Infrastructure Canada

Part of the Transport, Infrastructure and Communities Portfolio

Literature Review of Methodology to Evaluate the State of Infrastructure

Commissioned from Guy Félio, Dillon Consulting Limited

Research & Analysis Division
Infrastructure Canada
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Canada

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1.0 Introduction

1.1 The Mandate

There have been discussions within Infrastructure Canada (INFC) and with stakeholders about the need and feasibility of producing a state of the infrastructure (SOTI) report for Canada.

In 1985, the Federation of Canadian Municipalities (FCM) published the first report on an "infrastructure deficit". Since then, various groups have provided estimates of the commonly called "Canada's Infrastructure Gap" (the accumulated deficit between what needs to be invested and actual expenditures – the debt), which, depending on the methodologies used range from $57 billion[1] to $125 billion[2].

There are a number of national, regional or local initiatives in Canada and internationally that have produced state of the infrastructure reports in various formats, and therefore can be used as lessons learned.

Dillon Consulting was contracted by the Research and Analysis (R&A) division of INFC to provide a literature review of relevant and representative initiatives that have produced state of the infrastructure reports similar to those used in Australia and the United States, and to gain a better understanding of data gathering and analysis tools used in international initiatives on asset management.

1.2 Needs Studies versus State of the Infrastructure Reports

There are inherent differences between needs studies (usually referring to investment needs) and state of the infrastructure reports (focused on current condition and performance).

State of the infrastructure reports focus on the current or recent situation depending on the data available. It is most common to evaluate the condition of the infrastructure in terms of its engineering performance since this is the field where most of the data is available. Assumptions are usually made regarding levels of service for these types of reports since standards of health and safety only provide the lowest threshold for engineering performance and do not consider social, economic or environmental factors. Report cards and infrastructure audits are some forms of state of the infrastructure reports used in various countries.

Need Studies are aimed at forecasting (usually over a 5 to 15 year period) the resources required to maintain or improve the infrastructure. In order to achieve this forecast, authors make a number of assumptions which often are not reported in the studies. Some of these assumptions include, but are not limited to:

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[1] *Civil Infrastructure Systems technology road map*, Canadian Society for Civil Engineering (CSCE), 2003

[2] *The State of Infrastructure in Canada: implications for Planning and* Policy, Mirza, S. and Haider, M., report to Infrastructure Canada, 2003

• Condition of the infrastructure (usually in engineering terms)
• Current and future demand
• Existing and future practices
• Evolution of the technology
• Levels of service

The authors, implicitly or explicitly, consider the above assumptions to produce a "need", usually expressed in terms of financial investments.

The INFC Research and Analysis Division produced a review of key studies on infrastructure needs[3]. The study concluded that the variation in methodologies, scope and definition resulted in a wide range of investment needs and that a comparison between studies did not allow to arrive at a comprehensive, accurate figure for infrastructure needs in Canada.

Some organizations have done both, the current evaluation of their infrastructure condition and performance, and the investment needs to bring their infrastructure to an "acceptable level of service". Municipalities like Edmonton or Hamilton (see details later) have gone this route. Cities in Australia and New Zealand have also used such approaches.

2.0 Definitions

Adding to the complexity of various methodologies used in need or condition studies, there is the question of common definitions and terminology. There is no "adopted" glossary of terms for infrastructure. For example, the report to Infrastructure Canada by the Canada West Foundation (CWF)[4] provides a high level overview of these issues and proposes some definitions. The *InfraGuide* best practices each contain a glossary of terms; the overall glossary (from all the best practices) was never published.

Particularly when assessing needs, it is therefore crucial that a common terminology be adopted to allow for aggregation.

3.0 Literature Review

[3] *Assessing Canada's Infrastructure Needs: a Review of Key Studies*, Infrastructure Canada Research and Analysis Division, 2004

[4] *Municipal Infrastructure in Canada: Issues of Terminology and Methodology,* C.G. Vander Ploeg, Canada West Foundation, report to Infrastructure Canada, November 2003.

The literature review focused on **methodologies used to identify 1) the gap between infrastructure investment needs and actual expenditures; and 2) the current condition/performance of infrastructure systems** at national, regional or local levels.

The literature was screened for relevancy, including but not limited to the objectives of the work (e.g., awareness vs. policy development vs. investment planning), data requirements, and overall potential use in the present Canadian context.

The screening included, but not limited to, answering questions such as:

- Objectives of the study/report? (e.g., who is the target audience?)
- Scope? (e.g., how was “infrastructure” defined?)
- Drivers? (e.g., who championed the initiative, what led to the decision to do study, etc.)
- Methodology used? (e.g., surveys, document reviews, etc.)
- Who was involved? (stakeholder representation; selection of participants, etc.)
- Barriers/obstacles encountered?
- Validation of results? (e.g., process used, by whom)
- Communication process? (including reactions from targeted audience)
- Lessons learned? (if the process was repeated, what – if anything, was done differently?)

The review of the literature was conducted from various sources:

- Published literature: in addition to the extensive publications available to Dillon staff, a comprehensive search (national, international) using the Canadian Institute for Scientific Information (CISTI) at the National Research Council (NRC) was conducted. These searches included the social sciences and policy literature;
- Internet searches: provided general information on activities relating to the project as well as to point towards sources to be explored further;
- Knowledge from practitioners, academics and government officials (national, international): identified and contacted when required to obtain relevant information on the topics at hand.

The technical literature (CISTI search) provided articles and studies relating to methodologies for specific types of infrastructure assessments (mostly in terms of engineering) or theoretical works. The social sciences, economics and policy literature also mostly reported theoretical approaches. Both were not directly relevant to this project and therefore not reported here.

4.0 Results

As expected, the literature provided reports on studies with varying scopes (i.e., the types of infrastructure considered), goals (i.e., condition versus needs), approaches (i.e., surveys versus desktop literature reviews). The following sections present the studies that were found to be most relevant for this project.

4.1 International

From the international perspective, two types of studies were relevant to this project:

• **State of the infrastructure reports**: presented in different formats
- Report card formats are used by the following countries: Australia, South Africa, United Kingdom, and the United States
- "Stocktake": audit of infrastructure conducted in New Zealand

• **Asset management and long term community plans:** particularly in New Zealand where these plans are required under the NZ municipal act. Please note that the evaluation of these plans is not included in this report.

The Organisation of Economic Co-operation and Development (OECD) International Futures Programme – Infrastructure targets high level, policy oriented audiences and has produced several reports, mostly comparators between countries. These reports were not evaluated in this project.

4.1.1 Australian Infrastructure Report Card 2005 - Engineers Australia

The release of the Australian infrastructure report card of 2005 is the latest in a series of studies started in 2000 (National level) which was followed by an update in 2001 and state/territory report cards between 2003 and 2005. The report assigns letter grades to key infrastructure sectors on an A to D + F scale (***Appendix A - 2005 Australian Infrastructure Report Card***).

4.1.2 New Zealand Infrastructure Stocktake - Ministry of Economic Development (2004)

The report presents the findings of the Infrastructure Audit component of the Ministry of Economic Development's infrastructure stocktake project (2004). It was prepared by PricewaterhouseCoopers.

In general, the findings indicated:

> "… at a national level, New Zealand's infrastructure is in reasonable condition. Subject to an ongoing appropriate level of investment, it should not pose a barrier to the Government's growth and sustainable development objectives. But, notwithstanding the overall positive message, there are significant local and sector-specific issues. These may have significant impacts, both locally and nationally."

More details can be found in ***Appendix B*** **- New Zealand Infrastructure Stocktake**.

4.1.3 Infrastructure Report Card for South Africa - South African Institution of Civil Engineering – SAICE (2006)

SAICE, in the first infrastructure report card for South Africa, investigated nine of the built environment infrastructure sectors. Sectors not investigated included transport as in rolling stock and the operation of road and rail services, housing, schools, stormwater and flood management, and the natural environment.

The format used is that of a report card which assigned a letter grade in six categories (similar to the UK or US cards). Refer to ***Appendix C*** **– Infrastructure Report Card for South Africa** for more details.

4.1.4 State of the Nation Report - UK Institution of Civil Engineers (2006)

This is the fifth State of the Nation report prepared by the Institution of Civil Engineers (ICE) of the UK – the process started in 2002. Refer to **Appendix D – UK State of the Nation Report** for more details.

ICE presents the evaluation of the condition of infrastructure in a report card format and tracks the progression (positive or negative) over the years. For each infrastructure sector considered, the report indicates:

- The present grade
- Change since last report card (up, stable, down)
- A sustainability grade (a measure of how well the service meets the needs of today without compromising those of the future).

4.1.5 Report Card for America's Infrastructure - American Society of Civil Engineers (2006)

The ASCE 2005 report card (**Appendix E**) is the fourth produced by the ASCE. The Society's regional chapters have also produced report cards at the State level.

Public awareness and influence of the government(s) agenda are the primary objectives of the report cards (e.g., media reports of the collapse of the I-35 Bridge earlier this month in Minneapolis refer frequently to the report card).

4.2 Canada

4.2.1 National

At the National level, two studies were retained for a more detailed analysis:

• **Transit Infrastructure Needs for the Period 2006-2010 - Canadian Urban Transit Association (2006)**
This is CUTA's fourth biannual infrastructure survey. The Canadian Urban Transit Association (CUTA) has estimated the infrastructure requirements of transit systems across the country to be $20.7 billion for the period 2006–2010. In late 2005, CUTA surveyed its transit system members, asking them to detail their capital infrastructure needs for the next five years. Seventy systems responded; they represented 96.6% of total Canada-wide transit operations according to annual operating costs. Refer to ***Appendix F*** for more details.

• **Municipal Water and Wastewater Infrastructure: Estimated Investment Needs 1997-2012 - Canadian Water and Wastewater Association (1997, revised 1998)**
The report was sponsored by CMHC and asked the Canadian Water and Wastewater Association (CWWA) to examine future investment needs for the municipal water and wastewater industry over a 15 year period. Refer to **Appendix G** for more details.

The study focused on the following elements:
- Potable water: mains, storage tanks, treatment plants
- Wastewater: sewers, combined sewer separations, treatment plants

• **Canadian Community Infrastructure: An Analysis of First Nations on Reserve versus Canadians off Reserve Community Infrastructure Deficit - PWGSC for INAC (2005)**
The report presents an on-reserve and off-reserve infrastructure deficit analysis.

4.2.2 Provincial/Territorial

Provincial/Territorial jurisdictions have all, at one time or another produced either state of the infrastructure reports or needs studies. Methodologies and scopes are varied.

Although some of the information at the P/T or regional level was collected, no detailed analysis was conducted because of the short timeline of this study. However, it is worth noting that such information exists and could be the subject of a detailed analysis.

4.2.3 Regional/Local

Two examples were retained at the municipal level: Hamilton and Edmonton. These cities are the recognized Canadian, if not North American leaders in the development and implementation of asset management and investment planning systems and strategies.

• **Life-Cycle State of the Infrastructure Report on Public Works Assets - City of**

Hamilton (2005, 2006)
In 2005, the City of Hamilton undertook the life-cycle evaluation of some of its (public works) infrastructure assets. The 2006 State of the Infrastructure (SOTI) builds on the previous report and expands the types of infrastructure been evaluated (**Appendix H**).

• **Edmonton's City Council Infrastructure Strategy 2006 - City of Edmonton (including 2002, 2004 studies)**
The City of Edmonton's *Council's Infrastructure Strategy* builds on two previous key reports (**Appendix I**):

- 2002 update of the city's *Infrastructure Strategy*: this report identified "the gap", the difference between the projected cost of infrastructure projects and the financing available to pay for them. Two key figures in the report illustrate the expected service life of infrastructure assets as well as their condition as shown below
- 2004 report *Thinking Outside the Gap***:** this report explores corporate strategies in terms of how to close the gap (e.g., opportunities for revenues) and managing the gap (e.g., maximize use of infrastructure, asset management).

Work reported by the Canada West Foundation[5] established a context within which the infrastructure needs of the largest Western Canada cities (Vancouver, Calgary, Edmonton, Saskatoon, Regina and Winnipeg) were evaluated. The study used a three-pronged approach:

• A literature review and an in depth analysis of the cities' capital plans
• An analysis of past capital spending (national, regional, and local)
• The development of an economic model

4.3 Other Sources of Data/Information

A complete list of other sources of data/information that has the potential to support the development of a state of the infrastructure report for Canada is beyond the mandate of this report. It suffices to say that a number of sources of engineering, economic and other data exist. One of the challenges will be the acquisition of this data since it may resides in a multitude of locations (e.g., municipalities) and difficult to access in an acceptable format.

Some databases/data sources exist that can provide information directly or indirectly applicable to a state of the infrastructure report. These include but are not limited to:

• Statistics Canada: National Accounts
• Environment Canada: Water use statistics

[5] *A Capital Question: Infrastructure in Western Canada's Big Six*, C. Vander Ploeg, Western Cities Project Report #27, Canada West Foundation, October 2003

Furthermore, the National Water and Wastewater Benchmarking Initiative, and, at the regional level, the Ontario Municipal Benchmarking Initiative (OMBI) could provide information in terms of unit costs (e.g., low, median, high) and other common municipal activities if a needs study is considered.

5.0 Summary and Highlights

From the review of key international and national initiatives presented in this report, it is evident that not one approach (i.e., needs versus condition studies) is perfect. The following provides a generalization of the processes and lessons learned.

- Most state of the infrastructure reports are aimed at awareness (the target audience may vary but in general includes the public and elected decision makers). The second main common objective of these studies is to influence senior government decisions.
- Most studies are performed in a 12 month timeframe, considering that the first time around takes somewhat longer.
- Costs (expenditures) range generally between CAD $100K to CAD $300K with one exception. All reports have significant in-kind contributions from the stakeholders involved in the process.
- Basic infrastructure systems are at the core of the studies: transportation, water resources, energy.
- All of the international initiatives are uni-dimensional in terms of stakeholder involvement: most are produced by the engineering community with NZ as the exception.
- The main barriers to the production of these reports in consistently data availability and, for needs studies, costing. At the release stage, groups/organizations that did not participate in the production can be a major obstacle.
- In terms of lessons learned, three key issues stand out:
    - There needs to be tight evaluation (i.e., process) criteria from the beginning.
    - Multi-dimensional stakeholder involvement (i.e., from regions, sectors, professions, etc.) is essential.
    - No one should expect 100% accuracy

6.0 Asset Management Initiatives

Infrastructure assets management has its origins in the early 70's with the work conducted by the US Army Corps of Engineers (US-ACE) on pavement management systems (PMS) for airfields. The process was quickly expanded to highways as various US Departments of Transport, the US Federal Highway Administration (FHWA) and the US Transportation Research Board (TRB) built on that work, adding knowledge and technologies to the process.

In the early 90's, building on the PMS experience, asset management systems for other linear infrastructure were developed: water transmission and distribution, storm and wastewater collection, and sidewalks.

In 1995, the Institute of Public Works Engineers of Australia (IPWEA) joined with its sister organization in New Zealand, Ingenium, to produce the *International Infrastructure Management Manual (IIMM)*. This technical manual contains generic procedures on how to do inventory, condition assessment and prioritization, and also country specific chapters. In recent years, IPWEA/Ingenium have added country specific chapters for South Africa, the UK and the United States.

In AU and NZ as well, the IPWEA and Ingenium created *National Asset Management (NAM)* committees to support asset management activities. For example, NAMS-AU has the following objectives:

- To improve the Asset Management skills of practitioners
- To provide national co-ordination and guidelines
- To identify future research and directions for AM
- To raise the awareness of and commitment to sustainable management of assets amongst the community and by decision makers
- To develop and provide for exchange of ideas, information and technology
- To develop strategic asset management, its processes and to achieve practical outcomes
- To provide leadership and support to stakeholders
- To provide public policy advice and advocacy to advance asset management issues for the betterment of the wider community.

In recent years, there have been discussions for NAM type committees in the UK, USA and South Africa.

In the United States, besides State/Municipal asset management work, initiatives are sectoral with the FHWA mostly dealing with highways and bridges, the US Environmental Protection Agency (US-EPA) for water resources, and the American Water Works Association (AWWA) for potable water.

In Canada, as a result of the *Civil Infrastructure Systems* technology roadmap published in 2003, a Canadian National Asset Management Working Group (NAM-WG) was created. This group, co-chaired by CPWA and INFC, prepared a national asset management framework (in its final stage of publication at the time of this writing). It is composed of multi-sector, multi-profession representatives (public works, engineering, urban planning, government finance, academia, provincial/federal government, municipalities and accounting). The NAM-WG has also established a sub-working group on asset valuation.

Finally, the City of Hamilton organized in May 2007 the first CAN-National Asset Management forum which was attended by 35 municipalities, provincial/federal

representatives, and industry. The aim of the forum was to share issues and solutions. The city of Halifax will be the host of the 2008 CAN-AM forum.

7.0 Discussion

The literature review, and discussions about the various initiatives considered for this report indicate that there is a large body of data on the subject. The challenge for the production of a state of the infrastructure report or a needs study is thus to translate this data, which is sometimes difficult to access, into information that can be used in establishing condition or needs.

One good example is the Ontario Good Roads Association (OGRA) Municipal Data Works (MDW) system, a web-based data storage repository based on a common data standard used presently by approximately 150 Ontario municipalities. In addition to the core asset inventory repository, MDW features structure inspection, capital investment plan, and water and sewer modules.

The upcoming Public Sector Accounting Board (PSAB) requirements for municipalities to report on their tangible assets is in the process of generating inventory, condition and asset value (historical) data from a great number of municipalities across the country. This information will be reported starting early 2009 and thus provides an opportunity to access a broad body of information.

Finally, in deciding which type of study (e.g., needs versus state of the infrastructure reports) or on the format (e.g., audit versus report card) some key questions should be answered:

- What are the objectives?
- Who should be involved?
- What is the timeframe?
- Will this be a “one-of” or will there be follow-ups?

Appendix A

2005 Australian Infrastructure Report Card
Engineers Australia - September 2005

Summary

The release of the Australian infrastructure report card of 2005 is the latest in a series of studies started in 2000 (National level) which was followed by an update in 2001 and state/territory report cards between 2003 and 2005.

The report assigns letter grades to key infrastructure sectors on a A to D + F scale (see methodology for details). The summary results are shown in the table below.

The summary results are shown in the table below.

Infrastructure Report Card Results

Infrastructure Type Category	Sub-category	AUS 2005	AUS 2001	AUS 1999	NSW 2003	QLD 2004	VIC 2005	SA 2005	NT 2005	WA 2005	TAS 2005	ACT 2005
Roads	National	C+	C	C	C+	C+	C	C	B-	B-	B	
	State	C	C-	C-	C+	C	C-	C-	C-	B-	C	
	Local	C-	D	D	C-	C	C-	D	C-	C+	D+	
	Overall	C	C-	C-	C	C	C-	C-	C	B-	C	B
Rail		C-	D-	D-	D	C+	C-	C	A	C+		
Electricity		C+	B-		B	D+	C	B-	B-	B-	B-	B
Gas		C+	C			C	C	B+	A	B+		A-
Ports		C+	B			B-	C		B+	B-	B	
Water	Wastewater	C+	C-	D-	C-	C+	B	C	C	B-	D+	B
	Potable Water	B-	C	C-	C	B	B	C+	B-	B-	D+	C
	Stormwater	C-	D		D	C	C-	D	C+	C+	C-	C
	Irrigation	C-	D-			C+	D		B	C+		
	Overall	C	D+	C-	C-	C+	B-	C-	C+	C+	D	C+
Airports		B	B			B			B+			B
Overall Rating		**C+**	**C**	**D+**	**C-**	**C+**	**C**	**C**	**B**	**B-**	**C-**	**B-**

Objectives

The objectives of the report card are clearly expressed in the published document, quote:

"The purposes of the Engineers Australia 2005 Australian Infrastructure Report Card and Engineers Australia's State and Territory Infrastructure Report Cards include:

- Raising awareness that infrastructure underpins the community's quality of life and that inadequate infrastructure impedes economic and social growth.

- Generating debate on the quality and level of infrastructure provision required to meet society's needs (which includes condition, distribution, funding and timing).
- Encouraging the implementation of best practice infrastructure provision and management, including adopting total asset management principles, a sustainable approach and demand management.
- Identifying the state of the infrastructure sectors and the challenges facing infrastructure providers."

Scope

The report card evaluated three major infrastructure sectors :
• **Transportation**: roads, rail, ports and airports
• **Water resources**: potable water, storm and wastewater, irrigation
• **Energy**: electricity and gas

Drivers

Engineers Australia is the National body representing all engineers in the country. Part of its mandate is to inform governments and the public on issues that demand attention and that relate to the health and safety of the public.

The principal driver for the report card was a concern by the engineering community about the condition of public infrastructure and the need to bring awareness about these issues to government and public.

Methodology

All report cards were produced by a consulting firm. In general criteria were set by Engineers Australia and public documents were compiled – i.e. "best available information" was used, analyzed and presented to an expert panel of Engineers Australia who did the scoring. The process was enriched by interviews with key infrastructure providers (e.g., utilities).

Who was involved

The process involved only the engineering community with no other professions involved.

How long did it take

Approximately 18 months to produce the report cards for all states/territories and the national card.

How much did it cost

Approximate costs include:

Consultant: CAN $140K-$180K
Production (publish, mail): CAN $50K
Staff and volunteer time: N/A
Funded internally.

Barriers/Obstacles encountered

There initially was some government (State/Territory and Federal) resistance because of potential criticisms. However, indications are various governments in Australia have adopted some of the recommendations from the various report cards, set up advisory committees to support decision making, and using the results for investment decisions.

Validation of results

No specific process.

Lessons learned

Engineers Australia is in the process of planning the next report card. In terms of improvements, they are looking at tighter/different evaluation criteria.

Appendix B

New Zealand Infrastructure Stocktake
Ministry of Economic Development (NZ) - January 2004

Summary

The report presents the findings of the Infrastructure Audit component of the Ministry of Economic Development's infrastructure stocktake project (2004). It was prepared by PricewaterhouseCoopers.

In general, the findings indicated:

> "… at a national level, New Zealand's infrastructure is in reasonable condition. Subject to an ongoing appropriate level of investment, it should not pose a barrier to the Government's growth and sustainable development objectives. But, notwithstanding the overall positive message, there are significant local and sector-specific issues. These may have significant impacts, both locally and nationally."

The study reported particular issues, for example:

- Land transport (road congestion, lack of public transit) in Auckland
- Deferred maintenance of the rail network
- The Security of potable water supply in drought prone areas
- Small communities water and wastewater systems (particularly those with large seasonal population variations
- Future electricity generation

The study concluded with the need for continued investment across all infrastructure sectors in order to maintain or improve existing quality and, ideally, pre-empt issues that may emerge in the future.

Objectives

The aim of the this project was to assess the quality of New Zealand's energy, water, transport and telecommunications infrastructure and how they contribute to/impede achieving the Government's economic growth and sustainable development objectives.

The evaluation was been undertaken at a relatively high level:

- Assess the condition of the existing assets;
- Evaluate the extent to which the infrastructure meets current demand;
- Assess whether infrastructure is likely to be able to meet demand in the future, and the responsiveness of the infrastructure to changes in demand going forward;

- Provide some high level commentary on the sustainable development implications of the current and expected infrastructure stocks;
- Raise issues identified during the project for consideration in policy-making; and
- Provide a potential indicator framework for further development in the future.

Scope

• Electricity
• Gas
• Water
• Transportation; (roads, airports, ports, railways)
• Telecommunications

Drivers

Following a number of infrastructure failures (particularly in the energy sector but also with road congestion problems in the key economic centre, Auckland), the Central government wanted to have a "fresh look" at the infrastructure landscape of the country.

Methodology

The general approach mostly consisted of a literature review with limited interviews and survey. The project examined infrastructure at a national level with no consideration of local problems even if they may have national impacts.

The research focused in issues of supply and demand therefore taking primarily an economic perspective.

Who was involved

This was a central government lead initiative and the majority of the persons involved came from the central government, almost exclusively with high level economics background.

How long did it take

The study was done over a 6 month period.

How much did it cost

Estimated cost: CAD $200K. Funded by Ministry.

Barriers/Obstacles encountered

A particular challenge was obtaining data/collaboration from the telecommunications sector because of the competitive environment they operate in.

At the time of the release of the report, there was a “pushback” from the engineering community that felt the problems had been underestimated. Further, there was a background debate taking place at the same time regarding better use of infrastructure assets (in terms of pricing and demand management) which generated strong political reactions when the report came out.

Validation of results

No specific validation process.

Lessons learned

Some of the lessons learned include:

- Seek a more multi-profession (e.g., involve economists, engineers, planners, etc.) in the process.
- Better focus on the issues, particularly sustainability (too many sustainability dimensions were included)

Appendix C

Infrastructure Report Card for South Africa
The South African Institution of Civil Engineering - 2006

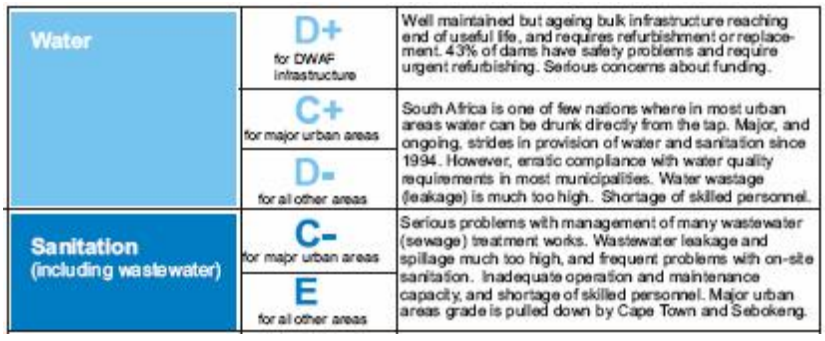
Summary

SAICE, in the first infrastructure report card for South Africa, investigated nine of the built environment infrastructure sectors (see scope section later). Sectors not investigated include transport as in rolling stock and the operation of road and rail services, housing, schools, stormwater and flood management, and the natural environment.

SAICE also confined its attention to the most significant of the infrastructure only for some sectors. For example, with respect to airports, it investigated only the airports owned and operated by the Airports Company South Africa (ACSA).

The format used is that of a report card (see sample below) which assigned a letter grade in six categories (similar to the UK or US cards). The authors cautioned however the interpretation of the results, indicating:

> "Caution needs to be exercised in interpreting the report card table adjacent. The single
> symbols for each sector (e.g. water) hide huge variations in the condition and performance of the infrastructure within each sector. Water quality, for example, is excellent in the metropolitan areas (although there are invariably problems of ensuring reliable supply at all times, and water losses are often unacceptably high), but water quality in many more rural areas, including small towns, is frequently below the standards laid down."



Water	D+ for DWAF infrastructure	Well maintained but ageing bulk infrastructure reaching end of useful life, and requires refurbishment or replacement. 43% of dams have safety problems and require urgent refurbishing. Serious concerns about funding.
	C+ for major urban areas	South Africa is one of few nations where in most urban areas water can be drunk directly from the tap. Major, and ongoing, strides in provision of water and sanitation since 1994. However, erratic compliance with water quality requirements in most municipalities. Water wastage (leakage) is much too high. Shortage of skilled personnel.
	D- for all other areas	
Sanitation (including wastewater)	C- for major urban areas	Serious problems with management of many wastewater (sewage) treatment works. Wastewater leakage and spillage much too high, and frequent problems with on-site sanitation. Inadequate operation and maintenance capacity, and shortage of skilled personnel. Major urban areas grade is pulled down by Cape Town and Sebokeng.
	E for all other areas	

Objectives

Awareness was the primary goal of the report, with a wide target audience composed of politicians, civil servants, local authorities, trade/regulatory/consumer bodies, and the media.

Scope

The infrastructure considered is as follows:

• water (including water resources and water supply)
• sanitation and wastewater
• solid waste management
• Transportation (roads, airports, ports, railways)
• electricity generation and distribution
• hospitals and clinics.

Drivers

N/A

Methodology

SAICE relied upon published reports and members' knowledge as the source of information. A panel of experts was created to analyze information collected and produce the letter grades.

Who was involved

Members of SAICE (Civil engineering community).

How long did it take

N/A

How much did it cost

N/A

Barriers/Obstacles encountered

N/A

Validation of results

Internal.

Lessons learned

N/A

Appendix D

UK – State of the Nation Report
Institution of Civil Engineers (UK) - October 2006

Summary

This is the fifth State of the Nation report prepared by the Institution of Civil Engineers (ICE) of the UK – the process started in 2002.

ICE presents the evaluation of the condition of infrastructure in a report card format and tracks the progression (positive or negative) over the years.

For each infrastructure sector considered, the report indicates:

- The present grade
- Change since last report card (up, stable, down)
- A sustainability grade (a measure of how well the service meets the needs of today without compromising those of the future).

The grades can be interpreted as follows:
A Good B Fair
C Average D Poor
F Bad

	2002	2003	2004	2005	2006
Overall	C–	D+	D+	D+	C–
Energy	C–	D+	D	D	D+
Waste management	D	D	D	D	C–
Water and wastewater	B	B+	B+	B+	B
Flood management	C	C+	C+	C+	C
Transport					
Rail	C–	D	C–	C	C
Roads	C+	C+	C+	C+	C+
Local transport	D+	–	C	C	C
Airports	–	–	B–	C+	C+
Seaports	–	–	B–	B–	B–

*Where no grade is given the sector was not included in that year's report.

Objectives

There are two main objectives to the report cards:

1. Raise the profile of the profession (civil engineering) and the issues relating to infrastructure.
2. Use the technical expertise of the profession to influence Parliament's agenda.

Scope

The infrastructure systems evaluated are presented in the table of the summary section above. The report card involved national and regional evaluations. At the regional level, the focus was on local perspectives and examples of infrastructure challenges.

Drivers

One of the drivers was the consolidation of information pertaining to infrastructure condition and needs. In addition, the civil engineering profession of the UK felt there was a pressing need in 2000 to raise issues concerning the state of the country's infrastructure.

Methodology

The data was collected and analyzed by engineering experts from the ICE Boards and from the regional chapters (10 regions). Some boards/regions used external data collection mechanisms but most relied on existing documentation.

Each sector (e.g., energy, waste management) provided recommendations to the State-of-the-Nation report Board who in turn did the grading.

The process is managed by the ICE and external help is sought when needed.

Who was involved

Civil Engineers members of ICE.

How long did it take

Twelve (12) month process.

How much did it cost

The main costs are associated with printing and mailing of the report (10,000 copies) and estimated at approximately CAD $200K. This does not include the time of ICE staff or members involved. It was funded internally.

Barriers/Obstacles encountered

N/A

Validation of results

Internal through ICE boards.

Lessons learned

From a report card perspective, the initial scoring influences future reports and therefore the process of assigning grades has to be rigorous from the beginning.

The consolidation of the data and research associated with the recommendations provided benefits in terms of identifying big-picture issues and sector specific challenges. The reports have generated “spin-off” studies that address particular issues identified in the process.

Appendix E

Report Card for America's Infrastructure
American Society of Civil Engineers (ASCE) - 2005

Summary

The 2005 report card is the fourth produced by the ASCE. The table below summarizes and compares the results of the ASCE report cards published to date. ASCE regional chapters have also produced report cards at the State level.

Category	2005	2001	1998	1988
Aviation	D+	D	C-	B-
Bridges	C	C	C-	C+
Dams	D	D	D	n/a
Drinking Water	D-	D	D	B-
Energy	D	D+	n/a	n/a
Hazardous Waste	D	D+	D-	D
Navigable Waterways	D-	D+	n/a	n/a
Public Parks and Recreation	C-	n/a	n/a	n/a
Rail	C-	n/a	n/a	n/a
Roads	D	D+	D-	C+
Schools	D	D-	F	n/a
Security	I	n/a	n/a	n/a
Solid Waste	C+	C+	C-	C-
Transit	D+	C-	C	C-
Wastewater	D-	D	D+	C

Objectives

Public awareness and influence of the government(s) agenda are the primary objectives of the report cards (e.g., media reports of the collapse of the I-35 Bridge earlier this month in Minneapolis refer frequently to the report card). The California report card states:

> "Long Term: Provide a report on what is needed to sustain well-maintained, efficient, and safe and secure infrastructure facilities and systems, sufficient to meet the current and future needs of a growing State and protective of our quality of life.
>
> Short Term: Educate the public and political leadership so that they will be supportive of developing, enacting and implementing the practices and funding mechanisms needed to realize our long term vision."

Scope

The report includes twelve infrastructure categories: roads, bridges, mass transit, aviation, schools, drinking water, wastewater, dams, solid waste, hazardous waste, navigable waterways, and energy. The 2005 report card added parks and recreational facilities, rail and security to its list of infrastructure systems evaluated (see table in summary section).

Drivers

N/A

Methodology

The ASCE assembled an Advisory Council - a panel of 24 experts ("leading civil engineers) and conducted an extensive literature review, analyzing "hundreds of studies, reports and other sources". ASCE also surveyed more than 2,000 engineers to obtain their impressions of issues and challenges in the field.

The grading system used for this report is based on an infrastructure category meeting a percentage of given criteria. Percentage ranges used were:
D 60 to 69%
C 70 to 79%
B 80 to 89%
A over 90%

For example, roads would receive a grade of C if 77% of roads were in good condition or better. The ASCE assigned grades based on condition and capacity, and funding versus need. The Advisory Council reviewed and revised base grades, sometimes adding a '+' or a '-', and sometimes adjusting for a full letter grade, to reflect current positive or negative trends.

Who was involved

ASCE members.

How long did it take

N/A

How much did it cost

N/A

Barriers/Obstacles encountered

N/A

Validation of results

Internal

Lessons learned

N/A

Appendix F

Transit Infrastructure Needs for the Period 2006-2010
Canadian Urban Transit Association - April 2006

Summary

This is CUTA's fourth biannual infrastructure survey.

The Canadian Urban Transit Association (CUTA) has estimated the infrastructure requirements of transit systems across the country to be **$20.7 billion for the period 2006–2010. In late 2005**, CUTA surveyed its transit system members, asking them to detail their capital infrastructure needs for the next five years. Seventy systems responded; they represented 96.6% of total Canada-wide transit operations according to annual operating costs.

Of the $20.7 billion required, 44% is needed to rehabilitate or renew existing infrastructure, while 56% is needed to expand service capacity for ridership growth. These figures speak to the dual need of replacement and of response to the growth potential for transit. Indeed, restoring transit infrastructure to a state of good repair and responding to the increasing mobility needs of the growing Canadian urban population are both critical.

Objectives

There were two main objectives to the studies:

1. Document, to the best of CUTA's ability, the order of magnitude of transit infrastructure needs as identified by the transit agencies.
2. Provide an image of the type of infrastructure transit agencies are responsible for, identify the gap between expenditures and needs.

Scope

All infrastructure under transit agencies' responsibilities, categorized by type:

1. buses (purchases or refurbishment);
2. other rolling stock — including heavy or light rail vehicles;
3. fixed guideways or rights-of-way (construction or enhancement);
4. maintenance facilities;
5. stations or terminals;
6. parking facilities — for commuters at stations, terminals or interchanges;
7. transit priority measures — infrastructure designed to give transit vehicles priority over other traffic flow;
8. customer amenities — including bus stop enhancements, shelters, signage, etc;

9. advanced technology — such as automatic vehicle location, advanced fare collection and customer information systems; and
10. other, which varied by responses.

Drivers

The key drivers to the studies have been:

1. Characterize future transit infrastructure needs for awareness and lobbying purposes.
2. Provide better information to business members (suppliers to the transit agencies) on future/potential work

Methodology

Surveys were sent to all CUTA member transit systems whose vehicles together comprise more than 98% of the national urban transit fleet.

Transit systems were asked to list their budgeted capital infrastructure needs for the next five years (2006–2010) by dollar value. It was categorized by:

- expenditures for **replacement or rehabilitation** versus expenditures for **expansion** in response to population growth or promotion of new ridership;
- expenditures **currently planned** (under existing funding arrangements) in comparison to **additional needs that could only be met through new external investment**; and
- relative priority levels.

Who was involved

Transit agencies (CUTA membership) were asked to provide information.

How long did it take

Approximately 6 months.

How much did it cost

Without including costs from transit agencies (in-kind), the cost estimate is $100K. Funded internally.

Barriers/Obstacles encountered

The process works well for CUTA since transit agencies form a cohesive group and there is no competition between agencies – therefore information is easier to share.

Influence of political decisions (e.g., Ottawa public transit) creates uncertainty in the long term forecast of needs. CUTA has settled on a 5-year forecast to address part of that uncertainty.

Validation of results

Internal, by CUTA staff.

Lessons learned

Extra care is needed when there is overlap in jurisdictions (e.g., City of Montreal plan and Regional transit agency plan) to ensure there is no double-counting.

Other comments

CUTA has started process for 2008-2012 report.

Appendix G

Municipal Water and Wastewater Infrastructure: Estimated Investment Needs 1997 to 2012
Canadian Water and Wastewater Association - April 1997 (Revised April 1998)

Summary

The report was sponsored by CMHC and asked the Canadian Water and Wastewater Association (CWWA) to examine future investment needs for the municipal water and wastewater industry over a 15 year period.

The study focused on the following elements:
• Potable water: mains, storage tanks, treatment plants
• Wastewater: sewers, combined sewer separations, treatment plants

The CWWA reported investment needs in the order of $90 billion broken down as follows:

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

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

Objectives

The study's main objective was to determine, using a simple methodology and available – albeit limited, data, investment needs for water and wastewater. In terms of infrastructure objectives, CWWA defined "end points" as follows:

> "The "end points" of the CWWA estimate are that all "urban" residents of municipalities should be connected to public water and wastewater systems; that water supplies should meet the Canadian Drinking Water Guidelines; that storm and sanitary sewer systems should be separate; and that wastewaters would be treated to Level III wastewater treatment standards."

The estimates considered four categories of investment needs:

- Maintenance of current infrastructure
- Expansion of current systems to urban population without complete services
- Improvements of current infrastructure
- Growth

Scope

The focus was on potable water and wastewater systems.

Drivers

N/A (CMHC requested study)

Methodology

CWWA used the best available aggregated statistics on the size of the water and wastewater industry based on populations served (available nationally and by province for several years – e.g., from Statistics Canada, EC Municipal Water and Wastewater surveys) and the levels of service (i.e., access to services) provided. The formulation of estimates was made for current and future capital investment, replacement capital needs and expansion or enhancement capital needs by applying to those population based data, aggregated investment, cost and other factors derived from various sources (e.g., American Water Works Association studies). Where required, the data was converted to standardized units (e.g., population served per km of water main, cost of a treatment plant per capita served) to facilitate the process of estimation. Unit costs were obtained from practitioners.

Quoting CWWA:

> "The advantage of this is fundamental simplicity and perhaps a minimization of overall error by the use of aggregated statistics and factors.
>
> The disadvantage is that the level of accuracy on a province-by-province basis may be high since the expansion factors are aggregated nationally, and may not, indeed will not reflect regional variations. Thus the value of the estimates diminishes as the level of disaggregation increases."

Who was involved

The study was conducted by CWWA staff using its membership for input. CWWA created an Advisory Board (from its membership) to oversee the project.

How long did it take

Approximately 3 months.

How much did it cost

CWWA was paid $10K in 1997 to produce the report. This does not include time from members (in-kind) to support the study.

Barriers/Obstacles encountered

The major challenge was finding the data:

> "Canada has little data readily available on municipal infrastructure. Provincial data exists, but it is largely not available. Federal data is reasonably good where it exists, but the coverage is incomplete. Industry data is sometimes relevant, but its reliability and applicability is moot."

Validation of results

There was no built-in validation process. The estimates were compared to other studies of similar nature (e.g., the FCM-McGill 1996 study, "Winnipeg as a model" – extrapolation, NRTEE estimates)

Lessons learned

A survey of municipalities of various sizes would provide means to better calibrate the model and validate the results.

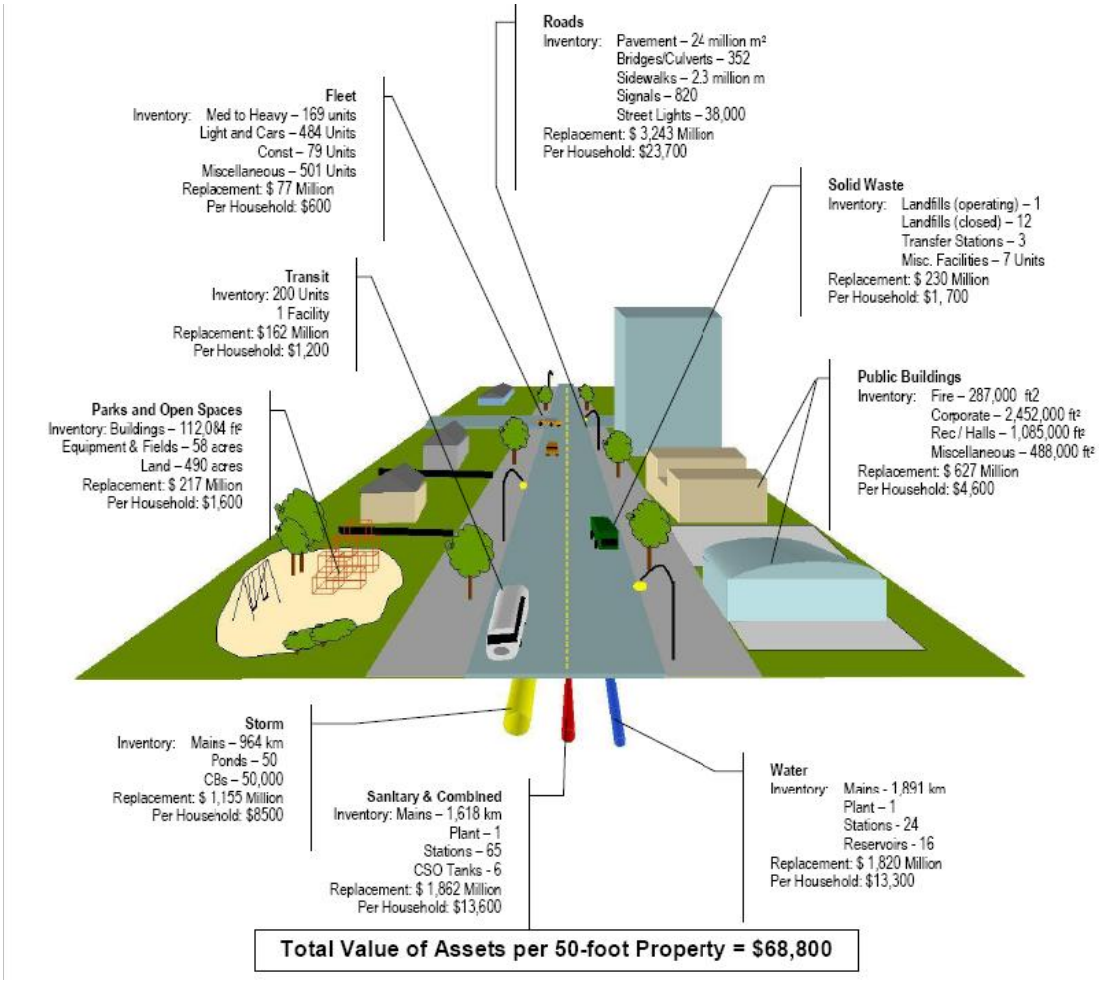
Appendix H

Life-Cycle State of the Infrastructure Report on Public Works Assets - 2006 City of Hamilton (ON) - February 2007

Summary

In 2005, the City of Hamilton undertook the life-cycle evaluation of some of its (public works) infrastructure assets. The 2006 State of the Infrastructure (SOTI) builds on the previous report and expands the types of infrastructure been evaluated.

A key finding of the report is the replacement value and its per/property cost represented in the graphic below, which illustrates the net worth of infrastructure assets for Hamilton (from 2005 SOTI):



The report, produced in an asset management context, uses a report card format with trends for a 15-year period.

City of Hamilton 2006 Infrastructure Report Card			
Asset Group	Rating 2006	Comments	Trend 2020
Public Transit Services	B	The transit system appears to be sufficiently funded at this time, on a full pay-as-you-go basis. Ratio of fares to subsidy is currently about 1:1, and is projected to increase to 1.2:1 as ridership increases. Future growth of the City, as well as plans to improve and expand service will require annual increases in the Transit budget of 3% plus inflation.	
Central Fleet Services	C	Fleet Services ins now on a full-cost recovery basis with full replacement charges to the user departments. Slight increases in reserve fund contributions can result in significantly lower cost over all and should be implemented as soon as possible.	
Waste Management Services	C	Waste Management Services are rapidly growing. This will create a "bubble" of assets that will require rehabilitation and replacement in a similar short time frame in the future. Future growth of the City will also put tremendous pressure on this service. The Waste Management Master Plan is currently being developed. However, failure to develop and implement the necessary infrastructure reinvestment policies in the short-term will cause the future trend to deteriorate rapidly.	

Objectives

The main objectives of the SOTI report were:

- Communications: with a broad audience in mind
- Long term planning: production of life-cycle based tools that include capital, operating and maintenance costs.

Scope

As indicated earlier, the 2000 SOTI report builds on the previous' year work. Between the two reports, the following infrastructure assets were covered:

• Water: networks (potable, wastewater, storm)
• Transportation:
    - Structures (roads)
    - Rolling stock (fleet, transit)
    - Transit system
• Waste management
• Facilities and open spaces
• Forestry services

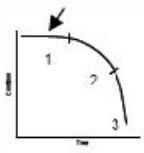
Drivers

The main driver for the SOTI report was and remains sustainability. The first exercise was conducted in the late 90's for water and wastewater services which produced a sustainability plan. The acceptance of the process resulted in the buy-in to expand and evaluate all municipal assets.

Methodology

The SOTI report is based on the InfraGuide assets management framework. It relies on an inventory and condition assessment to establish replacement costs and remaining service life. The work was done with the help of an external consulting team. The process used existing data as well as expert input when data was not available.

The detailed rating (letter grade – A: excellent; B: good; C: Fair; D: poor; and F: failed) evaluated the assets on: condition and performance, capacity and funding as shown below.

Asset Type	Asset Component	Condition	Detailed Rating (A, B, C, D or F)		2005 Rating (A, B, C, D or F)	Projected 2020 Rating
Distribution	Hydrants		Condition & Performance	B	B	
			Capacity vs. Need	B-		
			Funding vs. Need	B+		

Other assumptions, regarding for example deterioration models or financial, are well described in the report.

Who was involved

City of Hamilton staff with the support of a consulting engineering firm.

How long did it take

Approximately 1 year.

How much did it cost

Although difficult to estimate accurately because of the staff time involved, the cost is estimated (based on City of Hamilton information) at $200K.

Barriers/Obstacles encountered

Two major obstacles were noted:

- Lack of documented data easily accessible: since baseline data was required, interviews with operational groups provided input and were used to validate with some of the data at hand.
- Engaging different groups in the process: the interviews mentioned above helped in this process.

Validation of results

Validation was done at three levels:
• Internally
• Comparison with other cities
• Through benchmarking initiatives

Lessons learned

The SOTI report (and report card) were used to engage the internal stakeholders, to create buy-in, and therefore allow to move forward. Up-front communication was key in the success of the process. It was felt that an audit type exercise would not have achievement the level of buy-in required.

Other comments

Next steps:
The city of Hamilton plans to refine some of its asset estimates to ensure all public works infrastructure is covered. The SOTI report will then provide the foundation for the development of a management framework leading to the development of policies (e.g., about service levels). An audit may be conducted after this stage, possibly including revisiting the SOTI report in 3-4 years from the 2006 report.

Appendix I

Edmonton City Council's Infrastructure Strategy 2006
City of Edmonton (AB)

Summary

The City of Edmonton's *Council's Infrastructure Strategy* builds on two previous key reports:

- **2002 update of the city's *Infrastructure Strategy***: this report identified "the gap", the difference between the projected cost of infrastructure projects and the financing available to pay for them. Two key figures in the report illustrate the expected service life of infrastructure assets as well as their condition as shown below

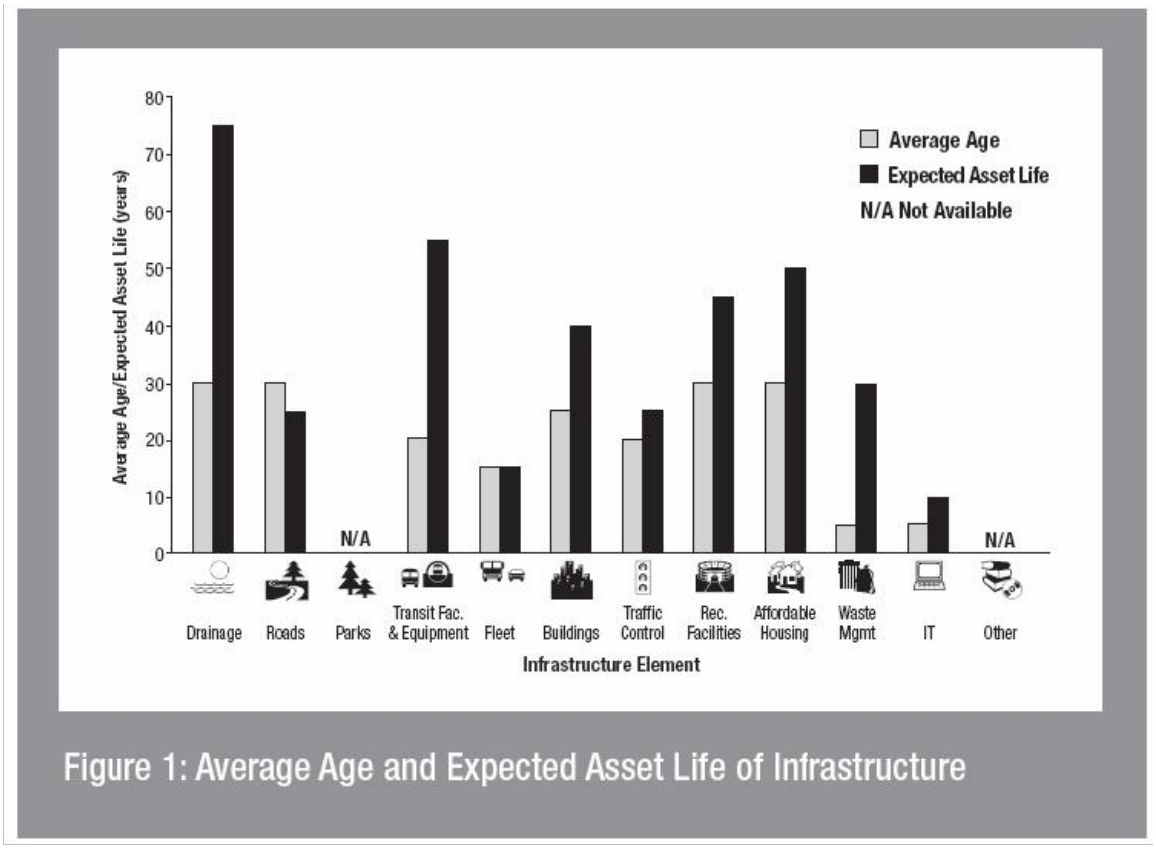
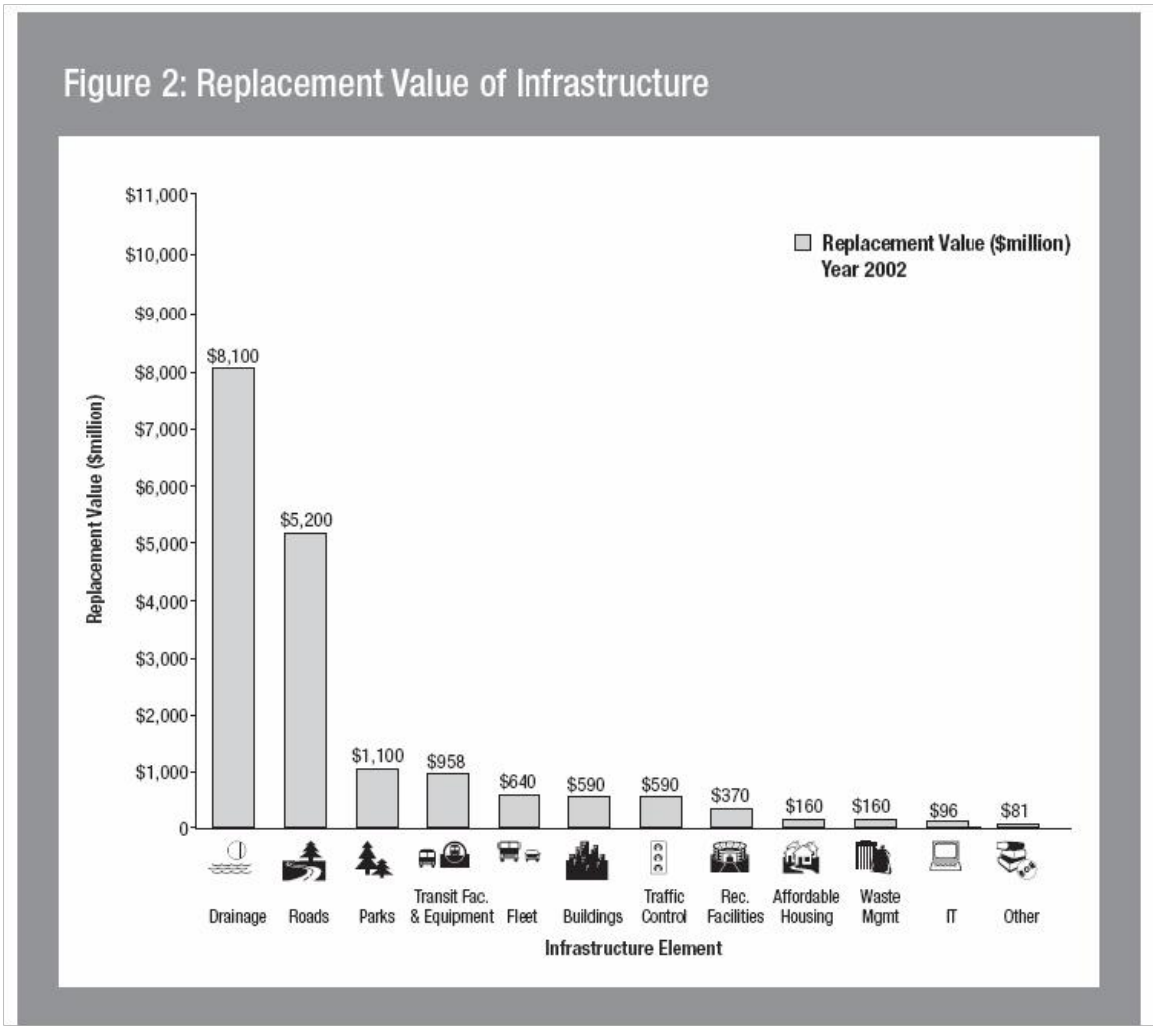


Figure 1: Average Age and Expected Asset Life of Infrastructure



- **2004 report *Thinking Outside the Gap*:** this report explores corporate strategies in terms of how to close the gap (e.g., opportunities for revenues) and managing the gap (e.g., maximise use of infrastructure, asset management).

The 2006 builds on these reports and presents the City Council's infrastructure strategy, including the Council's vision:

Council's Vision

Sustainable infrastructure, maintained through sound financial policies and asset management practices, will contribute to the vibrancy of the City's economy; the vitality of its neighbourhoods; safety of its citizens; protection of the environment; and its capacity to accommodate growth.

Objectives

The main objectives of the reports (2002, 2004 and 2006) are:

- Help council manage the infrastructure
- Have reliable information on inventory and condition assessment (for planning and operational purposes)
- Close the infrastructure gap (revenues + re-investment strategies)
- Manage the infrastructure gap (asset management)

Scope

All infrastructure owned and operated by the city of Edmonton (see Figures 1 and 2)

Drivers

The drivers for the 2002-2006 reports go back several decades including the 70's boom, the 80's bust (including a Council decision in 1983 of fiscal restraint – no borrowing), the early 90's high unemployment, cutbacks in terms of infrastructure grants and the first tri partite infrastructure program (Canada Infrastructure Works Program – CIWP). These events led the City to do a first "infrastructure gap" study in 1998 and the creation of the *Infrastructure Office* in 2000.

Methodology

The approach is based on InfraGuide's Asset Management framework and applied to the corporate and division (operations) level. It is life-cycle based and relies on data from the City.

Who was involved

Originally the reports were produced by City staff. The City has created an Infrastructure Advisory committee which includes public representation through the Edmonton Federation of Communities League.

How long did it take

The "evolution" of the report took approximately 2 years between iterations.

How much did it cost

Not available

Barriers/Obstacles encountered

During the production of the 2002 report, lack of data or lack of knowledge about the condition (except for roads and pipes) was an inherent problem. Age was used as a

proxy when no other data existed. Costing , i.e., unit costs (particularly for buried infrastructure) also presented challenges.

Initial concerns about the use of the results influenced the commitment to the process, adding resource obstacles.

Validation of results

Internal.

Lessons learned

The road from the first infrastructure gap analysis (1998) to the Council's Infrastructure Strategy (2006) led to a changing philosophy about infrastructure investment: from "this is the money we have therefore this is what we can do" to "these are the needs we have, therefore we will go get the money we need".

Other comments

A tri-lateral government committee – the Edmonton tri-lateral infrastructure working group (Edmonton, Alberta, Canada) was created as forum to share and find solutions to Edmonton's infrastructure problems.

The present challenges faced by the City are growth: managing the existing while ensuring longevity of the new. The focus is now on long term sustainability (i.e., a 30-year horizon) including assessments of demand/supply followed by an evaluation of impacts and options to prevent/mitigate these impacts (if negative).

Next steps:
The city of Edmonton is now moving to using risk assessment modeling to evaluate the impacts of investment decisions and prioritizing.

The City is presently developing public involvement plan with an education component.