for funding is increasing, the financing of WWA is characterized by two main features:

1. lack of proper funding: many municipalities and national studies have documented a substantial deficit in infrastructure funding
2. ad hoc nature of funding mechanisms: there is currently no stable long-term policy for funding.

Traditional financing mechanisms are insufficient, forcing governments to experiment with new financing mechanisms. Over the past few decades, all levels of government in Canada have increased their reliance on debt servicing for infrastructure investments. The Canadian federal government, which once relied primarily on transfers to provincial/territorial governments and/or municipalities for infrastructure financing, has expanded its repertoire of financing methods because transfers are no longer sufficient to meet the rising costs of maintaining and rehabilitating deteriorated infrastructure. Municipalities also increasingly rely on innovative financing methods because in addition to insufficient revenues to meet infrastructure needs they are confronted with increasing responsibilities off-loaded by federal and provincial governments (Infrastructure Canada, 2004b).

Local government revenues are not increasing at the same rate as federal and provincial government revenues. Between 1995 and 2001, local government revenues increased only 14% compared to federal government revenue increases of 38% and provincial revenues of 30%. At the same time, federal and provincial governments continue to download responsibilities to local governments. In contrast, cities in Europe and the U.S. have received more help from senior governments and have benefited from a wider range of financing options. One of the main issues is property taxes, which should be more closely related to the costs of delivering services (Infrastructure Canada, 2004b).

Appendix A provides a summary of some of the international best practices and benchmarks in the domain of asset management.

New trends in infrastructure systems

A Public Service or Industrial Commodity: Traditionally, water and wastewater are viewed as mostly public services provided by the government for its

citizens—as they represent the minimum human necessities and are a major element in public health. Consequently, the argument was made that water and wastewater pricing should be affordable—especially for those who cannot afford it. This is true. However, not all the modern elements of water and wastewater products fall under the "service" mantel. Many of the users of water and wastewater are industrial facilities. Such users should pay the full cost of the "product" that they use. It should be noted that while some of the industrial users are the sources of some of the worst polluted wastewater, substantial progress has been made in recent years to reduce the amount of such wasted water and reduce its negative impacts.

Traditional vs. new assets: Over the last three decades or so, water and wastewater infrastructure has been recognized as a national "asset" that needs to be managed well to preserve its function and value. Assets have traditionally meant the physical infrastructure used to produce and distribute clean water to users, and collect and discharge wastewater. However lately, because of environmental and social needs, municipalities also had to manage additional assets: storm water drains and whole water basins.

Old products vs. new products: recent social trends are impacting water and wastewater market. Many individuals are environmentally savvy and support conservation, which ranges from less use of water to use of recycled water. However, some of the cultural norms are contradicting such trends. Take for example the social and economic value of backyards in our society, which dominates our landscape. Such facilities consume considerable amount of very clean water. Eradicating such element of landscape will be hard and could have negative cultural and environmental impacts. There exists, at least theoretically, a market for new products that could balance the needs of both water conservation and such cultural norm. For example:

1. Sell technology to capture and re-use some of the "grey water" produced at our homes for garden use.
2. Sell technology to capture, store and use rain water to water gardens.
3. Sell "gray water" produced at wastewater stations or collected through storm water drains to water gardens.

Assets—the engineering vs. financial views: The engineering perspective of assets focuses on optimizing its performance and value over its economic life. The more traditional, financial perspective views assets as a means to attract investments. Recently, this has meant privatizing some or all of such facilities (most notably in this regard are the examples of UK and France). However, privatization initiatives for water and wastewater in Canada have been met with much resistance, and adequately, skepticism. Irrespective of the stand on privatization, two private-sector paradigms must be explored in the domain of water and wastewater management:

Management Style—A Private-Sector spirit: water, wastewater and related products and services are public services and industrial commodities. A minimum set of principles have to prevail:

- Accountability
- Transparency
- Long term planning
- Business efficiency
- Customer orientation

Use assets to attract investments: One of the main features of WWA is the reduced risk on investments. The risk profile on investing in water and wastewater systems is enhancing—especially with proliferation of "full cost pricing". Recently, pension funds have been very interested in acquiring such low-risk "assets". While this is not a call for or against privatization, any rational decision maker should realize and exploit the "value" that exists in WWA without jeopardizing public policy demands. For example, if we establish a market for grey water this can be sold to private entities without impacting the clean water part.

If we further separate the storm water assets from the other assets, this can be sold to private entities to collect such water and resell grey water to homes or industrial facilities. Selling is not the only option in this regard. The private sector can simply operate such facilities. Revenues from such operations can be used to further fund the "public" assets.

The establishment of infrastructure banks could be a way to attract private funds, especially pension funds, to invest in municipal WWA. This idea draws

on the apparent success of infrastructure banks and trusts used in the US, mainly, for transportation funding. Such banks are funded by the Federal Government to offer municipalities low-interest loans for funding environmentally-compliant projects. The advantage is that municipalities can deal with banks in a business-like environment. It is perceivable that pension funds could be interested in investing with these banks—providing more private funds to be used by semi-public banks to fund public utilities.

Public Infrastructure Banks allow for a professionally-run organization to manage public and private money to finance infrastructure. Such organizations would have rules of actions that are different from regular banks to take into consideration public safety, security, environmental stewardship and optimization of public investments on the long terms—most probably on the same lines of the World Bank model in terms of governance. They can conduct professional studies on the efficiency of their investments and fund management, the prediction of taxes and other federal grants and issue an unbiased, yet business savvy, report on the annual status of our investments in infrastructure answering questions such as: how are we doing? Where are the problems? What are the ROI's? and how successful have we been, as a society, in exploiting the value in our assets while preserving the environment and within the publicly acceptable levels of financial risks.

A model for urban asset management

Asset management is not just a "maintenance program". Rather, it is an organizational culture that leads business decision making, and policy direction of an agency.

Three core dimensions are at the heart of asset management systems (see Figure 1):

1. Performance: the essence of asset management is a focus on optimizing the performance of infrastructure. Performance encompasses, generally, three domains:
   a. Engineering Performance:
      i. the physical status of infrastructure
      ii. the safety performance of infrastructure
      iii. the sustainability performance of infrastructure
   b. Service Performance:
      i. Level of service
      ii. Customer satisfaction levels
   c. Managerial efficiency:
   d. Financial efficiency: how money and budgets are allocated and managed to promote enhanced performance
      i. Process efficiency: how processes are managed to reduce waste, enhance communication, and optimize work

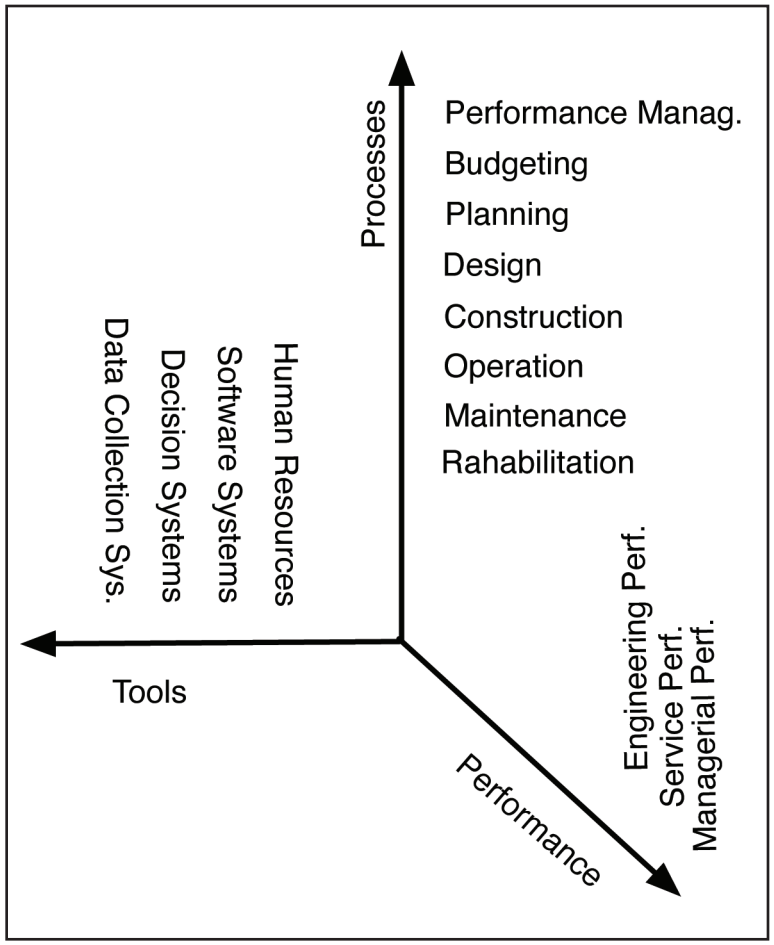

Figure 1: Three Dimensional Model of Asset Management

2. Life Cycle Management: traditional views of asset management limit its domain of application to the operation and budgeting processes. In fact, the cornerstone of any asset management system is an attention to integrating performance

optimization throughout the project life cycle and across projects. This spans the following processes:

a. Performance Management
   i. Data collection: the first step is to consistently collect reliable and relevant data about the current status of performance as described above.
   ii. Performance assessment: using the data collected to assess the current status, deterioration levels, and risks associated with existing systems. This is normally carried out via statistical or simulation models.
b. Budgeting: asset management principles should guide the allocation of funds to infrastructure systems including emphasizing preventive maintenance, efficient operation and adequate replacement.
c. Planning: planning infrastructure systems to assure the integration of asset management principles into the scope of new construction and/or any rehabilitation.
d. Design: directing design specifications and scope to incorporate strong attention to life cycle performance assurance.
e. Construction: enforcing quality standards on materials and workmanship and planning construction work to reduce impacts on the environment and on local communities. This also includes adequate documentation of as-builts as the starting point in collecting data about the project.
f. Operation: consistent and quality collection of data, periodic analysis and monitoring of structure performance and the levels of customer satisfaction.
g. Maintenance: organizing preventive maintenance in coordinated and timely manner.
h. Rehabilitation: proactive replacement of structures to guarantee system vitality and delivery of services.
i. Communication: effective communication of asset management principles and work plans to relevant stakeholders and training of staff.
j. R&D: analysis of performance trends and the impacts of various factors on the overall system performance.

3. Asset Management tools: a set of asset management tools/resources are used to support the conduct of each process. These can be categorized as follows:
   a. Data collection tools: Three main categories have been identified for data collection methods:
      i. Manual: data collected through human observation, by the aid of manual/small instruments/tools, or surveys.
      ii. Automatic: data collected through the use of sensors, videos and other smart/automated instruments.
      iii. Simulation/Modeling: data produced/interpolated/extrapolated based on simulations models.
   b. Information technology and software systems: tools and systems to analyze trends, study alternatives and support the decision making
   c. Decision making systems: means for optimizing decisions, decision criteria, and the engagement of relevant stakeholders in the process.
   d. Human Resources: the key tool in implementing asset management is trained, well informed personnel who can lead the process in an integrated and efficient manner.

The process of asset management works as follows: First, performance expectations, consistent with goals, available budgets, and organizational policies, are established and used to guide the analytical process, as well as the decision-making framework. Second, inventory and performance information are collected and analyzed. This information provides input on future system requirements (also called "needs"). Third, the use of analytical tools and reproducible procedures produces viable cost-effective strategies for allocating budgets to satisfy agency needs and user requirements, using performance expectations as critical inputs. Alternative choices are then evaluated, consistent with long-range plans, policies, and goals. The entire process is reevaluated annually through performance monitoring and systematic processes.

Source: FHWA 2003

The advantages of asset management

Using asset management as the basis of agency plans and project development has a set of advantages. Municipalities have realized that an effective asset management program as one reason they were successful in competing for additional funding in such an institutional environment (FHWA, 2005). An effective asset management program always conveys a sense of strong stewardship of assets to elected officials, public, and to other stakeholders (such as contractors, business owners and investors). Other advantages of implementing asset management include (Queensland Treasury, 2003):

- Document an agency's needs for asset resources.
- Improve analysis, planning, and monitoring of recurrent expenses by adopting a whole-of-life costing approach when procuring new asset resources.
- Improve the alignment of asset resources with output production requirements.
- Highlight the risks associated with asset resource acquisition and control.
- Encourage the examination of options for delivering services (capital investment, capital grants, and private-sector involvement).
- Foster a proactive planning culture of anticipating future asset requirements, which will minimize the risk of not providing needed services.

Hunter Water Corporation reported significant savings in real terms between fiscal years 1990 and 2001: a 37% reduction in operating costs; improved service standards for customers, as measured by such factors as water quality and the number of sewer overflows; and a reduction of more than 30 percent in water rates for customers. 13 Hunter Water officials believe that they achieved these efficiencies as a result of asset management.

Source: GAO 2004

Asset management strategies and policies

The implementation of asset management system can only be effective if its principles are entrenched in the business culture of the organization. A scan by the FHWA (Federal Highway Administration, 2005) concluded that in "successful asset management implementations asset management practice has been occurring over at least 10 years and is continuing to evolve. Continuity in agency leadership and long-term organizational commitment to asset management as a business process were apparent in each case". Specific observations from the scan include the following:

- Top-level agency commitment: this includes leadership sponsorship at the very highest levels.
- Cultural changes and process reengineering are key for success and a key challenge. Developing an asset management culture in an organization does not have to be delayed until the database information systems are developed. Agencies can start with modest efforts and evolve over time into a more comprehensive approach.

In addition, successful asset management programs are normally associated with relevant organizational structures and strategies including (FHWA, 2005):

- Line of Responsibility: assigning clear lines of responsibilities for asset management tasks is very important. Implementing asset management does not require dramatic changes to the organizational structure. Agencies can adapt asset management principles and tools to the organizational context.
- Changes to contracting strategies, including a strong commitment to asset management practices in maintenance contracts (especially if they are completely outsourced) and in any public private partnership.
- Partnering with other stakeholders: In some cases (e.g., New Zealand and England), very active asset management professional associations and user groups, spearheaded by local officials, have developed asset management materials and training programs aimed at both public offi-

cials and practicing transportation professionals.
- Communication: efforts should be made to reach out to public officials, the general public, to convey the importance of an asset management policy.

Asset management processes

Asset management should be strongly linked to planning and system operations at all stages of the facility life. This should start at the strategic planning stage. Asset management efforts are best achieved when they are linked to strategic goals and desired outcomes. Throughout the project life cycle, cross-functional teams, consisting of engineers, planners, finance analysts, operations staff, and communications experts, can serve as the best means of understanding the many aspects of asset management, such as data collection, strategy development, and quality assurance.

A considerable number of agencies limit the application of asset management to monitoring conditions and then planning and programming their projects on a "worst first" basis. Existing management systems typically function at the operations level and focus on one particular asset. The current approach to asset management in general, and resource allocation and investment analysis in particular, is tactical rather than strategic. Successful asset management include the following steps:

- Setting strategies and standards
- Recording the asset
- Identifying maintenance needs
- Prioritizing and managing maintenance needs
- Managing work programs and outcomes
- Influencing maintenance through design
- Measuring performance
- Innovating and developing

The concepts of asset management should be used to guide decision making at the design, construction and operation of assets including (Victoria Dept. of Treasury, 2000):

- Defining desired levels of services in consultation with the community, and matching these with assets that enable the services to be delivered
- Adopting a life cycle approach to planning asset investment and management decisions
- Balancing competing needs across all government functions and selecting options that best meet desired government outcomes
- Monitoring, evaluating, and improving service delivery
- Managing the risks of asset ownership/operation to ensure continuity of service
- Providing for present needs while sustaining resources for future generations
- Adopting a continuous improvement approach to asset management policies and practices

Performance measures

Asset management is a process centred on performance. Target performance or objectives are established for each asset and also for processes. A set of indicators are then established to measure the level of achievement of such performance. Consequently, a gap is established between the existing situation and target situations. The comparison of existing gaps against the strategic agency goals, and the most cost-effective improvement strategies are then identified. Performance measures used most often include those relating to physical condition as it relates to achieving reliable and safe levels of services. For example:

- Engineering Performance: physical (structural health) and operational conditions of an infrastructure asset.
- Serviceability: customer satisfaction, reliability and quality of service.
- Sustainability: impacts of the infrastructure asset on economical, social and environmental conditions in the surrounding area (such as overall pollution levels, general health indicators, and energy use).
- Finance: financial performance of an infrastructure asset, including solvency, profitability, value and life cycle cost.
- Safety: safe operation of infrastructure assets as it relates to the safety of the general public and the personnel operating the asset.

Indicators should focus on outcomes achieved rather than action taken. Some of the features of good indicators include:

- Consistency in definitions and methods of measurement is essential to ensure results can be analyzed and compared over time.
- Simplicity should be as highly valued as reliability. Complex approaches are expensive and often need a high level of expertise.
- Indicators should be explicit in their format and expressed as a percentage, ratio, or some other numerical format.
- Indicators should be underpinned by an information system that enables the information required by the indicator to be readily available.

Asset management tools

Data collection

Collecting data about capital assets is the first step in building an asset management system. An inventory of an organization's existing assets includes 1) descriptive information about the assets, including their age, size, construction materials, location, and installation date; 2) an assessment of the assets' condition, along with key information on operating, maintenance, and repair history, and the assets' expected and remaining useful life; and 3) information on the assets' value, including historical cost, depreciated value, and replacement cost. According to the Association of Metropolitan Sewerage Agencies the following types of data are normally collected:

- age, condition, and location of the assets;
- asset size and/or capacity;
- valuation data (e.g., original and replacement cost);
- installation date and expected service life;
- maintenance and performance history; and
- construction materials and recommended maintenance practices.

Information Technology and Software

Asset Management is a data-intensive process, with information management at the centre. However, Asset Management requires much more than collocating a collection of asset data. Managers apply analytical techniques to identify significant patterns or trends in the data they have collected on capital assets; help assess risks and set priorities; and optimize decisions on maintenance, repair, and replacement of the assets. In this context, increasingly sophisticated software is being implemented along with complicated analytical applications. These tools provide a means of communicating the importance of infrastructure investments to the public and politicians. Adequate information architecture is needed to integrate databases and analytical tools and communicate such information to relevant decision makers in a universally comprehensible form. Among other things, the organization's databases should be fully integrated; for instance, financial and engineering data should be compatible, and ideally each asset should have a unique identifier that is used throughout the organization. Seven steps have been identified to successful data management (Western European Road Directors (WERD) 1) determine business information needs, 2) review current situation, 3) analyze data, 4) design a data management regime, 5) develop an implementation plan, 6) establish a data management organizational structure, and 7) continually review and improve the strategy.

Major software systems that are being utilized to support information management include:

- Databases: data about infrastructure is normally collected by various agencies making it very difficult to conduct cross-agency analysis and to manage the quality and update of data.
- Risk Assessment: at the core of the decision making process is the understanding of the risks associated with any decision. Asset management systems use the concept of risk for establishing investment priorities. In this regard, what are the consequences of deferred maintenance and what are the impacts of various design configurations on the overall performance of assets? Risk assessment is also a very important tool in educating stakeholders of the benefits of asset management.

  Managers use risk assessment to determine how critical the assets are to their operations, considering both the likelihood that an asset will fail and the following consequences—in terms

of costs and impact on the organization's desired level of service—if the asset does indeed fail. Based on this analysis, managers set priorities and target their resources accordingly.
- Life cycle costing: the basic approach to program and project costing. Managers analyze life-cycle costs to decide which assets to buy, considering total costs over an asset's life, not just the initial purchase price. Thus, when evaluating investment alternatives, managers also consider differences in installation cost, operating efficiency, frequency of maintenance and repairs, and other factors to get a cradle-to-grave picture of asset costs.
- Valuation: government regulations on asset appraisal use accounting data standards that are not normally suitable for engineering analysis. Given the engineering nature of infrastructure systems, asset management systems are much more appropriate for determining asset valuation than are straight-line depreciation accounting rules (FHWA, 2005).
- Decision-Support Systems (Trade-off Systems): this includes analysis among different asset categories or among different program areas (such as maintenance, capital expansion, and capital renewal). In some cases, agencies made an effort to conduct such assessment using technical analysis. However, in most of the cases, this is done using engineering judgment, enabling appropriate risk assessment strategies to be formulated.

Decision Making

An Asset Management decision-making framework is guided by performance goals, covers an extended time horizon, draws from economics as well as engineering, and considers a broad range of assets that include physical as well as human resources. Asset Management provides for the economic assessment of trade-offs between alternative improvements and investment strategies from the network- or system-level perspective—that is, between modes and/or asset classes within modes. At the same time, it allows for the more complete comparative analysis of options for individual projects.

Asset Management should be supported by a rational sequence of steps, constituting a decision framework, including: 1) clear representation of organizational goals, policies, and budgets, 2) integrated information flow to support communication and sharing of decision parameters, and 3) technical data and models to support the analysis of decision criteria. All appropriate units within an organization should participate in key decisions to ensure that all relevant information is considered and to encourage collaborative definitions of goals and priorities. This should consider the following:

- Assessment of efficiency: levels of performance (physical and services) for agencies assets.
- Maintenance levels: the adequacy of current maintenance practices and whether they will allow the agency to meet its current and future requirements
- Future plans: what projects and actions are needed for the future including replacement of existing assets and new projects.
- Resource management: Identifying needed resources including finance and personnel.
- Clearly identify the risks and risk management plans.
- Communicating with relevant stakeholders including politicians, the public, and contractors and suppliers.
- Determining the cost of the outputs, products, and services the agency provides
- Assessing, where appropriate, the commercial competitiveness of the agency

Recent computer-based decision support systems allow agencies to perform some of the following (GAO, 2004):

- Support planning, programming, preparation, and policy research functions.
- Present relevant, reliable, and up-to-date information.
- Predict future impacts on the transport system and its users.
- Compare competing investment or policy choices.
- Consider both the infrastructure and the community.
- Allow for new work, maintenance, and upgrading.
- Provide a reliable calibrated modeling capability.
- Assess investment impacts over life cycles.
- Provide monetary and nonmonetary measures of investment effectiveness.

In the 1990s, The Louisville Water Company implemented a Pipe Evaluation Model to rank its 3,300 miles of aging pipes and water mains for rehabilitation and replacement. The utility found that two classes of pipes—those built between 1862 and 1865 and between 1926 and 1931—had the highest number of breaks per 100 miles of pipeline. Consequently, they decided to replace the pipes from those two periods. The model also showed that pipes installed between 1866 and 1925 were fairly reliable, thus these pipes were targeted for rehabilitation rather than replacement. The utility is lining the interior of these pipes with cement, which is expected to extend their life by about 40 years. The model along with other asset management tools are reported to have helped reduce the frequency of water main breaks from 26 to 22.7 per hundred miles and the frequency of leaks from joints from 8.2 to 5.6 per hundred miles.

Similarly, using asset management principles, the Sacramento Regional County Sanitation District reassessed a proposed investment in new wastewater treatment tanks and decided on a less expensive option, thereby saving the utility approximately $12 million. It was decided that increasing preventive maintenance on existing tanks would lower the risk of shutdown more cost-effectively than adding a new set of tanks. "Utility officials commented that their implementation of asset management helped change their decision-making process by, among other things, bringing together staff from different departments to ensure more complete information, and more effectively using the data to understand investment options

Source: GAO, 2004

Human Resources

An effective asset management program is mainly based on qualified personnel. A good asset management program requires knowledgeable staff capable of understanding the data-collection process and what the data means. One of the most technical challenges facing municipalities is the need for appropriately trained analysts who can translate the results of interlinked analytical processes into workable alternatives that can be easily understood by all stakeholders.

Observations from the FHWA scan include the following:

- Several agency personnel systems have created positions with asset management as a job responsibility.
- Asset management training has been an important aspect of asset management strategy in many of the agencies

Status of asset management in GTA

The study conducted an analysis of the current practices of asset management in the GTA through reviews of existing policies/programs and interviews with public officials and consulting firms. Appendix B shows the interview guide. The following represents a summary of the findings of this analysis on two major facets of asset management: governance structure (how supportive the current system is for effective asset management) and the technical aspects of asset management (the tools and software systems to implement asset management at the technical level).

Governance Schemes

Some of the highlights of the current governance structure of WWA in the GTA include:

Politics vs. Policy: At its core, asset management is a technical issue. Proven technical and managerial solutions are already available and are well established. However, many of the solutions adopted by consecutive governments were more influenced by political paradigms than by professional practices or long-term policies. Some examples in Ontario include: supporting privatization and then reverting such policy (in highways and electricity); the establishment and then dissolution of SuperBuild; passing and not enacting regulations that accompany the sustainable water and sewer legislation; encouraging all councillors in Toronto to vote on projects, those undermining some sophisticated technical aspects.

The establishment of Infrastructure Canada and the Ministry of Public Infrastructure Renewal (PIR) in Ontario are signs of positive progress. The establishment of such professional organizations to promote technical and professional management

of infrastructure is crucial towards any sustainable and optimized management of infrastructure.

Accountability and Transparency Status: Municipalities claim that they are short of money and federal and provincial governments claim that they have provided enough funds or are concerned about the lack of accountability when they fund. Construction industry and the public are weary of any calls for public private partnerships (PPP) without clear transparency regulations.

Unstable funding: It is inconceivable that in a developed country like Canada infrastructure funding continues in the current approach. Federal and Provincial governments downloaded many of their responsibilities to municipal governments without ensuring proper funding or adequate plans for management of infrastructure, particularity in smaller municipalities. Much of the effort has been wasted in debates between the three levels of government about who is responsible. Consequently, funding was provided in more political fashion. Take for example, the transfer of part of the Gas tax to cities, the various agreements between federal government and provinces to fund infrastructure and the latest call for devoting 1% of the GST to municipalities.

Lack of coordination: Various levels of governments, research organizations and non-government organizations have implemented many very relevant and valuable initiatives such as Infra-Guide and Green fund initiative. However, these initiatives lack any coordination. They are all relevant and needed but they do not add up to a national coherent implementation plan for action that puts the pieces together. Major players agree about the main issues and to an extent agree on some major and obvious solutions (at least from professional aspects). However, politically they are at odds—for example, Toronto is suing the Province to recoup about $600 million that was eliminated due to "downloading".

Decision making systems

Infrastructure decision and plans are characterized by the following:

- Lack of long-term vision: the lack of a firm and clear funding horizon and the ever changing politics related to infrastructure and urban growth has impeded the development of any stable long-term plans for infrastructure systems.
- Lack of regional perspective: In the GTA, the lack of coordinating bodies and mechanisms to integrate infrastructure plans is a drawback. Such coordination is urgently needed given that sustainability is a regional issue.
- Lengthy and complicated process: when plans are developed, their implementation takes substantial time. For example, there is a very limited consideration of the official plan during any EA review. This means repeated and lengthy procedures.

Asset Management Practices

GTA municipalities are in the early awareness stage of asset management. Their current focus is on technology of asset management—however the main challenge is to embed a true culture and organizational mentality for making asset management the main decision driver.

Fundamentally, there is a clear awareness of the need for asset management systems. However, in most cases such awareness lacks the depth of knowledge needed for actual implementation. In most cases, there is a "sort" of a program for asset management in the municipalities interviewed. However, these programs are, in many cases, a "side show". Some of the rationale given for such a situation is typical and include sentiments such as: "we already do it but not in a formal program", "we are more interested in putting out a fire now", "there is no momentum and political will/push for consistent/formal asset management systems", "there is no sufficient resources (people and money) to implement formal asset management systems". Further observations include: "we lack the know how", "available off-the-shelf asset management systems are not tested or easy to use and in many cases could require major changes in organizational decision making", "traditionally, asset management has been led by financial professional/departments—this does not suit the engineering needs and there is a need for a cultural change to blend the needs of engineers and finance personnel". Some of the municipal needs in this regard include: "we need a clear roadmap, guidelines, training and implementation tools to help rollout an asset management program—especially in smaller municipalities".

Data collection systems: the current data collection tools and systems are designed to meet the requirements of existing maintenance and operations code. In many cases, the data collected is very relevant to asset management; however, it is not sufficient. The fundamental drawbacks in current data collection systems include: large gaps in data (especially as it relates to older infrastructure and those built by smaller municipalities), and the low data reliability (in many cases data has low reliability given the insufficient resources or inadequate tools used).

Deterioration modeling & assessment: the rationale for data collection is understood by practitioners (albeit many inefficiencies), but the use of this data in modeling and estimating the current conditions of assets is still insufficient. Current systems used to deduct the level of performance of assets are rudimentary and, in many cases, very simplistic. The use of advanced deterioration modeling is hindered by the low quality of data, lack of trained personnel and, most importantly, the lack of a consistent and formal process for asset management. It was also clear that many of the existing deterioration models are not easy to implement and, in many cases, do not address the needs of users and do not demonstrate a clear business case for their use.

Planning and Design Practices: again, there is a wide awareness of the need for embedding asset management, long term planning and sustainability in the planning and design phases of the project. However, this awareness lacks implementation tools and is not embedded in the planning and design processes. In many cases, this is done on an ad hoc basis.

Maintenance & Rehabilitation Practices: lately, an increasing awareness and resources have been directed to maintenance of programs to overcome the problems created by deferred maintenance and face the challenges of an aging infrastructure. However, this is becoming a major burden on human resources. There are a large number of maintenance events/projects taking place concurrently which requires extensive coordination given the challenging work environment (traffic conditions, safety concerns and business impacts).

The increasing attention to maintenance and rehabilitation is still insufficient. Most municipalities in the GTA rehabilitate less than 1% of their WWA annually. This means that such assets will be replaced in no less than 150-200 years if the current policies are not changed. Changing rehabilitation policies (and replacement rates) is not easy. It will require substantial increase in funding/investments, fundamental change in work processes and cultures to adopt more proactive maintenance programs, coordination in the maintenance programs across departments, and enhancement in the efficiency of maintenance programs (through the use of technology and training).

Community engagement systems: the current community engagement systems are either absent or at maximum very simplistic. Other than few programs/brochures about conservation, municipalities do not have clear, formal and adequate programs for engaging communities in asset management. For example, there is no clear or consistent data about community needs and expectations, there are no consistent models for assessing the socio-economic impacts on communities, and while society is moving towards the use of more advanced web-based communication systems, tools used to communicate with communities are quite outdated in terms of style and content.

Software and knowledge management systems: the same incoherent practices are highly manifested in the software systems used to manage assets. Some municipalities have only a simple database for documenting assets; others have very limited software systems to house data and analyze deterioration. There is no proper linkage between asset data and computerized maintenance programs (which are relatively spread). The existing software systems lack interoperability and focus only on the management of data, not knowledge.

Analysis

Three dimensions are key to any effective management system in the water and wastewater utilities:

Functional analysis of the Water and Wastewater Management System.

Value analysis (also called functional analysis) is an orderly and creative method to increase the significance/value of a system. The functions of a facility

(or a product) are defined through careful investigation and analysis of "what is it supposed to do?" Value analysis establishes a network/hierarchy of basic and secondary functions (normally expressed in a verb-noun fashion) of a system that is under investigation. These "abstract" functions are developed in isolation from any design options. In other words, value analysis cannot be used to compare two street designs. Rather, it aims at defining what each design has to achieve.

Value analysis is not an end product or result, but rather a beginning. It describes the item or system under study and causes the team to think through the functions that the item or system performs. Once the functions of a system are defined, they act as a guide to stakeholders to develop and evaluate alternative designs that can achieve such function.

Appendix C provides a summary of the value engineering process.

Functional analysis is at the heart of the value analysis process. It aims at defining the fundamental functions and objectives of a design. Function Analysis System Technique (FAST) is a consistent and proven technique to systematically build a hierarchy of basic and secondary functions of a system (in this case: the design of an urban street). FAST permits people with different technical backgrounds to effectively communicate and resolve issues that require multi-disciplined considerations. FAST diagrams are built from left to right starting with the higher order functions that are then decomposed to functions of lower order as the diagram evolves to the right. In essence, reading the diagram from left to right answers the question "how can this function be achieved?" Reading the diagram from right to left answers the question: "why is this function needed?"

Figure 2 shows a preliminary FAST diagram for the W&W Management System. The main functions that this system should assure include the following:

- Assure Safety
- Assure Sustainability

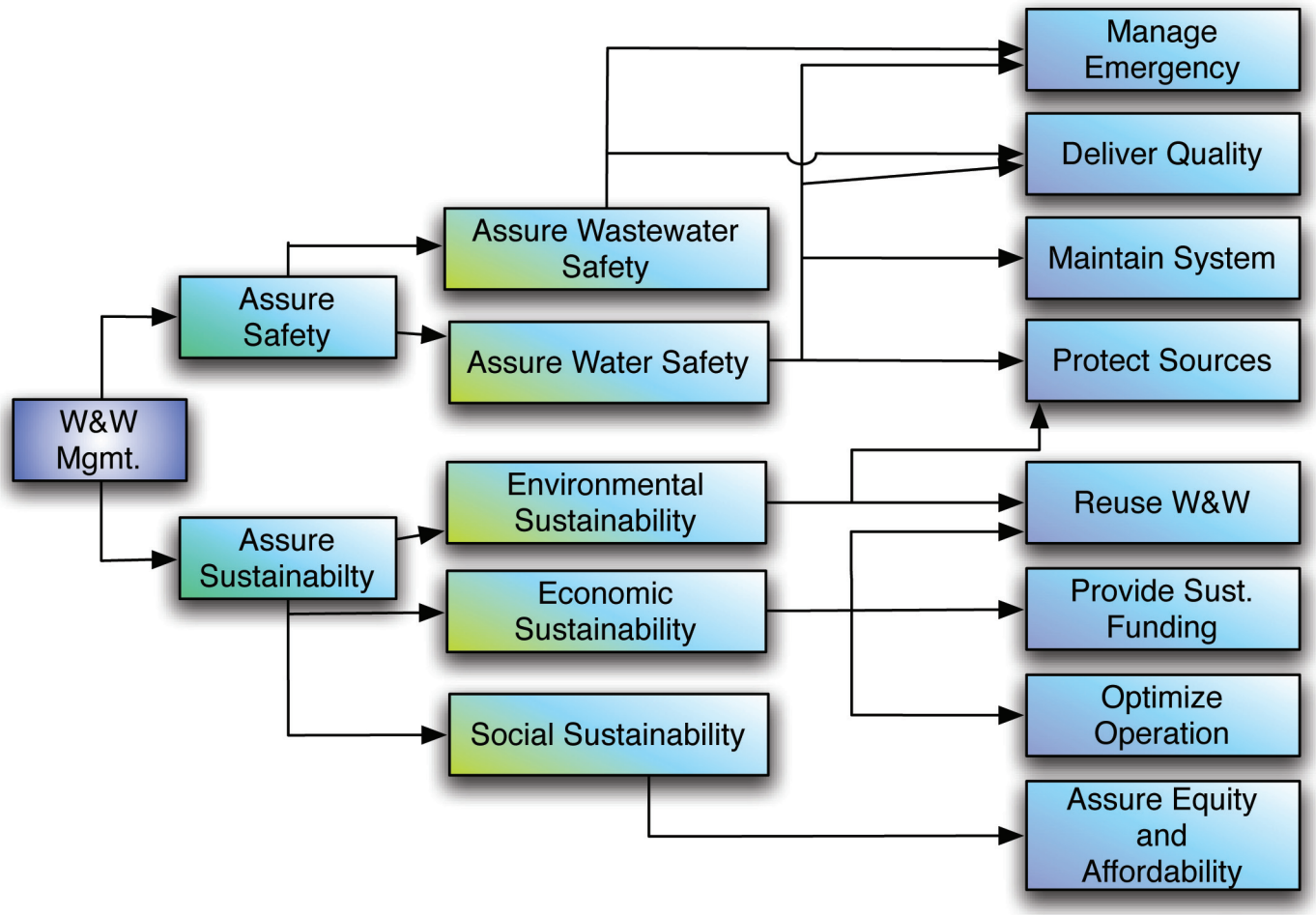

Figure 2: the Functions of WWA

Management Principles

A set of fundamental principles should guide the delivery and conduct of such functions. For example (see Figure 3):

- Accountability: every stakeholder should be held accountable against a set of benchmarks related to performance measures
- Transparency: work has to be conducted and communicated in a transparent manner.
- Life-Cycle Planning: plans have to integrate all aspects of WWA and consider life-long costs and impacts of such systems including conserving the physical assets, conserving water and sustainability.
- Coordination: plans have to be coordinated among regional players to assure that the overall sustainability, energy use and community impacts of the whole region are considered.
- Reliability: design and management practices have to be held to very high standards that emphasize system reliability and the use of advanced technology.
- Efficiency: technical and managerial aspects of W&W systems have to be conducted in the most efficient non-bureaucratic manner.

Figure 2 shows the interaction between WWA functions and the above principles. Of course all the principles are applicable to all the functions. However, some are very highly related as indicated by circles in Figure 3.

Continuous Improvement: Performance Measures and Information Systems

A major lesson that many jurisdictions have adopted is the need to emphasize continuous improvement. When the W&W systems were designed in the 50's and 60's they were done according to the best design practices at that time. State-of-the-art practices then emphasized design efficiency and minimization of direct construction costs (short term costs). Complacency with such practices and lack of adequate R&D/analysis contributed significantly to

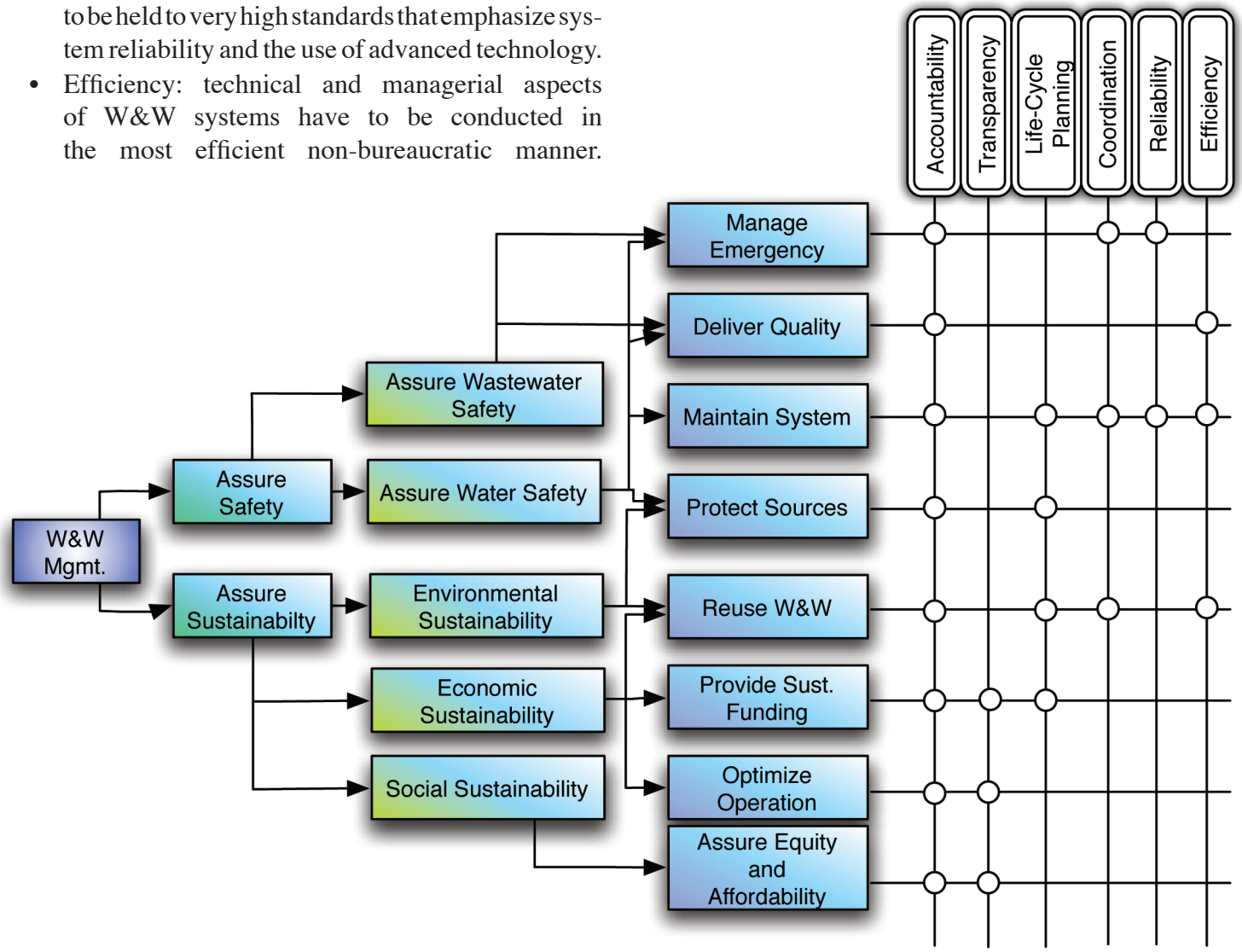

Figure 3: the Interrelationship Between Functions and Principles of WWA

deferred maintenance practices which produced the current situation of deteriorating assets. Orthogonal to the previous two dimensions, we need to assure a sustained critical analysis of system performance and adequate review. This includes:

- Information technology: collection and use of reliable relevant data about system conditions.
- Performance measures: clear and objective measure of system performance and its trends.
- R&D: this should cover the technical, managerial, policy and social aspects of the W&W management system.

Management tools

Four management tools are needed to manage and sustain the three aforementioned dimensions (see Figure 4):

National Policy: establishing clear long term benchmarks for all levels of governments across the lifecycle of WWA. Pooling and sharing knowledge and technology resources. Affirming accountability and transparency standards. Clarifying Federal government role and contribution to WWA.

Governance scheme: Provincial and Federal governments have to agree about governance schemes that define the responsibilities of each and those of municipalities, expedite decision making, emphasize coordination and long term planning, affirm the stewardship of sustainability, and engage and partner with all stakeholders. The hallmark of such governance schemes is to provide municipalities with proactive services that will allow them to clearly identify a clear list of long-term projects.

Funding System: professionally-run funding organizations that estimate, retain and possibly raise needed funds to finance infrastructure projects. Of course a major component of such funds will come from Federal and Provincial Governments. Another part could come from private sources. Different governments on the Federal and provincial levels can provide their share by various means according to their political inclination. The bottom line is that commitments of such governments will be estimated and managed by professionals. Municipalities can apply to such organizations to fund projects that are already on the priority list as long as they have met the national and provincial standards (technical and organizational).

Asset Management Systems: software and management systems to collect and analyze data, assess performance and support decision-making.

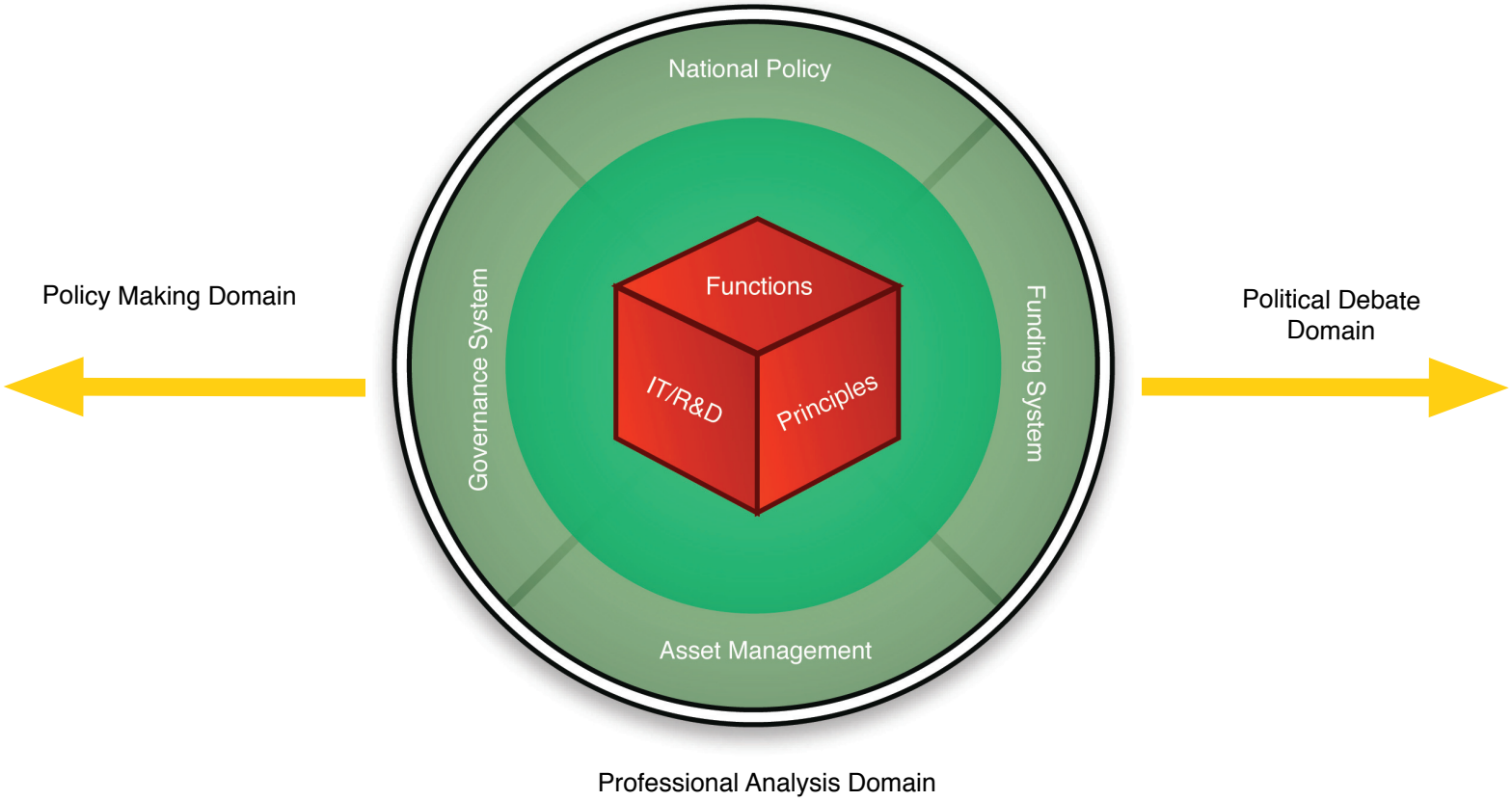

Figure 4: Framework for a National System for WWA Management System

Proposal for a national initiative on asset management

The fundamental solution for management of our infrastructure assets is the creation of a societal culture for sustainable asset management. We should capitalize on the increasing awareness amongst communities regarding the environment and the importance of infrastructure on quality of life, economic activity, public health, and security to establish a sustainable public push for better management of our infrastructure. This will hopefully get asset management out of national politics into national policy, establish clear technical objectives and guidelines for performance, encourage long term planning and funding, enforce accountability and transparency, positively engage the society in preserving the infrastructure systems.

The main features of such national culture include (see Figure 5):

National Policy On Asset Management

The minimum role of the federal and provincial governments is to lead a consorted sustainable effort to establish a clear policy on asset management. Federal and provincial government should collaborate in building national and regional long-term policies for infrastructure management and finance. It is not acceptable that we have no consistent definitions of infrastructure; numerous conflicting estimates of the infrastructure deficit, no national data standard or interoperable software systems for asset management, and no quantification of the impacts of various funding mechanisms on infrastructure systems sustainability.

The mandate of Infrastructure Canada and its provincial counterparts (in Ontario, MPIR) should be focused on establishing, promoting and evaluating clear long-term national and provincial policies for infrastructure management. The main elements of national and provincial policies should include some of the following:

1. Benchmarks: clear identification of expectations. This includes clear definitions of the gaps and means to overcome them, the objectives of the national and provincial policies, performance measures (for example, environmental, accountability and maintenance standards), and firm identification of funds and their sources.
2. Governance system: clarification of the deliverables of each level of government, decision making cycles, and clear identification of the roles, responsibilities and accountability standards for public and private entities.
3. Technology: identification of R&D needs, promotion of advanced technologies, support for innovation, and collection and dissemination of best practices and related knowledge. For example, developing and sharing a consistent deterioration models to help municipalities clearly identify the status of their systems, developing and sharing models to estimate the life cycle costs including objective measures for the analysis of the socio-economic impacts of the projects. Developing and sharing such common models will help small municipalities overcome the limited human and financial resources they have and will expedite projects and save money. Current efforts, such as Infra-Guide and service benchmarking, should progressively become a mandatory part of operations if we want to effectively and objectively assure the sustainability of our systems.
4. Information Systems: Federal and Provincial governments should agree/ develop interoperable data standards and common information exchange systems to support the effective collection, communication, analysis and synthesis of infrastructure systems. These are needed to assure effective decision making and to communicate with stakeholders.

The Australian experience provides a very fitting example in this regard. Nationwide and provincial plans were developed through leadership from government and with effective and thorough involvement from professionals and through clear communication with the public. To an extent, the plan was developed using some of the best practices of public policy making. The plan, essentially, has shielded long-term infrastructure management from politics by emphasizing

Limit the politics and promote a long term clear policy, standards and benchmarks.

professional input and consensus building. Each level of government assumes part of the responsibility according to transparent and accountable measures.

The national policy should then be cascaded down to guide the development of provincial and regional plans for actions. Such plans should specify clearly a priority list of projects to be pursued in each region—creating clear objectives against which local government can be accountable. Feedback from the execution of regional and provincial plans should be considered upon updating the national plan (see Figure 6).

Accountable and Transparent Government

While governance of the infrastructure should remain local, regional and cross-regional coordination organizations are needed to pool expertise and resources and to assure consorted planning and promote regional sustainability. Such coordinating organizations should not be a new layer of bureaucracy. Rather, proactive service-oriented enterprises.

It is important to establish governance and management schemes that make governments (especially at the local/municipal level) accountable for the achievement of the national and regional plans. This is more important given that most of the money is managed at the municipal level. The consistent adoption of these two concepts is even more important in case of any plans for greater private sector participation.

It is important to assure effective governance mechanisms for infrastructure systems. Such governance is and should remain local (at the municipal level). This means that immediate decision makers are closer to the community and that the community can hold such decision makers accountable. The local governance system should be geared at:

1. Increasing efficiency and conservation: this includes enhancing the efficiency of decision making through process reengineering, optimization of resources, training of personnel. This should also include emphasis on conservation of current systems through adequate design of projects, effective operation and proactive maintenance.
2. Accountability and Transparency: there should be clear communicable benchmarks of performance at project and organizational level. This may include publishing local budget statistics, including sources and use of funds, information about the efficiency of project planning and contracting, assessment of local sustainability indicators

The above features put greater emphasis on developing objective benchmarks and embedding them in the design and decision making. Many municipalities lack adequate resources to effectively develop project plans (especially in relation to assuring sustainability), and to develop, use and communicate governance and technical benchmarks. Moreover, the decision making in many municipalities is done by councilors or politicians (normally based on advice from professional staff). The engagement of all councilors in approving most projects may not be the most effective way of conducting business.

We have to strike a balance between assuring that elected officials are held accountable by the community in relation to infrastructure decisions and the need to reduce politics and boost "professional" analysis and long-term planning.

Drawing on some of the best practices from the Australian, UK and USA experiences, the following governance scheme merits further investigation/debate (see Figure 5 and 6):

1. Corporate Municipal Utilities: transfer municipal departments into public corporations managed by professionals.

2. Regional Sustainability Agencies (RSA): these are public corporations responsible for pooling municipal resources to establish regional plans in accordance with the best practices and existing standards. The regional sustainability agency should be modeled as a cross between MPOs (Metropolitan planning organization) and EPA: an independent, proactive organization that is centred on R&D, planning and communication of sustainable stewardship. Such organization should lead the regional planning efforts, promote sustainability,

collect and analyze relevant data and best practices. The mandate of such organizations should be to "serve" municipalities. Their funding has to be linked to such "service benchmarks" to prevent them from being an additional layer of bureaucracy.

3. Provincial Infrastructure Banks (PIB): these are also public corporations that hold and manage Federal and Provincial grants in a way similar to the State Revolving Funds (SRF) and the State Infrastructure Banks (SIB) in the USA. Their mandate is to use funding to effectively promote national plans and objectives.

In Ontario, the city of Hamilton is a good case study that should be further analyzed. The city is now seen by many as the most advanced in asset management systems. Maybe the lesson to learn is: within the framework of clear plans and benchmarks, allow professionals to conduct and manage a long-term coordinated plan with the oversight of politicians.

In general, councillors' or politicians' oversight will be more focused on guiding the process and evaluating the overall performance of professional staff in the three organizations, rather than second-guessing their estimates regarding technical issues. Requiring all councillors to vote on each project is not efficient, especially since some issues require an advanced technical understanding. Recent criticism of the governance mechanism of TTC goes in the same vein.

The interaction between these agencies could be perceived as follows (see Figure 6): within the national and provincial plans, regional plans should be developed by the RSAs. These plans should include a priority list of projects. Such regional plans will consider the long-term sustainability of the region—impacts on environment, local economy and the social fabric of the region. Such issues are not local, rather, they are regional and should be analyzed as such. Professional staff at each municipality should utilize the regional plans and design/commission of each project (based on the priority list) in a manner that meets the national and regional sustainability objectives. They will do so according to standard methodologies for estimating life-cycle costs, sustainability impacts. Municipalities can then apply to PFBs funds to supplement their financial resources, if needed.

Of course, this is one option for governance. Other options should also be considered—especially since it is so widely recognized that there is no one-size-fits-all solution. Essentially, any governance scheme should attempt to achieve the following paradigms which have been clearly demonstrated to be important upon review of successful systems in other countries:

Manage Infrastructure With a Private Sector Spirit

There is a need to instill a private sector mentality in the management of municipal infrastructure. This is not a call for or against privatization. Rather, a call for managing the municipal infrastructure by independent accountable professionals under the auspices of public officials. A publicly-owned municipal utility company is one model that can be considered in this regard. Such organizations are managed in a quasi-private model by professionals and not politicians. This guarantees a transparent flow of funds including PSAB- compliant, clear financial statements and technical and managerial performance indicators. Elected councilors should direct the pricing and overall objectives of the organization. The handling of public policy and technical and professional management in this fashion could be a reasonable solution to such a unique commodity (water and wastewater).

The governance of the infrastructure should be local and independent but professional (less politics) and accountable (clear benchmarks and results evaluation). Its fundamental role is to establish reliable long term plans for which projects have to be built; define the sources of funds, means for public communication, process reengineering and efficiency management, and clear mandate and benchmarks for conservation of existing systems and of the overall consumption of water. They should do so on a regional level or on a watershed basis (The Golden Horseshoe or the GTA for example).

Integrated plans

While federal and provincial governments are responsible for developing general and macro guidelines and national plans, the actual planning of infrastructure projects has to be done at a local level.

National and provincial plans have to be translated to regional plans. Such regional plans should encompass an adequate number of smaller municipalities. Impacts of infrastructure on the environment and economy are not local but regional. Also infrastructure is an interdependent network of engineering systems—we cannot plan it at the micro level. Ontario has developed a system for regions to coordinate the work of various municipalities. Such a plan is being praised and recognized worldwide as it allows for coordinated analysis and planning of infrastructure. However, we need to take this further. We should foster coordinated planning and information sharing between regions. For example, there has to be a clearer coordination of GTA plans (between Toronto, Peel, Halton, York regions).

It should be emphasized that such an organization should not be a new layer of bureaucracy. One way of doing this is through a set of performance reviews. This should start by self-evaluation, evaluation by municipalities and independent evaluation by universities. Rather these organizations should be fashioned as a service organization whose mandate is to:

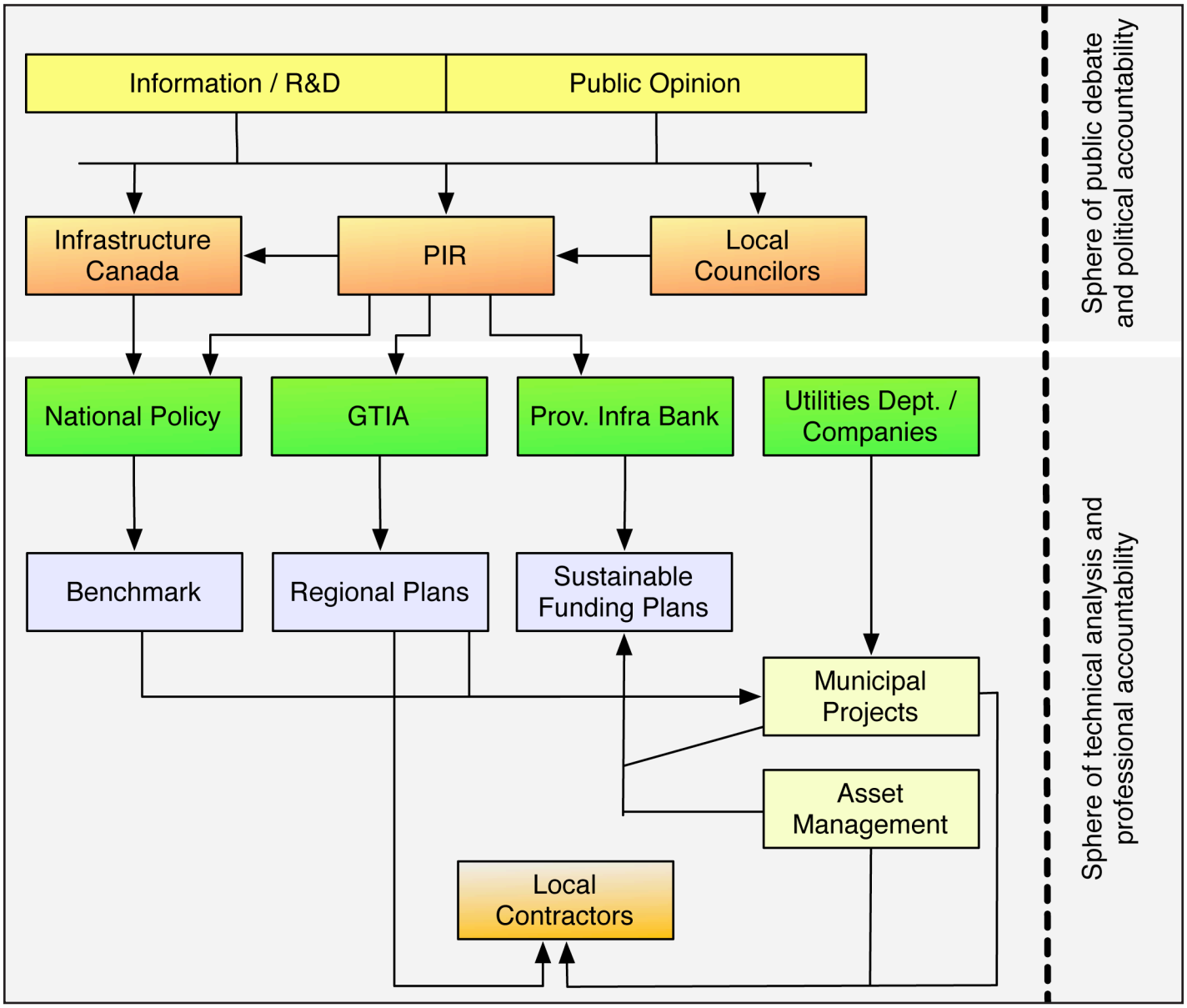

Figure 5: Outline of Governance Scheme

1. collect information
2. develop and maintain regional models and indicators
3. bring local authorities together to coordinate plans
4. link planners and decision-makers to the public, including preparation, study and environmental assessment of major projects—as a service.. GTIA should solicit information from municipalities to the analysis and lobby for the development and adoption of such plans

Long-term based planning

The regional plans should focus on long term plans. Maybe Infrastructure Canada, Infrastructure Ontario and PIR should "draw up a template for a 10-Year Infrastructure Renewal Plan that a water authority might follow, to facilitate the Planning activity. Such a template would be consistent with the Ministry's own 10-Year Infrastructure Renewal Plan (CWN 2003)". This should include listing of major projects that are needed at regional/local level for the achievement of national infrastructure goals. Such master/regional plans should then be approved by the EA. Municipalities should not have to then justify the project to EA, they however have to demonstrate that the plans/designs for a specific project meet the highest environmental standards possible.

In other words any local/micro plans for any project have to be in accordance and in compliance with the regional long-term plan.

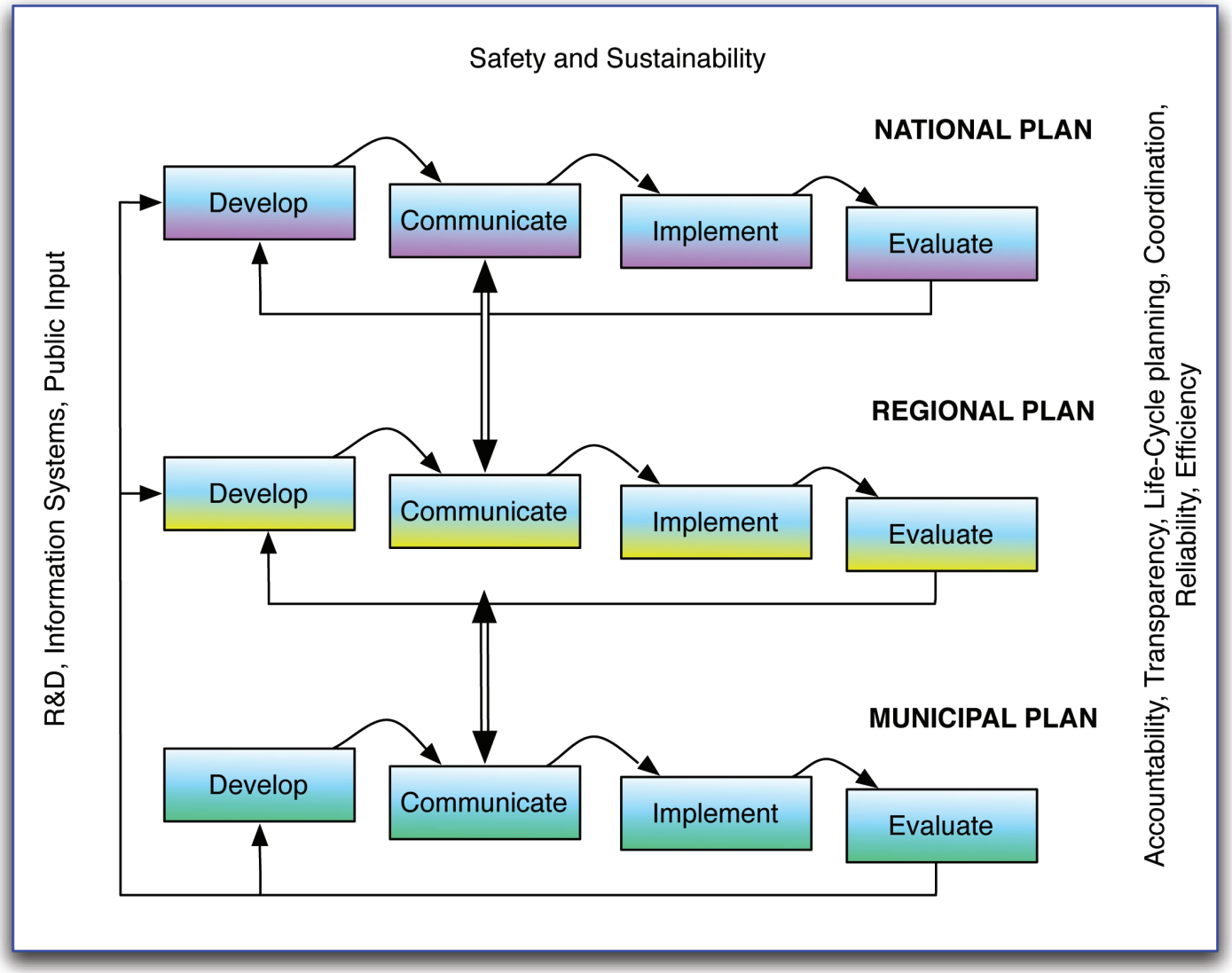

Figure 6: Outline of Nested Planning

Sustainable planning: from construction projects to urban projects

The next challenge after asset management is how to blend infrastructure in its community, how this "asset" can be "invested" to promote. Using the official plans: Make the infrastructure as an investment in the community---increase employment to combat poverty and increase social ties/utility in affluent areas. This includes promoting the practices of context sensitive design.

Sustainable Funding

Main point: there should be a clear and professional analysis of the deficit as well as a commitment to funding that covers such deficit. The deficit should also include replacements that are not necessitated because they are worn, but because they pose an adverse environmental or health impact, e.g. lead service lines and the joints for old cast iron mains can both leach unacceptably high levels of lead into drinking water systems. Other distribution systems may need to be downsized to avoid the need for frequent flushing, e.g. mains that used to serve both residents and industry after the industrial users have closed their factories. This includes systematic analysis of the property taxes and their fluctuation, clear/long term contributions from provincial and federal governments. This money should be managed very professionally and in a transparent way. Municipalities need to prove and live up to certain environmental and financial responsibilities to receive funds.

Even though full cost pricing is slated to help overcome the deficit, government finance is still important to help overcome the burden of deferred maintenance, stop the escalation of costs (Australian government bought back the debt of its utility departments before setting corporation) and to enforce/encourage technical and managerial reforms needed at the start.

Ontario municipalities have limited revenue sources and must rely on property taxes and user fees to generate revenue. There continues to be some constraints, due largely to the reluctance of local politicians to raise taxes and/or water rates to provide adequate resources to water utilities. Forward planning, investment in new technologies for drinking water production and for wastewater treatment, and continuous renewal of water distribution systems are essential (CWN 2003)

While it is understood that local funds should be the source of finance of WWA, especially in light of full cost pricing, federal and provincial funds are still needed. Justice O'Connor recommended a leading role for the province in assuring adequate funding for the protection of water sheds. Moreover, there is a fiscal imbalance between municipalities and federal/provincial governments in Canada. Property taxes account for the lion's share – almost half of municipal revenues in the GTA. Most large U.S. cities, in contrast, draw only about 20 percent of their revenues from this source, and make up much of the difference through municipal access to a variety of excise and income taxes, plus higher levels of transfers from senior levels of government.

Federal and provincial funds could also displace investments by municipalities. If municipalities are expecting substantial funding from federal/provincial governments they may be lax in their investments in infrastructure. Federal funding could also lead to some inefficiencies due to either its bureaucratic nature or the lack (or difficulty) of accountability. Finally, many federal/provincial investments are influenced by non-economic motivations (such as equality) or political reasons. Many of such funding initiatives are ad hoc and non-sustainable. Consequently, any federal or provincial funding of WWA should be strategically placed to ensure the most attainable returns. It seems that some of the best venues for using federal/provincial funds include:

1. R&D
2. Long-term planning
3. Incentives for better efficiency and sustainable development

In any case, funds, whether local, federal or provincial, should be stable, predictable, sustainable, tied to lucid policy mandates and directions, and accounted for. One way to achieve these goals is to consider provincial infrastructure banks. Such banks would be funded by federal and provincial governments to leverage local funds and augment other special funds and trusts in one entity. They also can attract funds from pension plans/organizations or other investment tools. The bank could study and analyze the econom-

There should be clear and professional analysis of the deficit as well as a commitment to funding that covers such deficit. This includes systematic analysis of the property taxes and their fluctuation, clear/long term contributions from provincial and federal governments. This money should be managed very professionally and in a transparent way. Municipalities need to prove and live up to certain environmental and financial responsibilities to receive funds.

ic indicators and provide an estimate for tax revenues and accordingly issue bonds or other investment means against the public asset (i.e. infrastructure).

Much of the discussion by financial analysts on the subject of asset renewal includes assumptions of the life cycle based on investors' normal depreciation rates, but normal depreciation and replacement calculations cannot be applied. Pipelines - both sewers and water mains – cannot be made to fit into a particular replacement schedule. Water and sewer main failures cannot be predicted and typically replacement time tables are not dictated by the age of the water or sewer main but by the replacement schedule of other infrastructure. For example, when a road is being repaved or replaced, often municipalities will use that opportunity to replace the aging water and sewer mains that rest in that location. We must also consider that climate will dictate when a water main or sewer fails (OSPE 2004).

There has to be an effective planning and communication on the part of the municipalities to demonstrate an effective long-term plan for asset renewal in a sustainable way. For a municipality to receive funds for a project, such a project has to be part of the national or regional plan, have a clear technical and economical plan, and satisfy environmental and governance mandates. Funding should be used as an incentive for more accountable, long-term, sustainable practices on behalf of the municipalities. This may include reduced interest rates for the financing of new water technologies, such as sharing some of the interest costs, or partial capital grants that encourage rural, urban and regional municipalities to modernize their plants and distribution systems. “Thus "Pooled Borrowing" could be used effectively by the Province to achieve the modernization of water infrastructure. The Municipal Finance Authority in British Columbia is an excellent example of being able to borrow at a rate based on the collective credit rating. If pooled borrowing is carried out for investment in new technologies, and this is done in tandem with watershed protection policies (announced in a white paper) then the new technology plants could and should include plans for the renewal of water and sewage pipes, and the elimination of combined sewer overflows (CWN 2003).

For example, the bank could use as a condition of funding, that a municipality has “identified and quantified water leakage within their system and developed a renewal plan to address same; a water conservation plan to ensure that per capita and per sector water demand is being reduced; and have undertaken a sewer system condition assessment and infiltration reduction program and is implementing programs to address same. Further, the operator’s ability in having achieved operational efficiencies (perhaps in comparison to a Provincial benchmark) should also be made a precondition to grant approval. Funding should encourage solutions that make sense from a broader perspective. Economies should be demonstrated in both scale and operation of a utility (city of Toronto, 2004)”

The bank, acting in the same manner as the World Bank, can promote financial accountability by tying funding to transparency and the application of proper accounting and financial standards. It could act as a tool for promoting sustainable practices by providing funds only if the projects have attained adequate levels of sustainable indicators as established by the national benchmarks articulated in the national policy and detailed by the Regional Sustainability Agency. The bank could also represent a venue to attract pension funds to invest in infrastructure renewal and the “environmental protection industry”. Finally, the bank could support/invest in ecologically-sensitive projects in other countries as means of supporting global sustainability and promoting sustainable environmental products industry.

The bank will indirectly hold CMU accountable regarding the efficiency of their pricing mechanisms. Water rates must be shown to be a function of national guidelines and the product of sound economic and financial analysis. The bank, being a public corporation, could establish a standard model for pricing based on best practices and local needs, clear understanding of current infrastructure status and the national and provincial plans. However, each municipality should have the flexibility to adopt variations of the same basic utility pricing approach (since no two municipalities are the same). Attracted to "cheap finance", municipalities will be encouraged to sustain accountable pricing practices. This model of public accounting could be more suitable for municipal finance and water pricing than a full fledged "water pricing board" which has been devised in the energy sector.

Part of the government funding should be directed towards pooling resources to help reduce redundant spending and help smaller municipalities. This includes investments in R&D, information technology and planning. The Bank should consider giving adequate incentives to water authorities for infrastructure renewal, encouraging them to plan for investment in new technologies that will ensure high quality drinking water and the sustainable stewardship of Ontario watersheds. Consistent with the new drinking water standards, the three key objectives of the new technologies would be the elimination of pathogens, the minimization of disinfection byproducts in the drinking water and the elimination of endocrine disruptors in wastewaters.

Asset Management

WWA are public assets. Municipalities have a responsibility to apply appropriate practices to the overall management of physical assets. At a minimum this includes (CWN 2003):

- Know the key what, when, and where features of their physical assets.
- Understand what service levels are expected from these assets and how those levels of service might change.
- Have enough knowledge of the system to be able to ascertain what is critical to achieving successful sustained performance.
- Acquire and maintain enough information to choose minimum life cycle cost pathways to achieve the desired service levels on a sustained basis.
- Have a fiscal plan for attaining the sustainable economic footing necessary for achieving the planned service levels.
- Customer focus and agreements on service levels;
- Rigorous risk and cost-benefit analysis in asset creation, maintenance, refurbishment, and replacement;
- O&M savings through optimizing maintenance methods and intervals;
- Proper use of condition monitoring, criticality and performance analysis, etc.;
- Operating effectively within an overall risk management framework.

The ultimate result of the national initiative on WWA is the enhancement of asset management systems at the municipal level. The national policy, the RSAs and the PFAs should promote the following:

- Understand the needs—Support of R&D in asset management. This includes, for example, expanding existing initiatives (such as Infra-Guide), study best practices in data collection and analysis, develop and evaluate decision making tools, study patterns for technology adaptation, assess the effectiveness of various communication systems.
- Manage Performance Data—the benchmarks: Develop and support efficient common tools for data collection, performance measures and decision making. Such software systems and web-based tools are commonly needed by all municipalities. However, many municipalities do not use such software. In those which use asset management software, there is no common standard agreed upon for data management or interoperability. One of the main tasks of RSA is to pool resources to select and use the most suitable software systems and collect and disseminate reliable and timely data.
- Asset management oriented processes—formally pool the expertise: asset management starts at the planning stage. Policies and regulations should encourage RSA and municipalities to engage as many stakeholders and experts at all stages of the project to assure that the project considers all aspects of urban sustainability and effective generation and communication of project objectives.

- Asset Management Culture—Training programs for designers and operators: while performance data and process structures are important, the attitude and skills of personnel at all levels is what makes assets management a reality. Municipalities and RSA should promote effective learning and training programs for all involved.
- Asset Management oriented finance—assure accountability: municipalities are the stewards of the national wealth embodied in infrastructure assets. They should be held accountable for how they take care of it—as much as they are accountable for public health and environmental protection. Funds/grants should only be given to municipalities that uphold national standards of asset management and sustainability.

An asset management plan consists of three elements:

1. A plan for maintaining the assets;
2. A schedule of capital reinvestment needs of the infrastructure; and
3. A funding plan for assuring the sustainable management of these assets.

Asset Inventory: as basis for the 10-year plan for each municipality, each municipality has to account for all its assets according to a national standard. This again brings the issues of interoperable data representation standards to integrate the flow of information between organizations. In addition, this also brings to the forefront the need for training and education for local professionals to adequately collect and manage such data.

Performance Measures: benchmarks (technical and managerial) are at the heart of any asset management system. One of the main challenges in the assessment of performance of WWA, indeed the overall management of WWA, is the lack of consistent consorted efforts of data collection and compilation at urban levels. Data is normally insufficient, very recent and scattered (Sahely et al. 2003). There has to be clear consensus and understanding of a set of national, provincial, regional and local benchmarks. Such measures have to be objective, measurable, and representative. These measures should be the base for accountability of local official, first by their constituencies and then by RSAs and PFAs upon embarking on new projects or applying for funds.

Renewal Plans: each municipality has to submit to RSAs as part of their 10-year plan a detailed account of their renewal proposal.

Since the 1980's the City of Copenhagen has introduced a general policy to replace 1% in length of their network annually (Dobel et al. 2001). Hunter Water has a policy of replacing or repairing water services between the water main and meter. This program costs $600,000 each year but results in savings of about 305 Megalitres per year. The program is relatively cost effective and addresses a very visible form of leakage. The rationale for that is the lack of strong incentives for owners to repair leaking services and it is likely that if Hunter Water ceased its current program, then the level of leakage would increase significantly. Also, there are overall efficiencies achieved through coordinating this work through a single agency, on behalf of the community. Within the water main replacement program, about 5km of pipes are replaced per year. Hunter Water currently replaces failed sections of water main based on an economic evaluation model. Under this model the economic, social and environmental value of lost water is included in the assessment. The program leads to estimated savings of 20 Megalitres per year (Hunter Water 2007).

The arguments in support of this approach include:

- Economical: replacement expenses are expected to go down if pipes in poor conditions are replaced or rehabilitated regularly.
- Conservation: leaky pipes waste water
- Capacity: there is a need already to increase the capacity of some mains to meet urban growth.
- Quality: pipes that are larger than needed create long residence times with negative impacts on the quality.
- Indirect costs: claims for compensation due to water pipe failure and impacts on traffic are some of the indirect costs of sub-standard pipes.
- Finance: gradual replacements alleviate the need for one-time large fund request and help enhance the cash flow.
- Common sense planning: setting a long term plan of what is to be replaced allows the city to integrate construction plans with other utilities and reduce overall construction costs and interruption to business and local communities.

Urban Landscape: the ultimate manifestation of asset management policies is to embed them in the fabric of each project and the overall city planning.

The management of storm water has evolved over the years. The traditional conveyance approach shifted during the 1970s to a storage approach that emphasized detention, retention and recharge. In the 1990s, it was realized that storm water could be a source of pollution. The focus of storm water management shifted again to focus on the protection of natural environment through local source control. Current practices include using small scale, environmentally friendly methods such as ponds, wetlands, root-zone systems, percolation facilities, soil infiltration, and permeable asphalt.

New trends views storm water as an asset that can be invested as part of the new concept of ecological village. This encompasses the re-use of storm water separately or with grey water for toilet flushing, irrigation in small-scale urban agriculture. Moreover, storm water ponds can be integrated in the urban form to create a more aesthetic and natural landscape—adding to the overall living and tourist aspects of cities.

The city of Malmo, Sweden is an example of integrating storm water management in the urban landscape. Instead of implementing technical standards (such as attenuation by infiltration and treatment in created wetlands), the urban plan combined the natural and aesthetics aspects of fresh water with attenuation and treatment of storm water. The significance of the idea is that it starts at a very small scale: a single house, a parking lot or a part of street. A set of ponds and wetlands have been constructed around natural streams around the city, which constitute a great recreational value.

The city of Stockholm, Sweden is taking a further step in the control of storm water pollution at the source. An extensive study found that the fundamental challenge is to find and use more environmentally friendly materials and technologies in construction and street cleaning to enhance the quality of storm water at the source.

Source: MaImquist and Bennerstedt 1997

Knowledge and IT

Research and Innovation: The province must reinvest in staff and research facilities similar to organization and capabilities of the 1980's and early 90's. For example, The Ministry of the Environment should return to their former role of being an integral part of the science and engineering of water supply and wastewater systems. This would greatly enhance the Province's capabilities of managing infrastructure (OSPE 2004).

However, it should be noted that new water technology has always been developed by the private sector and not by the public sector. With efficient markets, the private sector that develops new technologies should be able to sell these technologies to the public sector, provided that the public sector itself has been responsive to the needs of the consumers and has an incentive to provide product quality. Unfortunately, that incentive was missing in a complacent public sector due to lack of funding, lack of political will, and, until recently, a general malaise in the enforcement of drinking water quality standards. The main failure of the public sector was the failure to price water services in a manner that would have allowed it to plan and budget for investments in new infrastructure. (CWN 2003)

Knowledge Management: The domain of asset management is very dynamic. Regulations, needs, and plans are always changing. Best practices and domain knowledge are constantly improving. This calls for an effective collaboration between all stakeholders—especially professionals in this domain. Public officials must be part of a knowledge exchange initiative to promote collaborative advancement of technologies and practices. This implies an ongoing partnership between government and utilities, something that is being increasingly discussed. The partnership would include, at minimum, professional organizations, interested utilities, the Ministry of the Environment, and utility-oriented consulting firms.

Standards: assuring safety and sustainability will normally require the establishment of common rules, norms and standards which must be observed by the providers of services. Given that these standards include trade-offs between various interests, it is appropriate that these standards should be determined by thorough political processes, in view of the degree of political judgment entailed in determining society's needs and priorities at any time. It is therefore a task which is for governments.

Interoperability: it has been estimated that the capital facility industry in the USA loses about $16 billion annually due to the lack of interoperability between software. Government should create a standard IT platform to support consistent seamless exchange of information amongst all relevant stakeholders.

Communication, training and education :
We should use effective IT tools to communicate to a net-savvy society, as should municipalities, RSA and PFA.

Summary

In summary, the proposal presented is centred on three front-line organizations: municipalities, regional sustainability agencies and provincial infrastructure banks (see Figure 7). The three should be fashioned as public corporations performing with the spirit of private sector. Elected officials have oversight over the public corporations. Local councilors have an oversight over the municipal utility corporations. Infrastructure Canada and PIR have oversight over the RSAs and PIFs. The RSAs serves to facilitate the technical aspects of WWA, including development of consistent standards, long-term plans and benchmarks. RSA enforce some of the accountability required of municipalities by upholding adequate level of competency in the development of new projects and in the management of existing assets. Municipalities are accountable before PIFs to uphold the required financial and economic standards required and set forth in the national/ provincial policies.

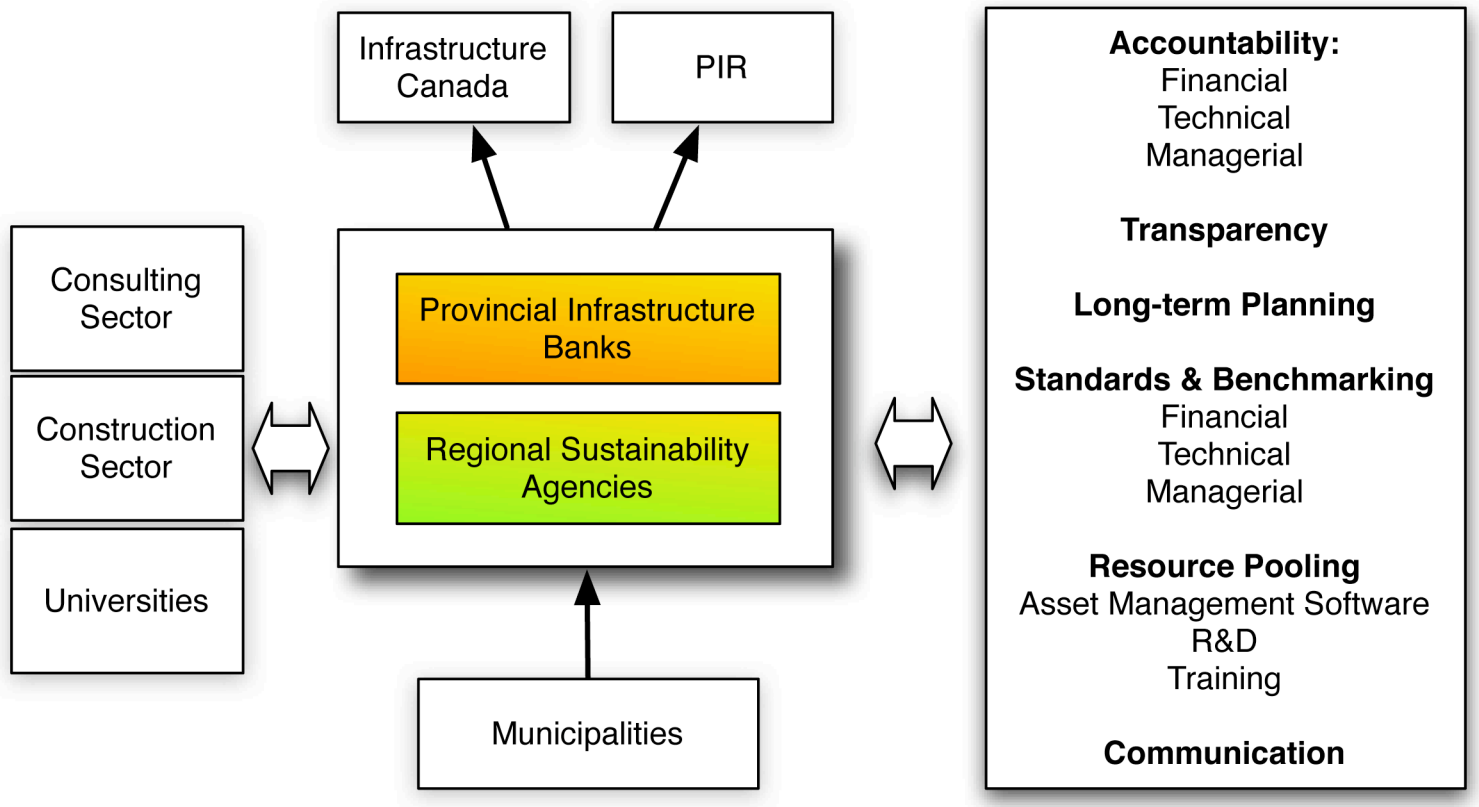

Figure 7: Integrating Planning, Finance and Asset Management

The role of non-government organizations

Like public officials, private entities have a major role in the establishment of an asset management culture.

Construction & Consulting industry

The construction industry should not wait for the government to develop the plans or to estimate the deficit. WWA is a major market for the industry. Like any industry, the construction industry should be proactive and bring about plans for estimating and eliminating the deficit, establishing a governance scheme, and setting national IT standards as well as accountability and transparency standards. They should even consider establishing and pooling experts to build and advocate preliminary regional plans and a priority list of projects.

The industry should embrace a leadership role in Green technologies. Ontario has more than 62,000 workers and 2,400 companies involved in activities such as water and wastewater treatment, waste treatment, air pollution monitoring and controls, energy conservation technology, and Brownfield site redevelopment. It is important to capitalize on the abilities and expertise of the local human resources to advance the performance of local projects, increase the resiliency of local markets against foreign takeovers, and secure an adequate market for Canadian contractors in the global market of environmental projects. Finally, the lessons of the manufacturing industry in the USA have shown that training and adaptation to new technologies are a must to survive in the 21st century. The industry should focus on training to assure that its labour is savvy with advanced technologies and green practices as these are going to be valuable skills in the 21st century.

Universities

- Need for better education of engineers in asset management
- Need for research in the engineering and, even more importantly, the non-engineering aspects/ sustainability of assets.
- Establish means to collect, analyze and communicate unbiased data about WWA. The periodical surveys by the Joint Program in Transportation at the University of Toronto is a good example. It should be expanded to cover more data about other infrastructure aspects: deficit, investments, sustainable indicators and governance benchmarks.

Hunter has spin offs and sells its expertise to others. The company provides a range of specialist technical and operational services to water agencies, councils, industry and urban developers. It works in the fields of water, wastewater, storm water, catchment and environmental issues. The company carries the following activities:

- Water and Wastewater Treatment Plants: Plant optimization and operational problem solving, Conceptual and detailed design of plants, Undertaking process and operational review of plants, Development of operations systems including web-based manuals, Specialist treatment advice in both municipal and industrial applications.
- Engineering and Technical Services: Investigation and modeling, Civil / structural engineering, Surveying and survey drafting, Engineering graphics
- Water Testing: Chemical, Microbiological, Sampling
- Corrosion Engineering and Materials Testing
- Management and Planning: Water and Wastewater Asset Management, Environmental, Community, Economic
- Specialist Surveying Services: Spatial data management, Data conversion, integration, auditing and maintenance, GIS data capture, Cadastre control and transformation, Dam and structure monitoring

.

Source: Hunter Water Web site

Some ideas for GTA

The Toronto Water assets are valued at $8.7 billion and includes: a 5015 km distribution of water mains and 510 km of trunk water mains, 52,900 valves and 40,460 hydrants, 470,202 water service connection, with 540 million litres/year. The Wastewater assets are valued at $17.9 billion and include: 4 wastewater treatment plants, 4,397 km of sanitary, 1,301 km of combined and 358km of trunk sewer, 4,305 km of

storm sewers and 546 km of roadside ditches, 463,300 sewer service connection with 438 billion litres of wastewater treated annually (City of Toronto 2004).

Toronto is suffering from deferred maintenance and the huge deficit, may be more than any other Canadian city. Urban sprawl is exacerbating problems. The GTA population is expected to increase 43% to reach 10.5 million by 2031 with an estimated 42% increase in greenhouse gas emissions. The GTA Task Force estimated in 1996 that, if development patterns continue in the Toronto area as they have over the past 25 years, we would require about $55 billion of capital investment over the next quarter-century to build new roads, water and sewer networks, as well as another $14 billion in operating expenditures. A more compact and efficient development pattern could save roughly $12 billion (Toronto Task Force 2006).

In recent years, the city has been faced with an increasing commodity and labour costs. For example, 12.5% increase in Hydro pricing, 5% in natural gas, 3.25% in salary and benefits and 10-15% in contracted services (City of Toronto 2004). The problem is exacerbated due to increasing citizen sensitivity to pricing increases. The region's labour force has grown about 30% in the last 10 years due to strong in-migration; however, jobs have not kept pace with this growth. The City of Toronto's unemployment rate is the highest in the region and above average for both Ontario and Canada.

Some of the barriers to effective asset management include (Toronto Task Force 2006):

- "The short-term nature of the electoral cycle, which works against longer-term investments and actions in areas like energy and water conservation. Often only projects with extremely short payback periods are adopted.
- Current lifestyles and standards of living, which provide little incentive for waste reduction, or energy and water conservation.
- Lack of coordination and cooperation among all levels of government.
- Lack of agreed-upon measurements and targets and the means to monitor them.
- An education curriculum with less than adequate environmental and outdoor education components."

In contrast, recent advancements are helping overcome the barriers (Toronto Task Force 2006):

- "The re-introduction of climate change programs by the federal government.
- The introduction of Ontario's Places to Grow Strategy, a long-term plan for managing growth for greater sustainability in the Golden Horseshoe, accompanied by action to protect the Oak Ridges Moraine and to establish a southern Ontario Green belt.
- The appointment of the first Chief Energy Conservation Officer for Ontario and the plan to install SMART meters in all homes by 2010.
- Establishment of the Greater Toronto Transportation Authority by the provincial government to coordinate transportation planning and delivery across the GTA and to promote more sustainable transportation use.
- Toronto, Markham, Kitchener and Waterloo green roof initiatives, which have made the broader Toronto region an international leader in this area. There are an estimated 5,000 hectares of potential green roof locations in Toronto alone.
- Municipal investments in energy reduction initiatives for both heating and cooling, such as the Oshawa City Hall retrofit and EnWave Deep Water Cooling project, as well as increasing use of biofuels and other alternative fuels for municipal vehicles and transportation."

The Way Forward:

- Be a leader, do not wait.
- Be accountable and transparent.
- Coordinate actions and emphasis life cycle management.

GTA municipalities should not wait for the government to act. As one of the largest metropolitan areas in North America, they should pool their resources to lead and develop a cutting-edge asset management plan for the region. This plan should go beyond the limited view of asking for funding or installing software. It should embrace a cultural change embedding conservation-oriented, proactive policies for asset reservation/ rehabilitation, customer services and life cycle optimization. Being on the front lines, they should lead various levels of governments in defining what is needed, how much funds

are available and how much is needed from the provincial and federal government. To be effective, these plans have to include several key principles:

- Effective governance: review the governance schemes in the area and introduce necessary reforms that embed efficiency and private-sector style in the management of WWA.
- Clear accountability and transparency measures including specific and objective performance measures.
- Equity and fairness in terms of pricing
- Environmental leadership including conservation of assets and water
- Clear and cutting edge plan for a futuristic city that is based on efficient infrastructure.
- Optimum use of information technology to assure efficiency and reliability of systems
- Effective public communication
- Long term plans that clarify future projects
- Work closely with stakeholders, including bold partnership with NGO's and contractors.

The benchmark in this collaborative effort is the very successful Water Services Association of Australia (WSAA). WSAA is an association formed by water utilities in Australia. Its 29 members and 27 associate members provide water and wastewater services to approximately 15 million Australians and many of Australia's largest industrial and commercial enterprises. WSAA was formed in 1995 to provide a forum for debate on issues of importance to the urban water industry and to be a focal point for communicating the industry's views. WSAA provides a national focus for the provision of information on the urban water industry for all interested parties. The Association aims to encourage industry cooperation to improve the water industry's productivity and performance and to ensure that the regulatory environment adequately serves the community interest. This includes (WSAA 2007).

- "Promoting knowledge sharing, networking and cooperation for the benefit of the urban water industry
- Identifying emerging issues of importance to the urban water industry and developing strategic responses
- Developing industry-wide approaches to national water policy issues
- Being the voice of the urban water industry at the national level
- Facilitating strategic standardization, industry performance monitoring and benchmarking
- Delivering projects and research outcomes of national significance
- Providing information and communicating in a timely and effective manner."

The association publishes a comprehensive and impressive performance benchmarking report that is the envy of other constituencies. The report:

- outlines water consumption trends and up to 155 indicators relating to the performance of the urban water industry
- provides nationally consistent definitions and approaches which enables comparisons to be made between utilities and jurisdictions
- informs customers about the level of service they are receiving
- builds community confidence and improves the water literacy of the community
- informs the decision making processes of government, regulatory agencies and water businesses
- encourages greater transparency in the way water is managed

This is used in identifying emerging issues for the water industry, providing a forum for industry discussion of priority issues, developing research strategies and communicating outcomes to stakeholders. Assessment of industry regulation issues including development of industry positions on regulatory issues and interaction with national organizations relevant to regulation of the industry. WSAA publishes high level performance information in WSAA facts, and is informing members of measures used by regulators to assess the relative efficiency of water service providers. WSAA is also active in stimulating consideration of customer preferences for service standards, together with the benefits and costs of increased standards. Finally, WSSA has a major role in strategic standardization including support for the development of codes for construction, design, maintenance, condition assessment, and rehabilitation of the industry's water and sewer network infrastructure (WSAA 2007).

References

Abdelrahman, A. (2003). "A schema for performance management in municipal infrastructure systems," MASc. Thesis, University of Toronto.

Albee, S. (2001). "The Australian Water Industry-Infrastructure A reform agenda", Presentation to the Association of Metropolitan Sewerage Agencies, Washington D.C.

Australian Public Services Commission (2007). "The Australian experience of public sector reform", http://www.apsc.gov.au/about/exppsreform9.htm (accessed July 2, 2007).

Blais, P. and Greenberg, B. L. (Dark Gabor Ltd.) (1995). The economics of urban form. Toronto", GTA Task force, The Office for the GTA.

Canadian Water and Wastewater Association. (1997). "Municipal Water and Wastewater Infrastructure – Estimated Investment Needs 1997-2012"

City of Toronto. (2004). "Response to Water Strategy Expert Panel"

Colombo, A. and Karney, B. (2002). "Energy and Costs of Leaky Pipes: Toward Comprehensive Picture" J. Water Resour. Plng. and Mgmt., Volume 128, Issue 6, pp. 441-450 (November/December 2002)

Clutterbuck and Novick. (2003). "Building Inclusive Communities: Cross-Canada Perspectives and Strategies", Prepared for the Federation of Canadian Municipalities .

CWN-Canadian Water Network (2003). "Building a Better Tomorrow: Investing in Ontario's Infrastructure to Deliver Real, Positive Change" www.cwnrce.ca

Dell'Isola, A. _1998_. "Value engineering: Practical applications for design, maintenance, and operations." R. S. Means Co.

Dobel, S., Palludan, E. and Jensen, F. (2001). "Environmental factors and health
the Danish experience".

FCM: Federation of Canadian Municipalities and the Department of Civil Engineering and Applied Mechanics –McGill University. (1996). "Report on the State of Municipal Infrastructure in Canada,"

FHWA-Federal Highway Administration. (2003). "Asset Management-a primer"

FHWA-Federal Highway Administration. (2005). "Transportation Asset Management In Australia, Canada, England, and New Zealand". Available at http://international.fhwa.dot.gov/assetmanagement/

FHWA-Federal Highway Administration. (2007). "Policy Highlights" http://www.fhwa.dot.gov/policy/2002cpr/highlights.htm (accessed May 3, 2007)

GAO-General Accounting Office (2004). "Water infrastructure comprehensive asset management has potential to help utilities better identify needs and plan future investments"

Harchaoui, T. M., Tarkhani, F., and Warren, P. (2003). "Public Infrastructure in Canada" prepared by Statistics Canada for Infrastructure Canada.

Hunter Water Corporation (2007). Main web page: http://www.hunterwater.com.au/links.asp (accessed June 20, 2007).

Infrastructure Canada- Research & Analysis Division. (2003). "U.S. Infrastructure Policies And Programs: An Overview"

Infrastructure Canada- Research & Analysis Division. (2004). "Assessing Canada's Infrastructure Needs: A Review of Key Studies".

Infrastructure Canada- Research & Analysis Division. (2004b). "Infrastructure financing: a literature review of financing mechanisms".

Infrastructure Canada- Research & Analysis Division. (2005). "Performance, benchmarking and best practices in infrastructure: developments in Ontario"

Infrastructure Canada- Research & Analysis Division. (2005b). "the importance of water metering and its uses in Canada"

Infrastructure Canada- Research & Analysis Division. (2006). "Methodologies for Assessing the Social and Cultural Impacts of Infrastructure"

Malmquist, P. A., & Bennerstedt, K. (1997). Future stormwater management in Stockholm. case study Hamarby strand. In Proceedings Stockholm water symposium. August Stockholm, Sweden.

Mirza, S. M. and Haider, M. (2003). "The State of Infrastructure in Canada: Implications for Infrastructure Planning and Policy", A study prepared for Infrastructure Canada.

OECD: Organisation for Economic Co-operation and Development (2000). "Environmental goods and services an assessment of the environmental, economic and development benefits of further global trade liberalisation"

OECD: organisation for economic co-operation and development (2005). "OECD workshop on agriculture and water: sustainability, markets and policies" 14-18 November, Adelaide, south Australia

OSPE-Ontario Society for Professional Engineers (2004). "Safe Water for Ontarians OSPE response to Water Strategy Expert Panel"

Owen, K., Mundy, T., Guild, W. and Guild, R. (2001), "Creating and sustaining high performance organization", Managing Service Quality, Vol. 11 No. 1, pp. 10-21.

Pilcher, R. (2005). "Local government financial key performance indicators – not so relevant, reliable and accountable", International Journal of Productivity and Performance Management, Volume: 54 Issue: 5/6 Page: 451 - 467

Queensland Treasury. (2003). "Asset Strategic Management Guidelines", available at: www.treasury.qld.gov.au/office/services/governance/strategic-planner/index.shtml

TD Bank Financial Group. (2002). "A Choice Between Investing in Canada's Cities and Disinvesting in Canada's Future"

Toronto Task Force. (2006). "main page" http://www.torontoalliance.ca (accessed June 20, 2007).

Victoria Dept. of Treasury and Finance. (2000). "Managing our assets", available at: http://www.beehive.govt.nz/nzts/downloads.cfm.

WERD-Western European Road Directors. (2003). "Data management for road administrations-a best practices guide".

WRIC-The Water Reform Implementation Committee (2006). "Water Use Efficiency", Government of Western Australia, www.water.wa.gov.au

WSAA-Water Services Association of Australia (2007). "main page" https://www.wsaa.asn.au/frameset2.html (accessed July 2, 2007)

Appendix A: Benchmarks & Best Practices

Asset management encompasses two fundamental domains:

1. Technical: related to the engineering and managerial aspects of planning and implementing asset management in municipalities.
2. Public policy: related to funding and national plans to achieve sustainable infrastructure systems.

Consequently, expertise from other jurisdiction can be benchmarked on the technical and public policy aspects related to asset management. Moreover, best practices in public policy in other domains (such as health and education) can also be used as guidelines for developing successful public policy in asset management:

Public sector reforms are taking place to assure efficiency, reliability, and sustainability. Understanding the reasons for organizations' failure is the starting point for any effective strategy of success (Owen et al. 2001):

- lack of understanding of the organization's external environment by the senior leadership which leads to failure in translating the organization's vision, mission and values into effective strategies and processes;
- lack of alignment between the internal business processes and customers' and market place requirements; and
- failure of the organization's systems and processes to support the organization's vision and strategy.

For an organization to be on track in its performance journey, the performance management system must embrace the following characteristics:

- senior leaders understand the organization's environment and respond effectively to changes;
- have a shared vision, mission, values, and strategies that are in line with the marketplace;
- leadership practices that are congruent with the organization's vision;
- adequate infrastructure that supports the work processes; and
- organizational culture that meets the customers' needs (Owen et al., 2001).

Performance indicators are essential to define the areas in need for improvement, set targets for improvement and persuade higher authorities of the need to change. These indicators simplify monitoring the operation of the utilities by government officials and thus allowing them to modify policies and programs accordingly. The performance indicators also serve the interest of private investors to identify market opportunities through the evaluation of the overall performance of utilities (World Bank, 1999).

However, applying performance measures through legislations is not enough. One key example in this regard is the Australian experience—heralded as the benchmark in WWA worldwide. The government of New South Wales (NSW) introduced a system of financial key performance indicators (FKPIs) upon which council performance was judged. Of the 170 councils in NSW, up to 98% recorded an error in depreciation of some component of transport infrastructure during 1999-2000 and 2002-2003. The error margin ranged from 11 to 73,520% significantly impacting on the three targeted FKPIs (Pilcher, 2005).

What is really needed is a healthy structure for a publicly-run, privately inspired industry to manage WWA. This includes:

- Identify government objectives and responsibilities.
- Communicate government plans to all stakeholders.
- Emphasize reliability and performance through effective use of indicators and performance measures.

Australian Experience

Australia is seen as the leading country in infrastructure asset management. Australia is also often seen as a key comparator for Canadian public policy and administration given its Parliamentary and federal system of government and other important parallels with Canada (Infrastructure Canada 2004b). The hallmark of Australia's extensive experience in asset management can be summarized as follows: a fundamental commitment to long-term forward-thinking planning and decision making; nested, collaborative approach for decision making encompassing all levels of government em-

phasis on exploiting private sector contributions in all possible stages and facets of asset management within the publicly-developed plans and benchmarks (Infrastructure Canada 2004; FHWA 2003).

The significance of the Australian experience is that the water reform initiatives have been formulated with a recognition that an important part of the solution lay in significant policy and institutional change. During the 1990s, many water utilities were incorporated as enterprises with the government as a sole stakeholder in an effort to expose Government Business Enterprises (GBEs) to competition, increased accountability, and other initiatives such as full cost recovery (Australian Public Service Commission 2007). The corporation was part of a larger policy that included three main paradigms:

- Integrated frameworks for the management of internal risks (e.g., from aging infrastructure) and external risks (e.g., from "competitor" actions) to the utility.
- The support of board level, executive management, and operational staff, as well as that of external stakeholders.
- The effective communication of risk and engagement within decision making processes both within companies and with external stakeholders.

This was implemented through the following means:

- Set the policy direction toward major changes in the industry
- Brought resources to bear in support of the reform agenda
- Provided financial incentives in the form of transfer payments to the State and local providers that proceeded with the changes
- Established financial incentives, frequently in the form of debt for equity swaps, where the State took over existing debt service payments to give the new organizations a clean balance sheet on which to build their water business
- The government arranged for Community Service Obligation payments (CSO) to address affordability issues of pensioners
- The government supported a more aggressive R&D investment

The businesses are managed as any private enterprise; they are licensed to operate by an environmental regulator and their price overseen by an economic regulator. The board of directors of such organizations is selected the same way as a corporate board is selected. The corporation has three equal drivers: meeting strong commercial performance, licensing (environmental) requirements and fulfilling community service obligations. They prepare annual financial reports and their finances are externally audited and reported against corporate standards. As public organizations, they have focused on:

- Price water for full cost recovery
- Establish secure access to water separate from land and provide for permanent trading in water entitlements
- Improve the institutional arrangements
- Engage in public consultation
- Foster public education

Infrastructure management system in New South Wales is managed through the following tools (GAO 2004, Albee 2001):

A multi-stakeholder infrastructure council: The Council is multi-stakeholder, consisting of senior government Ministers senior executives from the construction, engineering, banking enterprises, and union officials. The Charter creating the Council mandates it to identify the strategic infrastructure issues, collect feedback on policies and development priorities, facilitate shared learning and promote best practices, provide a forum in which the government and private sector can improve their mutual understanding and address common strategic infrastructure issues.

An infrastructure coordination unit (ICU): The ICU serves as the Council's secretariat. It reports directly to the Premier. The Unit is responsible for supporting the government's strategic directions through the facilitation of infrastructure coordination across the state and for providing advice to the government on infrastructure projects and issues, especially those requiring cross-department and cross-agency coordination.

State Infrastructure Strategic Plan: The NSW government released the first State Infrastructure Strategic Plan in December 2002. The Plan sets out the govern-

ment's priorities for major infrastructure (i.e. projects valued at more than $20M, which is considered the threshold to attract private financing) over the next ten years. The Plan is prepared by the ICU, based on input from all departments and agencies regarding their delivery strategies and capital investment plans and in close consultation with Treasury. One of the principal objectives behind the Plan is to enable the private sector to gauge the opportunities for future investment and to position itself to assist the government with the provision of services and infrastructure by providing private financing, expertise and appropriate risk-sharing. It is also intended to assist the government as a whole in communicating its infrastructure objectives to citizens and encouraging total asset management policies and processes in all sectors. In NSW the Hunter Water Board was corporatized in 1992. The Corporation's shareholders are the Treasurer and one other Minister of the Crown (on behalf of the State). It is governed by a Board of commercially skilled Directors. Hunter Water is regulated by a number of state government agencies, as follows (Albee 2001):

- The NSW Government through an Operating License, which sets standards of customer service and other customer protection mechanisms. The conditions of the license are recommended to the Government by the Independent Pricing and Regulatory Tribunal;
- The Independent Pricing and Regulatory Tribunal, which also sets the prices we charge;
- The Department of Natural Resources, which administers HWC's water access licenses. These licenses allow sustainable access and use of water resources;
- The Department of Environment and Conservation which licenses the Corporation's wastewater systems; and
- The Department of Health, through a memorandum of understanding that establishes procedures for communicating results of the Corporation's water quality monitoring programs.

The Hunter Water Board represents a sample success story of socially responsible corporation for managing WWA. Over the last decade average charges per customer were reduced by about 30% in real terms. The price reductions occurred during the period when improved service standards were adopted. At the same time, surveys documented improved customer satisfaction with better service levels, and 12 of 21 wastewater treatment plants achieved full compliance with all license conditions. The remaining 9 plants achieved 99.6% compliance.

Since 1990, their audited average operating costs per service have fallen by over 40% in real terms. Hunter Water went from 1500 employees to 450 in a decade. In addition, about 100 of their employees work for a subsidiary, that provides service to Hunter Water and earns external income from other utilities by providing a range of operating or consulting type service to other smaller utilities. They formed another subsidiary company for telemetry service and then sold that company for revenue for reinvestment in the base system.

Another example is Sydney Water, which employs around 4,000 employees. Of those, 800 employees are engaged in asset management activities! All of the operating, maintenance and capital cost come from fees collected from users & developers. In addition, Sydney pays $200 million a year to NSW as dividends, $28 million in Load Based Fees and $5 million in administrative fees. Their user fees are comparable to those in the USA. On the other hand, in Victoria, there is no discharge from facilities and most utilities, including some rural ones, are ISO1400 certified (GAO 2004).

Queensland opted not to incorporate its water utility. However, it is run on the same private-spirit. The infrastructure management system in Victoria is relatively similar and includes the establishment of a similar council. The Council began its work by articulating a vision for Victoria as it could be in 2020, taking into account the drivers and trends that are shaping the state. From this big picture, the Council then developed sector visions in each of the four areas within the mandate, i.e. water, energy, transport and communications. The sector visions were the foundation for the Council's consideration of infrastructure requirements and gaps. Significantly, the Council looked beyond only physical infrastructure in this regard. Requirements and gaps were assessed in terms of institutional and regulatory arrangements, future demands for different types of infrastructure and varying degrees of infrastructure quality (GAO 2004).

- Planning – determining the "what", based on gaps analysis and developing appropriate performance indicators;

- Delivery – determining the "how", and building, developing, operating and maintaining the required infrastructure; and
- Accountability – monitoring, evaluating and reporting to Parliament

Guidelines for governance based on best practices from other countries.

1. Institutional clarity – for both roles and relationships.
2. Clarity of mission and purpose – typically utilities are given commercial mandates, while the regulator is given a public policy mandate, so everyone is clear about their priorities and responsibilities.
3. Representation of all stakeholders.
4. Regulatory integrity and equity – consumers must expect to be treated fairly and have faith in the probity of the regulator.
5. Accountability and transparency – this ensures that stakeholders can see that the regime is fair, particularly if water utilities are corporatized, and help the government in measuring whether policy objectives have been attained. An ombudsman should be assigned for dispute resolution between owners and operators and customers.
6. Effectiveness of the regulator – a regulator which is given too narrow a remit or too little authority will be unable to achieve its goals.
7. Coordination with other institutions and their regulatory frameworks.
8. Independence – an impartial, fair and equitable regime would relieve some of the haphazardness of current arrangements.
9. Clear rules and direction from one source.
10. Practical guidance, which would be particularly valuable for small or remote communities that may lack the relevant expertise.
11. Incentives to improve performance (which could include investment in infrastructure, improved cost efficiency, better customer service, higher water quality standards, etc.)

Source: GAO 2004, Albee 2001

USA Experience

The United States does not have a central office or a national infrastructure policy or program for coordinating infrastructure planning. Neither do the federal government and most state governments coordinate infrastructure spending or planning across their agencies. However, appropriation of funds for infrastructure is a top priority to most congressmen, if not all. Congress tends to appropriate funds in the form of trust funds, revolving funding/loan schemes, and recently, infrastructure banks. The hallmark of funding legislations is that they tend to cover a relatively long period of time, which establishes a clear horizon for states and local governments about federal contributions. Funding legislations link funding to clear performance measure and in particularly environmental stewardship. Congress receives critical analysis of the performance of these funds periodically to evaluate their performance and guide future policy.

The Government Accounting Office (GAO) has a "Physical Infrastructure Team," which assists Congress in its oversight of federal infrastructure policies and expenditures. Furthermore, the Congressional Budget Office (CBO) provides nonpartisan, economic and budgetary analysis to Congress, including the information required for the Congressional budget process. Finally, the National Academies corporation (created by Congress) provides further scientific analysis of related issues.

Congress has used funding to promote and control public policy in the infrastructure domain. The passage of the Transportation Equity Act for the 21st Century (TEA-21) in 1998 changed the face of transportation infrastructure policy, including funding, in the US. At the time, it was the largest public works program ever authorized in the US, with total authorized expenditures of $218 billion from 1998 to 2003 for the development and maintenance of transportation infrastructure (Infrastructure Canada 2003).

Most politicians, policy analysts, and affected parties agree that the TEA-21 has been an overwhelming success. It has improved the nation's surface transportation infrastructure including highways, mass transit and railroads. Combined investment by all levels of government in highway infrastructure has increased 25 percent since TEA-21 was en-

acted and "highway capital spending alone rose to $64.6 billion in 2000, a 33.7 percent increase over 1997." In fact, under TEA-21, State and local governments did not simply substitute Federal funds for their own. While increasing their expenditures on transportation, they surpassed the minimum increases necessary to meet Federal matching requirements and increased the State and locally funded share of highway capital outlay (FHWA 2007).

TEA-21 has not only increased spending on infrastructure, it has changed the way federal transportation infrastructure is funded "by establishing guaranteed funding for transportation and linking transportation expenditures directly to revenues collected into the Federal Highway Trust Fund" (Infrastructure Canada 2003).

In 2004, Congress passed "The Safe, Accountable, Flexible and Efficient Transportation Equity Act of 2003" (SAFETEA). It serves as the largest surface and public transportation investment in U.S. history and more than doubles funding for highway safety over levels provided by TEA-21. (FHWA 2007). The act presents a sample of how public/federal funding can drive sustainable policies at state and local levels. Funds allocation include: a) increasing the motor fuel tax to increase revenue sources; b) congestion pricing; c) streamlining the environmental review process for transportation projects; d) improving safety; e) promoting technology; and f) increasing flexibility to address state and local funding needs. On the water and wastewater front, most federal funding is controlled by Environmental Protection Agency—an independent, professional Government agency. This presents a clear policy on linking funding to environmental stewardship.

The State of California is one of the most advanced states in terms of infrastructure planning (infrastructure Canada 2004b). In 1999, state government appointed the independent Commission on Building for the 21st Century to provide recommendations regarding California's infrastructure over the next 20 years. This Commission included 48 representatives from the business, labor, environment, academic and government sectors. The Commission's final report, submitted in 2001, stated that California's infrastructure was suffering because funding had not kept pace with population growth. It recommended, among other things, establishing a statewide energy infrastructure plan, a statewide water infrastructure plan, a permanent, public-private entity – the California Infrastructure Partnership – for infrastructure investment and planning, and a permanent infrastructure fund separate from funds already budgeted or allocated for infrastructure.

Also in 1999, California passed the California Infrastructure Planning Act, which requires the Governor to submit annually a five-year infrastructure plan to the Legislature with the intent that the Legislature will adopt the five-year plan for the State. The first five-year plan was adopted in 2002. The 2002 Plan identified two factors critical to filling information gaps regarding infrastructure: "the lack of resources and experience within departments to do long-range planning, and the uncertainty of the future direction of programs that drive capital outlay needs." In the 2003 plan, it was apparent that some departments have improved the planning process, but many departments still lacked basic data necessary for calculating future needs and had few or no systems for monitoring and planning their capital needs. The five-year planning process is forcing departments to undertake such needs assessments (infrastructure Canada 2004b).

In 2001, New Jersey produced a State Development and Redevelopment Plan, which included an assessment of infrastructure needs. Along with California, it is one of few states to take a statewide approach to infrastructure planning. The assessment found that "the average New Jerseyan pays $543 per year for public investments in infrastructure, nearly evenly divided between state and local governments and [allocated] primarily for highways and education. On a per capita basis, New Jersey now invests more than most of its surrounding states and more than the national average in infrastructure improvements." The assessment also found that local governments across the United States provide an appreciably larger share of capital investments relative to state governments (Infrastructure Canada 2003).

New Jersey created an innovative method to administer its CWSRF. An organization called the New Jersey Environmental Infrastructure Trust (NJEIT) works in conjunction with the New Jersey Department of Environmental Protection to administer the

SRF NJDEP makes zero percent loans to finance half of a wastewater treatment project's allowable costs, and the NJEIT matches each NJDEP loan to finance the other half of a project's eligible costs. "NJEIT issues revenue bonds and then loan the proceeds at market rate. By matching the loans of NJDEP, NJEIT doubles the amount of loan money available for wastewater treatment improvements. Since the combined money is provided at half the typical market interest rate, the State Revolving Fund program reduces the costs that must be passed on to a project's users" (Infrastructure Canada 2003).

European Experience

Many European countries have developed systems that overlap with those of Australia and the USA. Interestingly unique experiences can however be seen. For example, England and Wales have privatized all their water and wastewater utilities. Of course this has received mixed reviews. On the one hand investment in infrastructure have increased significantly. On the other hand there has been much criticism for the governance structure which allowed contractors to be on the board that controls the decision making, opening the door for conflicts of interest. Although water quality improvements were associated with privatization in a non-competitive environment, our research shows that there was no demonstrable evidence that complete privatization resulted in lower prices. In fact, the evidence in both UK and France indicated that consumers paid higher prices because of privatization (CWN 2003).

Canadian Experience

Canada has developed a set of best practices in the domain of infrastructure management. For example, in Ontario infrastructure of small municipalities is managed by a regional department. This creates a better environment to coordinate the plans and pool resources. Another example is the development of infra-Guide which collects best practices in technical and managerial aspects of infrastructure management. Recently, Ontario enacted the Municipal Performance Measurement Program (MPMP), which requires all Ontario municipalities to report on the performance of their services. The program enhances the capacity of citizens, local officials and others to compare costs and levels of performance. While the measures are rudimentary and exclusively quantitative in nature, they should be seen as representing a degree of progress towards the development of policy- and operationally-relevant "indicators" and "criteria" for infrastructure policies and programs, and also rough proxies for municipal capacity for effective infrastructure management (infrastructure Canada 2004). Finally, The Ontario Municipal Benchmarking Initiative (OMBI) was established through collaboration between the Ontario Ministry of Municipal Affairs and Housing, regional chief administrative officers from across the province and 15 municipalities. The goal of the Initiative is two-fold:

- to identify and develop appropriate service specific performance measures, capture performance data and analyze and benchmark results; and
- to provide a useful management tool that integrates financial and performance data to assist municipal decision-making (e.g. methodologies and systems for activity-based cost accounting and asset management).

The Ontario Strategic Investment Financing Authority (OSIFA) will make loans for municipal water and wastewater infrastructure. The Canada-Ontario Municipal Rural Infrastructure Fund (COMRIF) will provide direct capital grants to smaller communities.

A recent study (Abdelrahman, 2003) found that in the water and wastewater sector indicators related to public safety (such as water quality and public health statistics), impacts on the environment, and the effective use of chemicals dominated the most important indicators in water/wastewater systems (see Figures 8 and 9). Interestingly, although the amount of lost water reflects the system's unreliability, the experts thought it should be categorized under financial performance measurement since lost water will cause financial losses. Similarly, energy efficiency was categorized as a financial performance measure rather than an environmental sustainability measure. Finally, efficiency in using hazardous substances was seen as more of a safety performance measure rather than as an environmental/sustainability measure.

The various indices and data collection methods used in water and waste water systems were documented and are shown in Tables 1 and 2, respectively (Abdelrahman, 2003).

Table 1: Sample of indexes used in assessing performance in the water supply sector

Index	Data Presented	Service interruptions	Interruption durations	Restoration time
System Average Interruption Frequency Index (SAIFI)		•		
System Average Interruption Duration Index (SAIDI)			•	
Customer Average Interruption Duration Index (CAIDI)				•
Momentary Average Interruption Frequency Index (MAIFI)		•		

Data / Indicator	Data Collection Method	Visual inspection	Sampling	Closed Circuit TV (CCTV)	Optical sensors	Intrusion detection sensors	Infrared sensors	Radar	Simulation
Water Quality			•		•				
System security						•			
Pipe conditions		•		•			•	•	•
Pipe breakage pattern									•

Table 2: Sample data collection methods used in water supply sector

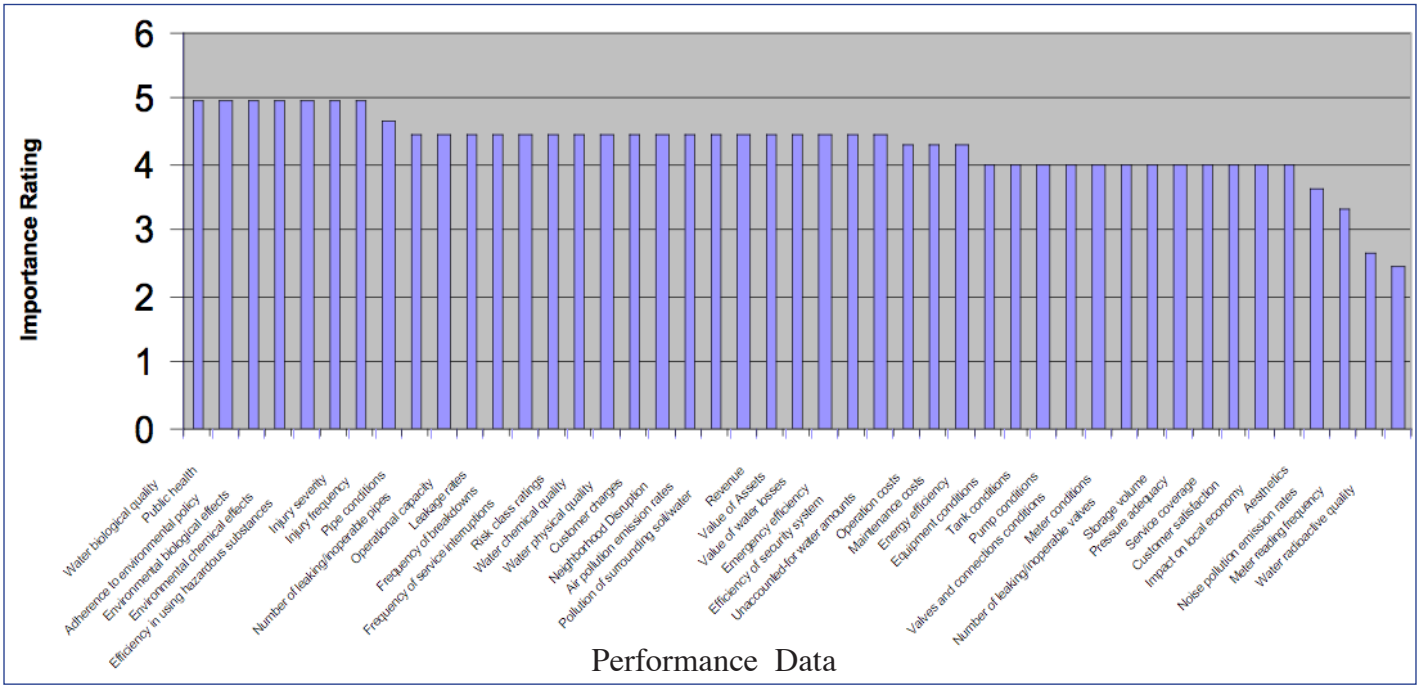

Figure 8: Water Performance Indicators (Abdelrahman, 2003)

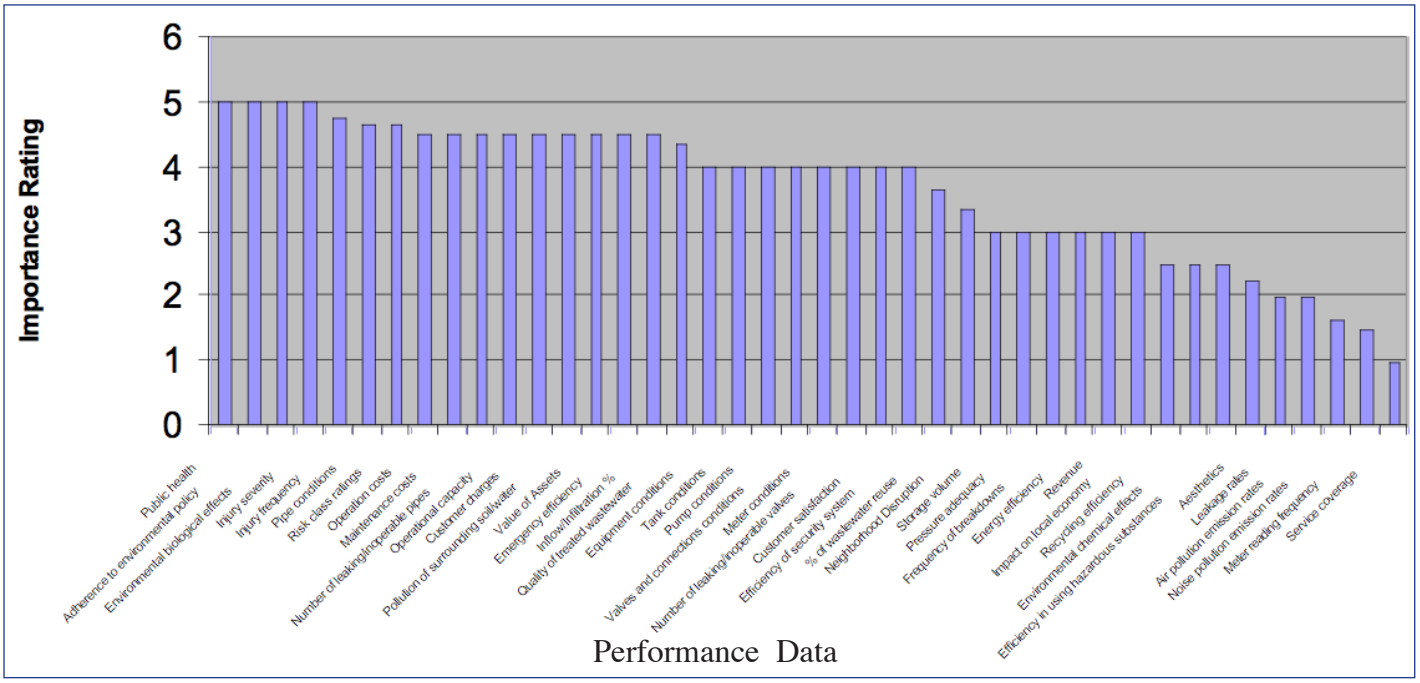

Figure 9: Wastewater Performance Indicators (Abdelrahman, 2003)

Appendix B: Survey of asset management practices in the GTA

This survey aims to document the current practices of asset management in water and wastewater infrastructure in the GTA. This will cover technical and organizational aspects.

Scoring System

When applicable, please use a scale of 1-10 (with 10 being the best) when answering questions.

Technical aspects of asset management

Performance Measures:

1. What are the macro measures used in assessing the water and wastewater system performance?

Data collection

Contents

1. What is included in the inventory of assets?
2. What are the main indicators used for assessing the performance of water and wastewater assets?

Reliability

1. How adequate are the available data: do they cover all assets? Do they cover the whole life cycle of the asset?
2. Is the data collection methods/test suitable/adequate for the intended purposes?
3. How accurate are the available data?

Process

1. How consistent and effective is the data collection process? What are the types of inspection and tests currently used?
2. What is the level of training/competency of existing staff?
3. Do you track the costs of data collection?

Information Management

Data interoperability

1. Do you have an organization-wide asset management system?
2. How integrated are your database systems
3. Do you use a common data model (MIDS, MDW)?

Analysis tools

Which of the following tools do you use/have?

1. Forecasting Tools: mainly deterioration models to assess the status of current systems and their future states. Linking system performance to surrounding environment
2. Engineering-economic analysis: These tools include lifecycle cost analysis; benefit/cost analysis; optimization and prioritization; and risk analysis. These analytical tools attempt to identify the option that will achieve established performance objectives at the lowest long-term cost, or provide maximum benefit for a given investment/funding level.
3. Long term planning and econometric analysis tools: linking future investment levels to future condition and performance. Assessing the impact of various maintenance options.

Decision making

Decision criteria

Rate the level of consideration of the following criteria in your decision making system?

1. How can we preserve, maintain, or improve our assets to ensure the maximum useful life and provide acceptable service to the public?
2. What resources are available? What is the budget level? What is the projected level of future funding?
3. What investment options may be identified within and among asset component classes? What are their associated costs and benefits?
4. Which option, or combination of options, is “optimal?”

5. What are the consequences of not maintaining our assets? How can we communicate the impact of the condition and performance of our assets on the system and end user?
6. How do we monitor the impact of our decisions? How do we adjust our decision-making framework when indicated?
7. How can we best manage our assets in order to least inconvenience the motoring public when we repair or replace these facilities?

Decision making system

Please assess the adequacy of the following features in your decision making system?

1. Access to information: timeliness and reach to all stakeholders.
2. Representation: clear representation of asset management issues at various project development processes
3. Level of group decision making and communication tools

Organization aspects of asset management

Organizational goals, policies, and budgets establish a driver and an umbrella for the asset managed system.

Mission and Strategic Plans

1. Clarity of asset management mission? What are our goals and policies?
2. What are the Non-engineering/non-economic factors that reflect an agency's values, perceptions, and objectives?
3. Clarity and objectively defined user priorities, values, and standards?
4. How clear are the following the merits of system preservation, needed upgrades, and continued operating reliability that customers expect of a highway agency and all the facilities and assets it manages. The relationship between preservation, upgrading, operation, and return on investment and customer
5. How much of your work is driven by clear asset management tools and plans:

Integration

Intra-organization communication (horizontal and vertical) is key for successful implementation of asset management systems. Traditionally, agencies that have established systems that focus on individual asset classes. The result has been so-called "stovepipe" operations with limited horizontal coordination.

Please comment on the following:

1. Efficiency of communication channels in transmitting information required by legislators, the public, and other stakeholders; agency executives; and front-line practitioners?
2. What type of information is exchanged? How detailed or adequate?
3. What are the coordination mechanisms?
4. How are long term plans developed? How are changes made and managed?
5. Integration of maintenance program with the planning and design programs.
6. Levels of partnering with other companies and contractors?

Appendix C: Value Engineering

Value engineering is an organized, systematic, and multi-disciplined team approach that analyzes the functions of systems, equipment, facilities, services, and supplies for the purpose of eliminating unnecessary costs while maintaining the required performance, quality, and safety of the functions required by the customer (Dell'Isola 1998). Since its inception, Value Engineering has evolved into a fundamental process that is aimed at identifying cost and/or performance improvement opportunities while maintaining or improving the functions desired by the customer.

Value analysis is made up of the following six different phases:

1. Information Phase: The objective of the information phase is to gather information in addition to that collected in the pre-study for the project under analysis.

2. Functional Analysis Phase: Considered the heart of the VE process. The objective of this phase is to develop a baseline system through defining the fundamental product, process, or service task and breaking it down into its basic and secondary or supporting functions. This breakdown can be accomplished through building a functional model. The functional model will provide a graphical representation of the functions of the product or service under analysis and the relationship between each function.

3. Creativity Phase: In the creativity phase the value analysis team "brainstorms" and identifies as many alternative ways of performing the functions of the candidate items having the greatest worth/cost mismatch, as identified by the functional analysis. Every alternative possible should be recorded, even if considered outrageous or wildly impractical. The time devoted to brainstorming alternatives should be relatively short. The alternatives should not be evaluated or discussed during this phase. Evaluation of alternatives occurs in the next phase.

4. Evaluation Phase: The objective of the evaluation phase is to evaluate the alternatives identified in the creativity phase. A first cut through the alternatives should eliminate impractical or unfeasible alternatives and those that obviously do not meet the requirements established in the pre-study. The alternatives are grouped by their similarities and each group is analyzed for the advantages and disadvantages that can be expected. Each group should also be evaluated as to its importance to the project. With a ranking of the groupings and the advantages and disadvantages of each, the alternatives are evaluated both as a group and individually to determine which alternatives offer the greatest potential for improvement and should, therefore, be further developed.

5. Development Phase: In this phase, the remaining alternatives are refined and developed into a value engineering proposal. These proposals will include detailed descriptions of the alternative(s); the benefits to be expected by implementation (both cost and performance), initial cost summary, expected life cycle costs, and any impacts that would affect the project schedule.

6. Implementation Phase: The final phase of value analysis is the implementation phase. This phase sometimes is broken into two parts, one for presentation and approval, and the other for formal implementation. The objective of this final phase is to get the approval of the sponsor to proceed in implementing the recommendations in the final design.