Canada's guide to sustainable municipal infrastructure: decision-making framework

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CANADA'S GUIDE TO SUSTAINABLE MUNICIPAL INFRASTRUCTURE: DECISION-MAKING FRAMEWORK

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Abstract

Canada has embarked in the development of a National Guide to Sustainable Municipal Infrastructure to support the decision-making process for investment and long term planning as well as provide users with technical tools and proven methodologies. The project was officially launched in July 1999 after several years of consultations with public and private stakeholders across the country.

The article examines the process used to involve municipal infrastructure practitioners, public and private, in the definition of the Guide and the results, to date, of that involvement. The development framework for the Guide is also presented. Finally, several best practice documents are presently being elaborated and will be released to Canadian municipalities as consultation documents. The article describes the decision-making framework and as well as examples of prioritisation criteria being discussed.

Keywords: municipal infrastructure, best practices, decision-making processes, infrastructure management

1. Introduction

Effective public administration requires a thorough appreciation of the interdependent quality of government operations. Not least among these are decision making and planning as they relate to municipal infrastructure. However, these functions are best considered in the context of the constraints imposed by the often-contradictory objectives of public policy. Municipal governments are no less susceptible to this reality than are the senior levels of government. Faced with growing demands, and yet possessing limited financial and personnel resources, municipalities are becoming increasingly concerned with the methods and techniques appropriate for municipal decision making.

It is arguable that the complexity of decision making as it relates to infrastructure has significantly increased in recent years (Bingham, 1991). This growth can be seen on many levels, be they technical, legal, political, social, environmental or financial.

In terms of legal complexity, the growth of interdependence between various levels of government has resulted in a commensurate growth in the complexity of regulations. Increased political complexity for its part can be traced to a growth in the number and variety of stakeholders. The consequence of which is a paradox whereby the necessity for political consensus is aggravated yet, necessitated by a commensurate increase in the number of preferences and interests. It is important to note the linkage between the growth in political complexity and the changes in the dynamics of society generally. There exist genuine differences between relevant interests that are premised on conflicting value hierarchies. Case in point is the increased salience of the environment to some stakeholders relative to the emphasis placed on economic growth by others. Finally, with respect to financial complexities one must appreciate the increased cost of capital and constrained fiscal discretion.

The demands placed on municipal administrators and decision-makers are complicated and often founded on conflicting considerations. The fact that Canadian municipalities are creatures of their respective provincial governments constrains the discretion of decision-makers while obligating them in other ways. The dependence of municipalities on provincial treasuries for a significant measure of their fiscal capacity serves to intensify the challenges confronted by municipal public administrators and decision-makers. Most salient among these challenges is determining how to respond to municipal infrastructure exigencies.

Infrastructure can be defined as the underlying framework of a system. Accordingly, municipal infrastructure consists of physical man made facilities such as transportation, water supply and distributions systems and sewage collection and treatment facilities. This network provides the essential foundation for the economic and social activities that comprise the basis of a community's existence. While the importance of municipal infrastructure might be appreciated, any suggestion that this is paralleled by recognition of the complexity inherent in decision making relative to infrastructure is dubious.

Providing adequate infrastructure implicates numerous mutually dependent tasks. These include sustaining existing structures, increasing existing capacity and establishing new facilities. In addition, there is mounting pressure for the integration of different variants of infrastructure, in particular transportation and telecommunications. Aggravating matters is the incidence whereby infrastructure issues are lost to general political debate. This mandates that administrators and politicians be proactive relative to infrastructure, in the face of prevailing ignorance or worse yet, apathy. Effective political leadership is needed to provide vision and fashion consensus, both of which are indispensable ingredients for effective infrastructure policies (OECD, 1993). Finally, there is the issue of financing.

As implied earlier by reference to the limited fiscal discretion of municipalities, the financing capacity of municipal governments is significantly more constrained than either of the senior levels government. The net manifestation of which is the inability of municipalities to assume and implement all the projects deemed desirable. Rather what occurs more often than not is an ad hoc decision that often lacks sufficient deliberation. The drawback of which is an increased risk that public funds and effort will not be expended in the most propitious of ways. Consequently, a framework or process according to which capital expenditure projects are evaluated and prioritised in the context of limited financial resources is required.

2. The Guide to Sustainable Municipal Infrastructure Concept

Following a year of public consultations regarding the needs, by Canadian municipal infrastructure practitioners from the public and private sectors, the National Research Council of Canada (NRCC) decided in 1999 to start the development of a best practices guide (referred hereafter as "the Guide") to address critical issues associated with decision-making, investment planning, and the use of innovative technologies for potable water and wastewater systems, and for municipal road networks.

The participants at two National workshops determined the main objectives and goals of the Guide as shown in the text-box below.

OBJECTIVES OF THE NATIONAL GUIDE TO SUSTAINABLE MUNICIPAL INFRASTRUCTURE

In support of the protection and enhancement of municipal infrastructure, and taking into consideration level and quality of service, protection of the environment, and health and safety, the *National Guide to Sustainable Municipal Infrastructure* will be a best practices tool for decision-making and long term planning.

OBJECTIVES
In order to improve service and satisfaction with infrastructure, the Guide, while considering risk management and addressing the local and regional diversity of Canadian municipalities (small/large, urban/rural, old/new, arctic/temperate, seismic, etc.), will

- help in prioritising funding allocations
- assist in decision-making and long term planning
- assist in the selection of best technologies;
- illustrate best strategies for highest return on investment
- assist in the evaluation of life cycle costs; and
- support benchmarking

Source: Based on NRC / FCM / CPWA National Workshop, Aylmer, March 1998 - see www.nrc.ca/irc for report.

In July 1999, the NRCC created a pan-Canadian Project Steering Committee. The function of this committee lay in the identification of priority areas for the development of pilot best practices, the establishment of a process by which best practices would be developed - modelled after the highly respected Building and Fire Codes processes, which have been managed by the NRC for more than 50 years, and the creation of a National network of experts that will participate in the development of the Guide.

The following are key considerations under which the Guide is being developed:

- The Guide will build on the vast array of existing knowledge regarding municipal infrastructure practices and development. Its content will reflect the experience of practitioners and will be validated through input from academic and institutional researchers as well as from the public at large/citizenry, owing to its status as primary stakeholder. The content will not be a radical departure from current and familiar practices and will be introduced gradually.

- Regional input and feedback, ongoing communication, and information sharing in the design and development of the Guide will come from First Nations representatives and from Provincial/Territorial associations.

- The Guide will be a practical and user friendly tool **for** municipal infrastructure and therefore will be developed **by** municipal stakeholders. To develop and maintain a relevant Guide a number of critical elements are key:
    - Development will be based on consensus.
    - Every effort will be made to avoid "reinventing the wheel" (i.e., in the areas where acceptable and accepted best practices exist, the Guide will simply refer to them).
    - The process will involve all municipal infrastructure stakeholders and will rely on technical expertise and regional input from them. Regions will be defined using a matrix approach, which will consider six principal geographical areas and key attributes as outlined below.

Regional Considerations Matrix	
Regions	**Key Attributes**
• British Columbia • Prairies • Ontario • Quebec • Atlantic Canada • North (including Northern Quebec & Labrador)	• Climate (freeze/thaw, temperate, severe, etc.) • Topography (hill/ mountain side, plains, etc.) • Size (large/ small cities, rural) • Geology (inc. seismicity) • Others

The main sectors for project work have been identified through extensive consultations. The three initial target areas are:

1. potable water systems (production, distribution),
2. storm and wastewater systems (collection, treatment, disposal), and
3. municipal roads and sidewalks.

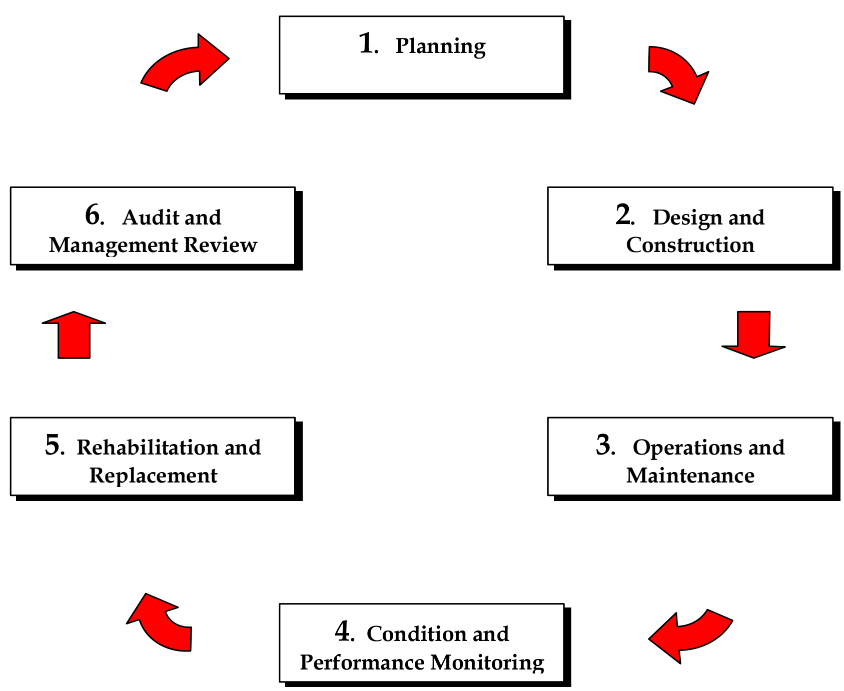
The Guide will consist of two interrelated parts:

Part A: A decision-making and investment-planning tool.

This tool is intended for use by municipalities. Specifically, the tool will aid in assessing their needs while helping technical staff, as well as elected officials, manage their infrastructure assets more effectively. All of which will be accomplished through reliance on best practices in the selection, development and implementation of infrastructure projects. This tool will also facilitate a process that includes ongoing monitoring, evaluation and feedback.

Part B: A compendium of technical best practices.

Various sets of technical modules will provide municipal infrastructure practitioners with best practices for the choice of best available technologies and methodologies. These best practices will be developed in the context of the life-cycle asset management functions illustrated below. The technical best practices will comprise the majority of the Guide.



Best practices, in the context of the Guide are defined as follows:

> "A best practice describes the best available technology or methodology to provide a deliverable by optimising return on investment while recognising local conditions and objectives."

3. A Municipal Infrastructure Asset Prioritisation Framework

The purpose of this framework is to assist in the evaluation of infrastructure alternatives under consideration by municipal decision-makers. This is realised by a methodology that is consistent, transparent and comparable across alternatives. Consequently, the capacity of political decision-makers to convert information into knowledge is augmented, thereby improving the quality of their decisions (Hamilton-Wentworth, 1999). Note that any possible framework should not be construed as an attempt to usurp the decision-making discretion of political representatives. Rather it should be conceived as a servant of the public interest, intended to determine which project is most worthy of implementation.

Accordingly, a framework should facilitate:

- First-class information within the context of transparent and fixed decision criteria;
- Knowledgeable decisions by government on priorities and investment alternatives;
- The maximisation of economic and social results within prescribed financial limitations;
- An unprejudiced, yet co-ordinated investment plan characterised by an optimal blend of infrastructure projects; and
- Implementation that relies on existing analysis models and procedures.

It should be emphasised that any framework intended to support prioritisation and investment decision making must be based on an unfettered appreciation and comprehension of the local government's strategic focus. Anything less will engender cross-purpose action, thus mitigating the attainment of the strategic goal(s). In order that this risk may be averted, the most comprehensive set of criteria possible should be utilised. Doing so will ensure that decisions are premised on a consideration of all factors deemed relevant. The result of which will be an optimal trade-off analysis (Danylo and Lemer, 1998). Consequently, so too will the decision made be the best attainable.

The process by which information is converted into knowledge for the purposes of evaluation is contingent on the application of decision criteria or attribute categories (Hamilton-Wentworth, 1999). Accordingly, a series of quantitative weights and scores may be used in the derivation of a composite evaluation index. At this point, a detailed description of some of the considerations inherent in a prioritisation framework will be illustrated. It is important to note that the description is not intended to be exhaustive nor complete, but rather provide ideas and guidelines for the development of frameworks unique to the requirements of respective municipalities.

3.1 Decision Criteria

Major decision criteria worthy of consideration include:

A. ***Correlation with government strategies;***

Correlation with government strategies considers the extent to which a project complements broad formal government strategy. This requires an assessment of a project both in its own right and as a constituent part. While a project might contribute towards government strategy in isolation, it may be that in concert with other projects it elicits contradiction and cross purpose outcomes. The concern essentially is the effect of a project candidate on municipalities' growth strategy.

B. ***Financial impact;***

Financial impacts deal with the issues of cost and return on investment. In short, is the cost of a project justified by the expected benefits?

C. ***Economic impact;***

Economic criteria are concerned with economic benefits from a number of perspectives. For example:

- Poor roads can slow the flow of goods and traffic, which has negative economic effects;
- The work to repair and replace infrastructure is labour-intensive and can be an excellent source of job creation, with its own set of positive economic effects; and,
- A well maintained infrastructure is a positive feature in relation to the attraction of business.

D. ***Social and community impact;***

Social and community impact includes health and safety considerations. Accordingly, effects are categorised in terms of their impact on identified urban and regional communities especially as they relate to safety and security. The health and safety of citizens should therefore be the primary consideration in the development, maintenance, repair and replacement of infrastructure. For example:

- Lack of an adequate sewer system can create significant environmental problems and dangerously effect the health of individuals;
- Lack of lighting can increase the incidence of crime and accidents; and,
- Poor roads can increase the rate of accidents and slow the flow of goods and traffic.

E. ***Environmental impact;***

The environmental criterion relates to the impact of a project on the surrounding natural environment. Matters worthy of consideration extend from habitat loss to toxic leachate from landfill sites.

F. ***Asset management and risk; and,***

Asset management and risk relates to the management of risk factors associated with respective projects. Accordingly, asset condition and maintenance costs are pertinent as are public and worker safety.

G. ***Legislated/contractual obligations.***

Legislated/contractual obligations refer to commitments imposed on municipalities by either contracts, or orders and guidelines mandated by senior levels of government.

This framework does not attempt to assign weights or scores to the preceding criteria. This task is the purview solely of decision-makers. They must imbue their value assumptions upon the criteria.

Finally, in order to make weights and scores meaningful it is necessary that performance measures exist that reflect the respective attributes. In order to assess its progress a municipality generally and a public works department in particular, needs to develop a set of performance measures, or indicators, for each asset (APWA, 1998). The development of performance measures that suggest to managers, elected officials and the public how well the municipality is fulfilling its obligations is a process that takes time and effort. At best, such metrics are clues rather than definitive measures of the status quo. They are thus meaningful only if knowing the results will make a difference to the decision-maker. It is better to rely on a few reliable measures as the basis for evaluating asset performance than rely on many of dubious quality.

3.2 Management/Decision Support

The presence of an *Asset Data Management System* becomes fundamental at this juncture. Information and data must be available to administrators and decision-makers in order that project evaluation and prioritisation may be realised. The knowledge required with which to make decisions is simply unattainable without the basis provided by information and data. As alluded to earlier this support should include:

- An inventory of prior expenditure and future planned capital programs; and,
- A legacy of the status and condition of the entire infrastructure network, including its interrelations.

3.3 Summary

- Candidate investment projects should be identified in the context of a long-term strategic planning framework. This framework should avail broad directions and priorities for infrastructure development.
- The use of clear and relevant decision criteria and standards should be employed in assessing candidate projects against one another. The weighting of criteria serves to enable such trade off.
- An investment evaluation framework is intended to augment rather than appropriate the accountability and discretion of decision-makers. As such, the relative weighting of the impact categories considered is the responsibility of decision-makers exclusively.
- A standardised format for the evaluation of infrastructure and capital expenditure alternatives enables projects to be methodically and critically assessed. Accordingly, a comprehensive and consistent methodology is assured.

Sample evaluation criteria, their corresponding indicators and metrics are illustrated in the table below.

A Model Evaluation Criteria Table

Decision Criteria	Indicator	Metric
♦ **Support of government strategy** ▪ Interaction with other projects	▪ Key strategy element ▪ Other reinforcing projects	▪ Contribution to strategy ▪ Increase/reduction in impact
♦ **Financial** ▪ Cost ▪ Return on investment	▪ Capital and operating costs ▪ Commercial return	▪ Cost time streams ▪ Net Present Value ▪ Present Value Costs
♦ **Economic** ▪ Return on investment ▪ Growth /development ▪ Industry support ▪ Industry competitiveness	▪ Economic return ▪ Multiplier effects ▪ Specific industry impacts	▪ GNP, jobs, government revenue ▪ Breadth of project benefits
♦ **Social/community** ▪ Safety and security ▪ Community support	▪ Safety	▪ Number of dangerous incidents
♦ **Environmental** ▪ Public health ▪ Aesthetics ▪ Wildlife	▪ Hazardous emissions ▪ Habitat loss ▪ Parks land	▪ Number of sewer and landfill leaks ▪ Changes in habitat area ▪ Amount of greenspace
♦ **Asset Management and Risk** ▪ Project risk	▪ Asset condition ▪ Risk factors such as changes in demand and financing	▪ High maintenance cost or risk ▪ Public/worker safety ▪ Variations in risk factors and associated outcomes
♦ **Legislated/Contractual Obligations** ▪ Imposition of unavoidable commitments	▪ Legal text/contracts ▪ Provincial government policy and priorities	▪ Impact on discretion in municipal strategy ▪ Impact on financial discretion

4. A Municipal Infrastructure Asset Management/Decision Making Framework

While it is important for municipalities to be able to choose among competing infrastructure alternatives, it is also important to manage their life cycles. This is the objective of the *Municipal Infrastructure Asset Management/Decision Making Framework*. There are two considerations within the context that this framework operates that should be observed. One is the fact that infrastructure assets experience deficiencies and breakdowns. The other is the capacity to plan and anticipate these deficiencies in order that optimal infrastructure management is assured. The following framework attempts to provide a blueprint for dealing with both the reactive (immediate) and proactive (long-term) aspects of municipal infrastructure management.

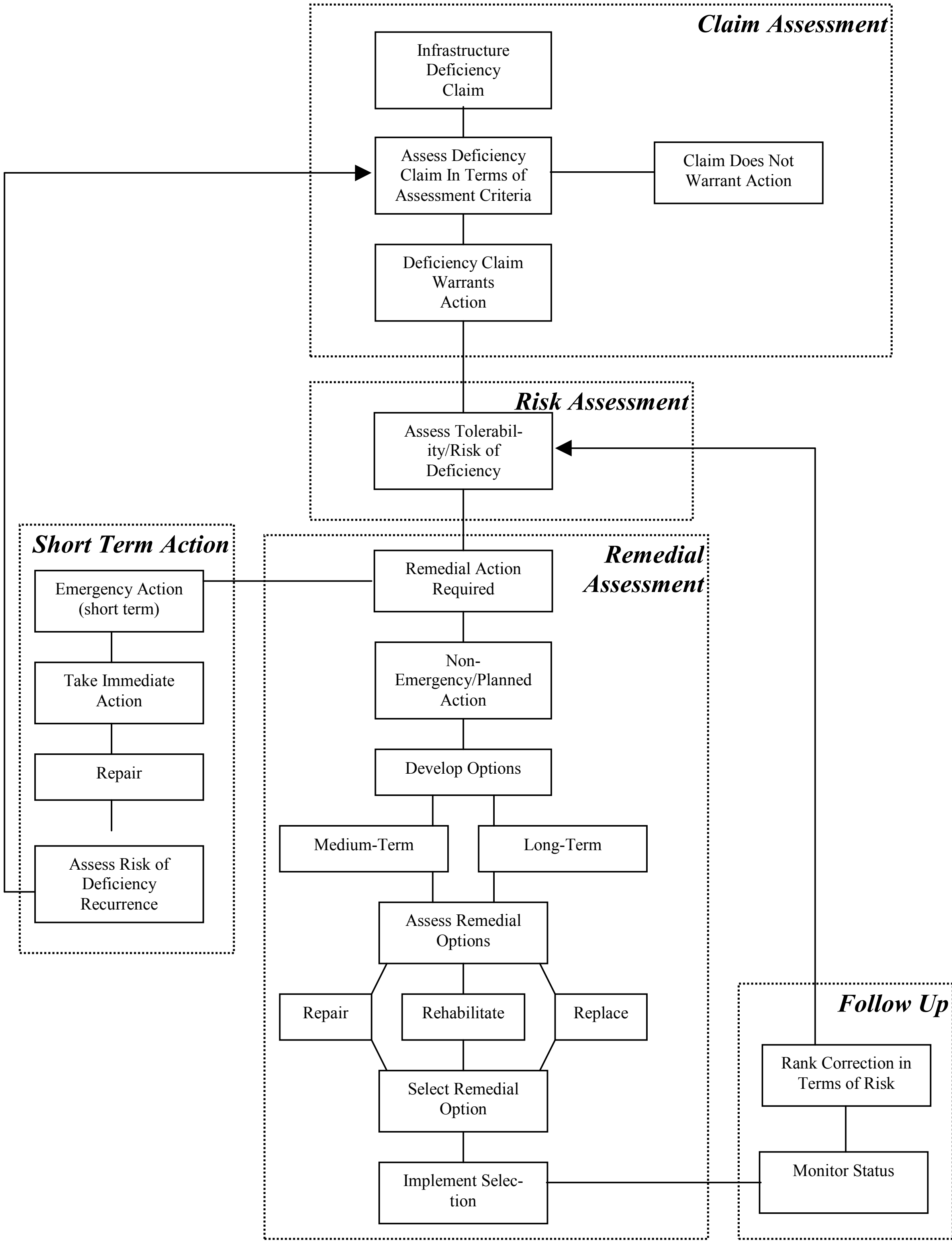
A decision support framework most likely to acknowledge these aspects is one that:

- Balances competing and often conflicting needs;
- Is sensitive to project inter-dependencies;
- Supports adopted plans, policies and initiatives;
- Addresses environmental constraints and impacts;
- Addresses implementation opportunities; and,
- Is open to public input and scrutiny.

The flow chart below illustrates the proposed decision making framework. It should be noted that without the facilitating capacity of an Asset Data Management System (ADMS) the capability of this decision making framework to convert information into knowledge, thereby optimising the quality of decisions, is compromised. While this decision tree may be capable of organising, processing, analysing and converting information into knowledge, this cannot be accomplished without timely, accurate and reliable inventory metrics

A Municipal Infrastructure Asset Management/Decision Making Framework

The following decision making logic tree is predicated on the presence of an Asset Data Management System (ADMS). This system should be founded on a pre-existing monitoring regime that provides for an inventory of all municipal infrastructure assets. Included in this inventory should be a documentation of asset conditions, prior treatments and future needs assessments.



4.1Claim Assessment

This component is concerned with determining the veracity of a claimed infrastructure deficiency, failing or shortcoming. It is intended to ensure that limited resources, be they financial, labour or time are not invested without adequate justification. The mere claim of a deficiency is insufficient justification for the investment of limited public resources. Instead, a claim must be assessed by means of a pre-determined Claim Assessment framework.

A Claim Assessment framework may be modelled on the following generic components:

1. A criteria or attribute determination stage in which the more salient considerations are defined;
2. A graduated criteria/attribute scale by which a deficiency can be measured;
3. The assignment of weights to the respective attributes that is parallel with their importance; and,
4. The determination of an acceptable minimum/maximum composite index against which can be measured the composite score of a particular deficiency claim, as determined by parts 2 and 3.

The composite claim score relative to the minimum/maximum acceptable composite index will indicate whether subsequent action is required.

Creating an assessment framework necessitates making value judgements that belie the measure to which one is willing to sacrifice on one value in order to receive more of another. This task is the purview solely of elected decision-makers. Consequently, an assessment framework is a means of augmenting rather than usurping the accountability and discretion of elected officials.

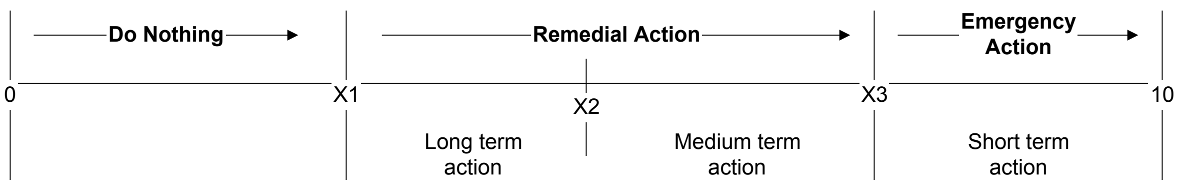
With respect to public communication and consultation, it is important that the public be aware of the seriousness with which claims of deficiency from it are dealt with. Decision-makers should consider availing the public with at least a semblance of the means employed by them in assessing claims of infrastructure deficiencies. A methodical, critical and objective methodology should not be concealed but rather proudly displayed. A transparent approach to the issue of municipal infrastructure management would assure this.

4.2 Risk Assessment

If the composite claim score exceeds the minimum/maximum acceptable composite index, the deficiency claim becomes an actual deficiency, whose tolerability or risk must be assessed. One of two situations may arise in which the tolerability or risk associated with the deficiency warrants action:

1. Emergency action in the context of the short term, or,
2. Remedial action in the context of either the medium or long term

Distinguishing between emergency and remedial action is facilitated by a Risk Assessment framework that resembles the Claim Assessment. What sets the Risk Assessment framework apart is its incorporation in a Tolerability/Risk Continuum:



Where:

X1 is the threshold below which no action is required or conversely above which action is required;
X2 is the threshold above which action is medium term and below which it is long term in character; and,
X3 is the threshold above which short-term emergency action is required and below which action can be characterised as medium term.

Placing the deficiency in terms of its risk, on the Risk Continuum, facilitates a decision as to what sort of action is warranted:

1. Short term emergency action;
2. Medium term remedial action; or,
3. Long term remedial action.

It is important to note that the need for a full and formal assessment of risk, the result of which would be emergency action, will not always be required. For example, it should be obvious at the point at which it is confirmed that the public is suffering physical harm that emergency action is warranted. The need for a full risk/tolerability assessment in such a scenario is gratuitous. In fact, a full assessment is likely to exacerbate the risk already present, owing to the time required to conduct a formal assessment of risk.

4.3 Short Term Action

Upon determination that a deficiency warrants short term action, immediate emergency action can be taken. Most often this action will take the form of repair as opposed to rehabilitation or replacement.

Repairing the deficiency is intended to correct the problem by maintaining the structure's integrity without necessarily adding to its structural strength.

Following the repair, the risk of a recurrence of the deficiency should be assessed. This involves replicating the deficiency Claim Assessment. Accordingly, the quality of the action taken and its remedial capacity is verified.

If the replicated Claim Assessment does not verify that a sufficient quality of action was taken or that the deficiency has been adequately remedied a replication of the Risk Assessment may be warranted.

Following the replication of the Risk Assessment and its application to the Risk Continuum one of three conclusions may be drawn:

1. The emergency action has sufficiently ministered to the deficiency;
2. The emergency action has proven inadequate so that more intensive emergency action is mandated; or,
3. That a consideration of medium to long term remedial action is required.

4.4 Remedial Assessment

If the application of the deficiency's composite Risk Assessment score to the Risk Continuum indicates that remedial, as opposed to emergency action is warranted, preparations can be taken to plan remedial measures. Remedial options that are in keeping with the time constraint implied by the Risk Continuum can now be developed.

A Remedial Options Assessment framework in keeping with the Claims Assessment framework should be developed. With this framework in place the remedial options that have been developed can be objectively assessed.

Following a comparison of the remedial option composite scores with the minimum/maximum remedial composite index a remedial option can be chosen and implemented.

It is important to consult the public at this stage of the decision process. However, the precise nature of consultation will be defined by the context of respective projects (APWA, 1998). Each project engenders its own set of factors. Therefore, the design of public consultation is contingent on the type of project and its potential effect on the public. Public consultation is in keeping with the public's status as the primary stakeholder. The measure of consultation with the public should peak during the development of remedial options. Allowing for public consultation will militate against the potential for a "public veto" while providing considerable credibility to decision-makers.

The importance of prior status reports and past treatments, constituting an asset inventory, provides the basis of an Asset Data Management System (ADMS). This becomes especially important in the development of planned remedial actions.

4.5 Follow Up

Following the completion of remedial action, the status of the structure should be monitored in a consistent manner and at regular intervals (TAC, 1999). Monitoring of the structure's status should be correlated with the Risk Assessment. Doing so will provide reliable and timely indications of the structure's potential need for future investment.

The most valuable consequence of Follow Up lies in its capacity to promote long term, sustainable strategic planning. In terms of infrastructure asset management, Follow Up allows administrators to adopt an holistic view of municipal infrastructure so that technical, financial and political factors can be harmonised in the interests of sound, long term public policy.

However, it is vital that this submission's initial counsel regarding the fundamental importance of an Asset Data Management System (ADMS) not be taken lightly. *Without an Asset Data Management System in place there is no context in which infrastructure asset management can occur*. The capacity of whatever asset management regime might exist will be severely circumscribed by the quality, not to mention the presence or not, of an Asset Data Management System (ADMS).

Finally, the benefits that may accrue to a municipality from an infrastructure asset management system can only be realised if Follow Up is implemented without reservation, conscientiously practised and continually optimised. Follow Up is that component of the asset management system that engenders the greatest potential for the optimisation of municipal infrastructure asset management.

Conclusions

Studies have shown that Canadian municipalities can save (or avoid costs) up to 10% of their present infrastructure expenditures by using proven, innovative technologies and methodologies. In addition to these substantial economic benefits, positive social and environmental impacts can be expected. The main barrier to achieving these results was the lack of existing mechanisms to bring together public and private stakeholders to share and develop solutions in a consensus based approach.

The Canadian Best Practices Guide to Sustainable Municipal Infrastructure offers the necessary framework for the development of common, practical tools - best practices, for decision-making and investment planning, and for the design, construction, operations and maintenance, repair and rehabilitation of water, wastewater, and municipal road systems. The Guide owes it strong public and private sectors support because it is a grass-roots initiative. Over the next few years, hundreds of experts from small and large, urban and rural municipalities, consulting firms, construction companies, manufacturers and suppliers, will be mobilising to work hand in hand on these practices. The framework described here will guide them in their tasks.

Acknowledgements

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References

APWA, (1998), Moving Forward: A Public Works Perspective on Strategic Planning; APWA; Kansas City, U.S.A.; 1998.

BINGHAM, RICHARD D. et al, (1991), Managing Local Government: Public Administration in Practice; Sage Publications; Newbury Park, U.S.A.; 1991.

COOK, WILLIAM B., (1999), Public Works Performance Management: Creating Accountability and Increasing Performance; APWA; Kansas City, U.S.A.; 1999.

FELIO, GUY Y., (1998), "A Best Practices Technical Guide to Support Municipal Infrastructure Planning and Decision-Making", Presented at the First International Conference on New Information Technologies for Decision-Making in Civil Engineering, held in Montreal, Canada, October, 1998.

DANYLO, NORMAN H. and LEMER, ANDREW, (1998), Asset Management for the Public Works Manager: Challenges and Strategies; APWA; Kansas City, U.S.A.; 1998.

GRIGG, NEIL, S., (1988), Infrastructure Engineering and Management; John Wiley & Sons; New York, U.S.A.; 1988.

HAMILTON-WENTWORTH, REGION OF, (1999), City /Region Capital Budget Rating Process; Region of Hamilton-Wentworth; Hamilton-Wentworth, Canada; 1999.

OECD, (1993), Infrastructure Policies for the 1990s; OECD; Paris, France; 1993.

TRANSPORTATION ASSOCIATION OF CANADA (TAC), (1999), Highway Asset Management Systems: A Primer; Transportation Association of Canada; Ottawa, Canada; 1999.

U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, (1998), A Guide To Effective Solutions: Decision Process Guidebook; U.S. Department of the Interior, Bureau of Reclamation; Denver, U.S.A.; 1998.