MUNICIPAL EXPERIENCE WITH INNOVATIVE INFRASTRUCTURE RENEWAL

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Municipal Experience with Innovative Infrastructure Renewal

FINAL REPORT

prepared for

Canada Mortgage and Housing Corporation
Research Division

prepared by

CONSULTING LTD.

Marshall
Macklin
Monaghan

Consulting Engineers · Surveyors · Planners

November 1995

Canada Mortgage and Housing Corporation (CMHC), the federal government's housing agency, is responsible for administering the National Housing Act. This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part IX of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to publish and distribute the results of this research. CMHC therefore has a statutory responsibility to make widely available information which may be useful in the improvement of housing and living conditions. This publication is one of the many items of information published by CMHC with the assistance of federal funds.

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Abstract

This study provides a summary of municipal experiences with innovative infrastructure renewal and rehabilitation techniques (defined as any technology or application that requires minimal surface disruption). It focuses on repairs and improvements to linear, below grade components of water supply and wastewater treatment systems (watermains, storm sewers and sanitary sewers). The information was gathered via a survey questionnaire sent to municipal infrastructure professionals across Canada in mid-1995. The survey obtained just over an 85% response rate and determined that, although conventional construction and repair techniques are still preferred by the majority of municipalities, interest in and experience with innovative techniques is growing. Six of the responding municipalities with innovative renewal or repair experiences are highlighted in a series of brief case studies in an appendix to the report. The report concludes that the more rapid diffusion of these newer techniques is hampered by a series of barriers. These barriers relate to how municipal infrastructure is designed, financed, constructed, operated and maintained — and how information on infrastructure alternatives is shared with infrastructure professionals. A series of conclusions and observations are offered which address these barriers in the hopes of hastening the uptake of technological innovation in municipal infrastructure repair and rehabilitation.

Municipal Experience with Innovative Infrastructure Renewal

Executive Summary

Introduction

Many indicators point to the need for a massive reinvestment in infrastructure. The cost of such reinvestment could be high because infrastructure work is inherently expensive and there appears to be a substantial backlog of deferred work. For municipalities to make sound decisions on technical infrastructure problems, they need accurate and unbiased information about new products and technologies. At present, only commercial claims for performance are easily available to municipalities. The long term performance of newer technologies, essential information for decision-makers, is not generally known. As a result, municipal decision-makers often rely on older technologies where the liabilities are known.

The situation is sub-optimal because newer technologies can offer the potential of better performance and cost-effectiveness, over the longer term, for many municipalities. Several municipalities have taken some risks and have tried newer technologies and their experiences are being shared with others through this report.

Objectives

The study objectives were to:

- Survey the experiences of municipalities across Canada with new infrastructure technology and practices;
- Determine how extensive the uptake of new technology might be;
- Document those jurisdictions which are employing new techniques to address problems;
- Provide information on why these municipalities have adopted new technology and what their experiences have been in applying the new technology; and,
- Develop several case studies.

Methodology and Scope of Work

A survey instrument, in the form of a questionnaire, was developed to determine the experiences of municipalities across Canada using non-traditional methods of maintenance, repair, rehabilitation and replacement of in-ground linear infrastructure. The questionnaire focused on watermains, sanitary/combined sewers and storm sewers.

CMHC had stipulated that a minimum of 50 municipalities were to receive the questionnaire, however, a total of 56 municipalities actually received the questionnaire, which included five municipalities targeted as candidates to field test the survey.

A 70 percent response rate to the survey was also required. Given the length of the survey and its subject matter, the study team determined that, to ensure this high level of response would necessitate pre-selecting each municipal contact at participating municipalities. This was done by calling each municipal works department and explaining the nature of the survey and confirming the correct individual to answer the survey.

The survey was faxed, along with an annotated glossary of terms used in the questionnaire, to survey participants. This was followed-up within a week with a reminder phone call, where necessary. The recipients had the option of answering the questions over the phone or faxing the answers to the team office. Forty-nine respondents completed the questionnaires without assistance and returned them by fax.

Once the questionnaire had been administered, the preliminary results were analysed. In addition to recording the data, the project team made note of those municipalities which had adopted new technology. These municipalities were shortlisted as candidates for the development of a series of six case studies on municipal experience with innovative infrastructure renewal.

The shortlisted municipalities were later contacted by phone for a more detailed interview to confirm the details of their particular experience(s) with innovative or alternative infrastructure renewal technologies and practices. Out of these interviews, six municipalities were selected for development of case studies, which appear in Appendix 3.

Findings

The survey and the case studies show that municipal interest in and experience with innovative infrastructure renewal technology is growing, albeit, slowly. For example, while nearly 90 percent of respondents reported using conventional sewer flushing as a method of cleaning sewers, about 40 percent have used sewer rodding or hydro-cleaning. Further, about 25 percent have used pigs and about 15 percent have used swabbing for cleaning watermains.

With regard to repairs, conventional technology — excavation and repair with traditional materials — is still the option of choice for most municipalities. However, internal sleeves, resin injection and reaming and chemical sealing have been used by between 25 to 35 percent of respondents. Further, keyhole technologies have been used by about 15 percent of respondents.

Survey respondents reported having had limited experience with in-situ, no-dig technology to rehabilitate water and sewer lines. About a third of the respondents have reported some experience with cured-in-place pipe liners, robotic cutters, and sliplining.

A much smaller percentage of respondents have had any direct experience with no-dig alternatives as a method of replacing water and sewer lines. Only about 15 percent reported using pipe jacking and less than 10 percent reported any experience with microtunneling and small diameter directional drilling.

Less than 10 percent of respondents reported experience with no-dig installations for new piped services or for directional drilling or microtunneling. However, 40 percent did report having used the auger method of horizontal boring, while about 35 percent reported having used pipe jacking for new services.

Conclusions

Municipal experience with innovative infrastructure renewal technologies is growing. But, before these newer techniques can obtain a greater market share, a number of barriers will need to be addressed. These barriers cover a wide spectrum of issues dealing with how municipal infrastructure is designed, financed, constructed, operated and maintained.

Users and providers of municipal water and sewer services need to develop a better understanding of the true cost of providing these services — including the broader environmental and public health externalities. Currently, most consumers tend to undervalue the water and sewer services they receive, as municipalities themselves tend to underprice virtually all services (for example, sewer and water services and garbage collection). This is done in an attempt to keep taxes and user fees from rising. Consequently, the revenues raised bear no relationship to the true costs of providing the service. Under such conditions, municipalities are often forced to address only the most serious and immediate problems. This approach to sewer and water maintenance is inimical to the orderly and effective introduction of new technology.

One answer is a movement by municipalities towards full cost accounting practices, especially in the provision of sewer and water services. This will likely be a painful transition but it does relate the use of the service to the actual cost of providing the service. One necessary precursor to implementing full cost accounting practices, in the case of water services, is universal water metering. Hand in hand with the introduction of full cost accounting practices must come an array of demand management and related conservation measures, the purpose of which would be to cushion the impact of higher per unit costs for water supply and wastewater treatment.

The current trend towards reducing hidden subsidies and transfer payments from senior levels of government to municipalities should continue. In Ontario, this is already underway. The Ontario Clean Water Agency is now making the distribution of capital grants for sewer and water system expansions conditional on municipalities completing system optimization studies first, including detailed demand management plans which demonstrate alternative ways to accommodate new growth.

Several of the public-private partnership models involving the construction, operation and rehabilitation of municipal infrastructure need to be explored, documented and disseminated in more detail. As greater experience with public-private partnerships develops, the interest in and uptake of innovative infrastructure rehabilitation and repair technologies can be expected to increase.

More case studies which document and explore the experiences of other Canadian municipalities need to be developed and disseminated. This dissemination could best take place through workshops on innovative technologies — perhaps sponsored by CMHC in collaboration with NRC — where municipalities would have the opportunity to present case studies on their experiences with technological innovations. These workshops could emphasize hands-on issues targeting municipal practitioners in the field. Such successes (and failures) will be a strong factor which will encourage more municipalities to examine and take up the innovation challenge.

In the area of codes and standards, the National Research Council should accelerate its efforts at the development and introduction of its proposed National Technical Guide for Urban Infrastructure. This would accelerate the development and promulgation of testing protocols and standards covering the design, fabrication, installation and maintenance of innovative sewer and water renewal technologies.

On the subject of growth and development, there is a need for more public education on the benefits of alternative development standards — this way, the public will come to accept, for example, that a grassed drainage swale at the boulevard that floods once every five years is a cost effective and acceptable alternative to a dedicated storm sewer that costs ten times as much to build while providing the same level of performance and service.

CMHC can play a pivotal role in this information dissemination process. Working with the Intergovernmental Committee on Urban and Regional Research (ICURR), which it helps fund, CMHC should be exploring how to use existing technology transfer mechanisms (print media and workshops in particular), as well as emerging mechanisms (such as the Internet) to hasten the adoption of innovative infrastructure renewal technology. This could include the identification and promotion of research priorities within the college and university system in Canada.

Better information incorporating Canadian examples of municipal experience with innovative infrastructure renewal will go a long way to removing many of the barriers noted above. This will, in turn, accelerate the uptake and introduction of cost-effective alternatives to conventional infrastructure repair, renewal and rehabilitation practices.

This report and an associated IRC/NRC report (Assessing the Condition of Municipal Infrastructure, March 1995) can serve as a starting point for others who may wish to expand and refine the national position in these issue areas.

Les municipalités et l'innovation dans la réfection des infrastructures

Résumé

Introduction

De nombreux facteurs semblent indiquer qu'il faut réinvestir massivement dans les infrastructures. Le coût d'un tel réinvestissement pourrait être élevé, du fait que les travaux d'infrastructure sont en soi coûteux et qu'on a longtemps reporté des travaux qui s'imposaient. Pour que les municipalités prennent de bonnes décisions quant à leurs problèmes techniques d'infrastructure, elles doivent pouvoir compter sur de l'information précise et objective sur les produits nouveaux et les techniques nouvelles. À l'heure actuelle, les municipalités n'ont facilement accès qu'aux caractéristiques de performance que leur présentent les fournisseurs. La performance à long terme des nouvelles technologies, une information essentielle pour les décideurs, n'est généralement pas connue. C'est pourquoi les décideurs municipaux s'en tiennent souvent aux techniques anciennes dont ils connaissent déjà les limites.

Cette situation n'est pas idéale, car les nouvelles technologies peuvent offrir, à long terme, une performance supérieure à meilleur coût pour bien des municipalités. Plusieurs municipalités ont pris des risques en faisant l'essai de nouvelles technologies et c'est de cette expérience qu'il est question dans ce rapport.

Objectifs

L'étude avait pour objectifs :

- d'examiner les expériences de municipalités canadiennes ayant eu recours à de nouvelles techniques et pratiques en matière d'infrastructure;
- de déterminer dans quelle mesure les nouvelles technologies sont adoptées;
- de trouver des administrations qui emploient de nouvelles techniques pour régler leurs problèmes;
- d'expliquer pourquoi ces municipalités ont adopté une nouvelle technique et quelle a été leur expérience dans l'emploi de cette nouvelle technique;
- de réaliser plusieurs études de cas.

Méthode et portée de l'étude

Un questionnaire de sondage a été rédigé afin de déterminer les expériences de municipalités d'un bout à l'autre du Canada dans l'emploi de méthodes non traditionnelles d'entretien, de réfection, de réhabilitation et de remplacement des infrastructures linéaires souterraines. Le questionnaire mettait l'accent sur les conduites maîtresses ainsi que sur les égouts pluviaux et sanitaires.

La SCHL avait stipulé qu'un minimum de 50 municipalités devaient recevoir le questionnaire. Or, 56 municipalités l'ont en fait reçu, dont cinq qui se sont avérées de bonnes candidates pour mettre à l'essai le sondage sur le terrain.

Il fallait aussi obtenir un taux de réponse au sondage de 70 %. Compte tenu de la longueur du questionnaire et du sujet abordé, les responsables de l'étude ont déterminé que pour obtenir le taux de réponse élevé requis, il faudrait présélectionner chaque personne-ressource au sein des municipalités participantes. C'est ce qu'a fait l'équipe en communiquant avec le service des travaux publics de chaque municipalité pour expliquer la nature du sondage et confirmer quelle était la personne la plus apte à y répondre.

Le questionnaire et un glossaire annoté définissant les termes utilisés ont été télécopiés aux participants ciblés. Au bout d'une semaine, on a communiqué avec certains participants par téléphone pour leur rappeler l'importance du sondage. Les participants pouvaient choisir de répondre au questionnaire par téléphone ou en télécopiant leur questionnaire au bureau de l'équipe responsable. Quarante-neuf personnes ont répondu au questionnaire sans aide et l'ont retourné par télécopieur.

Sur réception de tous les questionnaires, les résultats préliminaires ont été analysés. En plus de saisir les données, les responsables de l'étude ont pris note des municipalités qui ont adopté une nouvelle technologie. Ces municipalités ont été placées sur une liste de candidats susceptibles de servir à l'élaboration d'une série de six études de cas portant sur l'expérience municipale relativement aux procédés innovateurs de réfection des infrastructures.

Les municipalités placées sur cette liste ont par la suite été jointes par téléphone pour qu'elles expliquent en détail leur expérience à l'égard de technologies et de pratiques novatrices ou différentes en matière de réfection des infrastructures. Sur ces entrevues, six municipalités ont été retenues en vue de l'élaboration des études de cas, lesquelles figurent à l'annexe 3.

Résultats

Le sondage et les études de cas révèlent que l'intérêt et l'expérience des municipalités à l'égard des techniques innovatrices de réfection des infrastructures vont croissant, encore que lentement. Ainsi, même si près de 90 % des répondants disent utiliser la méthode traditionnelle du lavage sous pression pour nettoyer les égouts, environ 40 % ont déjà utilisé l'insertion de tiges spiralées ou le nettoyage à l'eau sous pression. De plus, près de 25 % ont utilisé les racleurs de nettoyage et 15 % environ ont eu recours au décolmatage à l'aide d'un racleur peu rigide pour nettoyer les conduites maîtresses.

En ce qui concerne les réparations, la technologie usuelle - excavation et réparation avec des matériaux traditionnels - constitue toujours la solution de choix pour la plupart des municipalités. Toutefois, les manchons internes, l'injection de résines de même que l'alésage et le scellement à l'aide de produits chimiques ont été utilisés par 25 à 35 % des répondants. En outre, la technique du perçage de petites dimensions a été employée par approximativement 15 % des répondants.

Les répondants ont indiqué n'avoir que peu d'expérience dans le domaine des technologies sans excavation pour réparer les canalisations d'eau et d'égouts. Environ le tiers des répondants ont mentionné qu'ils possédaient une certaine expérience des chemisages mûris en place, des couteaux robotisés et des chemisages à expansion.

Un pourcentage beaucoup plus faible de répondants possèdent une expérience concrète des techniques de remplacement des canalisations d'eau et d'égouts sans excavation. Seuls 15 % environ des répondants ont dit avoir utilisé le fonçage horizontal des canalisations et moins de 10 % ont indiqué avoir une certaine expérience des microtunnels et du forage directionnel de faible diamètre.

Moins de 10 % des répondants ont affirmé qu'ils avaient eu recours à des installations sans excavation pour les nouveaux réseaux de canalisations, pour le forage directionnel ou pour les microtunnels. Toutefois, 40 % ont indiqué qu'ils avaient utilisé une tarière à forage horizontal tandis que 35 % ont dit avoir fait appel au fonçage horizontal pour les nouveaux réseaux.

Conclusions

Les municipalités se familiarisent de plus en plus avec les technologies innovatrices servant à la réfection des infrastructures. Mais avant que ces nouvelles technologies puissent obtenir une meilleure part de marché, il faudra lever un certain nombre d'obstacles comme la façon dont les infrastructures municipales sont conçues, financées, construites, utilisées et entretenues.

Les usagers et les fournisseurs de services municipaux d'égouts et d'alimentation en eau doivent mieux comprendre ce qu'il en coûte vraiment pour offrir ces services et être au fait des externalités relatives à l'environnement et à la santé publique. À l'heure actuelle, la plupart des consommateurs ont tendance à sous-évaluer les services d'eau et d'égouts dont ils bénéficient, et les municipalités elles-mêmes tendent à demander un prix insuffisant pour pratiquement tous les services (services d'eau et d'égouts et enlèvement des ordures ménagères, par exemple). Les municipalités veulent ainsi éviter d'augmenter les taxes et les frais aux usagers. Par voie de conséquence, les revenus perçus n'ont aucune mesure avec ce qui leur en coûte réellement pour offrir ces services. Dans ces conditions, les municipalités sont souvent forcées de ne s'occuper que des problèmes les plus graves et les plus urgents. Cette approche de l'entretien des réseaux d'eau et d'égouts ne peut favoriser l'adoption ordonnée et efficace de nouvelles technologies.

Pour remédier à cette situation, il faudrait que les municipalités adoptent la méthode du coût de revient complet, surtout en ce qui a trait aux services d'eau et d'égouts. La transition serait vraisemblablement douloureuse, mais c'est le seul moyen d'établir un lien entre l'utilisation du service et ce qu'il en coûte réellement pour l'offrir. L'une des mesures qui s'imposeraient pour préparer la mise en place de la méthode du coût de revient complet pour les services d'eau serait l'installation de compteurs d'eau chez tous les usagers. De concert avec l'introduction du coût de revient complet, il faudrait prévoir une série de mesures pour gérer la demande et faire des économies dans le but d'adoucir les répercussions d'une augmentation des coûts unitaires de l'alimentation en eau et du traitement des eaux usées.

L'actuelle tendance des paliers supérieurs de gouvernement qui consiste à réduire les subventions cachées et les paiements de transfert doit se poursuivre. Ce processus est déjà amorcé en Ontario. L'Agence ontarienne des eaux procède en ce moment à l'attribution de subventions d'immobilisations devant servir à l'expansion des réseaux municipaux d'eau et d'égouts à la condition que les municipalités mènent d'abord des études d'optimalisation de leur réseau qui comportent des plans détaillés de gestion de la demande et qui illustrent des façons nouvelles de gérer la croissance.

Plusieurs des modèles de partenariats publics-privés formés autour de la construction, de l'utilisation et de la réhabilitation des infrastructures municipales doivent être explorés, documentés et disséminés en détail. Plus on acquerra d'expérience dans le domaine des partenariats publics-privés, plus on verra croître l'intérêt envers les technologies novatrices de réhabilitation et de réfection des infrastructures ainsi que leur adoption.

Il faudra donc réaliser et diffuser davantage d'études de cas qui documentent et explorent les expériences d'autres municipalités canadiennes. Cette diffusion serait le plus efficace dans le cadre d'ateliers sur les technologies innovatrices, susceptibles d'être parrainées par la SCHL en collaboration avec le CNRC, au cours desquels les municipalités auraient la possibilité de présenter des études de cas portant sur leur expérience des innovations technologiques. Ces ateliers pourraient mettre l'accent sur les applications concrètes destinées aux agents municipaux travaillant sur le terrain. Les succès remportés (tout comme les échecs) encourageront un plus grand nombre de municipalités à envisager le défi de l'innovation et à le relever.

Dans le domaine des codes et des normes, le Conseil national de recherches devrait accélérer l'élaboration et la présentation de son guide technique national sur les infrastructures urbaines. Il favoriserait ainsi la rédaction et la mise en oeuvre de protocoles d'essais et de normes visant la conception, la fabrication, l'installation et l'entretien de réseaux d'eau et d'égouts fondés sur des technologies innovatrices.

Sur la question de la croissance et de l'aménagement, il importe d'informer le public sur les avantages des nouvelles normes d'aménagement. De cette façon, le public en viendra à accepter, par exemple, qu'une rigole de drainage gazonnée sur un boulevard qui est inondé tous les cinq ans puisse constituer une solution de rechange efficace et acceptable à un égout pluvial spécifique coûtant dix fois plus cher sans offrir un meilleur rendement.

La SCHL peut jouer un rôle central dans le processus de diffusion de l'information. Avec l'aide du Comité intergouvernemental de recherches urbaines et régionales (CIRUR), dont elle contribue au financement, la SCHL pourrait examiner de quelle façon utiliser les mécanismes actuels de diffusion d'information (publications et ateliers en particulier) de même que les nouveaux médias (comme Internet) pour accélérer l'adoption des techniques innovantes de réfection des infrastructures. Ce processus pourrait inclure l'établissement et la promotion des priorités de recherche dans le réseau des collèges et universités du Canada.

Une meilleure information donnant des exemples de l'expérience des municipalités canadiennes dans le domaine de la réfection innovatrice des infrastructures contribuera grandement à lever bien des obstacles. Il sera alors possible d'activer l'adoption et l'usage de techniques économiques en remplacement des pratiques traditionnelles de réfection, de renouvellement et de réhabilitation des infrastructures.

Ce rapport ainsi qu'un autre rapport de l'IRC du CNR (Évaluation de l'état des infrastructures municipales, mars 1995) pourront servir de point de départ à d'autres qui pourraient vouloir étendre et préciser la position nationale sur ces questions.

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Section 1
Introduction

1.1 Overview

In February 1994, the Research Division of Canada Mortgage and Housing Corporation issued a proposal call to conduct a study of municipal experience with innovative infrastructure. In the context of the study, "infrastructure" was confined to below-grade linear types — water distribution, sewage collection and stormwater run-off collection.

As the agency responsible for administering the National Housing Act and improving the affordability of housing and living conditions of Canadians, CMHC has a longstanding interest in the state and condition of infrastructure in Canada and a stake in its maintenance and upkeep. For example, the provision of water and sewer services can have a direct impact on the cost of housing, either through the imposition of development charges, in the case of new housing, or through the levying of property taxes in the case of existing housing.

In recent years, jurisdictions at all three levels of government — federal, provincial and municipal — have identified the growing need for a massive reinvestment in municipal infrastructure. The cost of this reinvestment is likely to be considerable, especially in light of recent estimates which suggest that the replacement cost, just for Canada's water and sewer infrastructure alone, is in excess of $100 billion.

In the face of shrinking municipal budgets and diminishing transfer payments from senior levels of government, municipalities across Canada are beginning to search for infrastructure alternatives. At the same time, due to the high cost of infrastructure investment, many municipalities have deferred repairs and rehabilitation. This has only served to exacerbate the problem.

In light of these constraints, an increasing number of municipalities are looking to technology alternatives which promise to provide the same or enhanced levels of infrastructure service at reduced life cycle costs. However, as the CMHC proposal call identified, before municipalities embrace new products and technologies, they must have reassurances that they perform as manufacturers claim. In the absence of this information, *"municipal decision-makers prefer to rely on older technologies where the liabilities are known, rather than risk incurring the liability which may be associated with a new technology."*

1.2 Purpose of the Study

The purpose of this study has been to survey the experiences of municipalities across Canada using new infrastructure products and technology. The definition of 'innovation' was left to the respondent, recognizing that what is innovative in one jurisdiction due to recent experience may be commonplace in another. Generally, the project team took 'innovation' to include any technology or application that requires minimal surface disruption.

The intent has been to determine how extensive is the uptake of this new technology and to document those jurisdictions which are employing new techniques to address problems. Additionally, the study is intending to provide information on why these municipalities have — or have not — adopted new technology and what their experiences have been in applying the new technology.

1.3 Scope of the Work

The contract required the development of a survey instrument, in the form of a questionnaire, to determine the experiences of municipalities across Canada in the area of renewal of in-ground linear infrastructure. The questionnaire sought information about municipal experiences with new technology in the design, operation, repair, maintenance and replacement of watermains, sanitary/combined sewers and storm sewers.

While the principal survey instrument in the initial information gathering was a questionnaire, once the questionnaire had been administered, the preliminary results were analysed and those municipalities which had adopted new technology were identified. These municipalities were shortlisted as candidates for the development of a series of six case studies on municipal experience with innovative infrastructure renewal. These case studies will be found in Appendix 3 of this report.

Section 2
Survey Methodology

2.1 Overview

During the design of this survey, the project team worked closely with the Infrastructure Laboratory of the National Research Council. NRC was planning a municipal survey with subject matter overlapping that of this survey and they subsequently incorporated portions of the CMHC questionnaire into their own survey[1].

To obtain greater municipal coverage and value added for the money invested in the two surveys, both NRC and CMHC agreed to contact municipalities not directly covered by each other's survey. In addition, the project team had field tested the CMHC questionnaire with six municipalities: New Glasgow, Nova Scotia; Moncton, New Brunswick; Montreal, Quebec; Ottawa, Ontario; Saskatoon, Saskatchewan and Edmonton, Alberta. The first five of these municipalities were included in the planned NRC survey coverage. To accommodate NRC's more accelerated schedule, the project team released the results of these five field tests to NRC for their use[2].

The principal survey instrument utilized in this study was a nine page questionnaire. As stipulated by the client, a minimum of 50 municipalities was targeted to receive the survey. Initially, the CMHC study team selected all the larger metropolitan areas in Canada. Twenty seven of these 50 — including five field test municipalities — were ultimately dropped from the list and released to NRC for their survey.

The study team located an additional 27 municipalities to bring its survey total back up to a minimum of 50 municipalities[3]. The list of municipalities who ultimately received and responded to the CMHC questionnaire is shown in **Table 1** on page 4.

CMHC further stipulated that at least a 70 percent response rate to the survey be obtained. Given the length of the survey and its subject matter, the study team determined that one key to ensure this high level of response would be to identify and work with a municipal contact at participating municipalities. This was achieved by explaining the nature of the survey and confirming with the municipal works department the correct individual to answer the survey.

The survey was faxed, along with an annotated glossary of terms used in the questionnaire, to survey participants. Follow-up phone calls within a week, where necessary, ensured the high response rate. The recipients had the option of answering the questions over the phone or faxing the answers to the team office. Forty-nine respondents filled the questionnaire in without assistance and returned them by fax.

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1 See Executive Report entitled *Assessing the Condition of Municipal Infrastructure*, prepared by Shelley McDonald and Guy Félio for the CMHC *Workshop on Municipal Infrastructure and Housing*, March 1995.

2 NRC's timing was more advanced than CMHC's, as they wished to present the findings of their survey (see footnote 1) at the CMHC Conference on Housing and Infrastructure in March, 1995.

3 The project team eventually surveyed 56 municipalities.

Table 1

Municipalities Who Received the Questionnaire

	Municipality	Prov.	Response	Results Status
1	Gander	Nfld.	√	included
2	Dartmouth	N.S.		dnr
3	New Glasgow	N.S.	√	to NRC
4	Kings County	N.S.	√	included
5	Fredericton	N.B.	√	included
6	Moncton	N.B.	√	to NRC
7	Jonquiere	Que.	√	included
8	Laval	Que.		dnr
9	Montreal	Que.	√	to NRC
10	Riviere du Loup	Que.		dnr
11	Rouyn-Noranda	Que.	√	included
12	Aurora	Ont.	√	included
13	Barrie	Ont.	√	included
14	Belleville	Ont.	√	included
15	Burlington	Ont.	√	included
16	Durham Region	Ont.	√	included
17	East York	Ont.	√	included
18	Halton Region	Ont.	√	included
19	Hamilton Wentworth Region	Ont.	√	included
20	Kingston	Ont.	√	included
21	Kirkland Lake	Ont.	√	included
22	London	Ont.	√	included
23	Markham	Ont.		dnr
24	Metro Toronto	Ont.		dnr
25	North Bay	Ont.	√	included
26	North York	Ont.	√	included
27	Oshawa	Ont.	√	included
28	Ottawa (City)	Ont.	√	to NRC
29	Ottawa Carleton Region	Ont.	√	included
30	Peel Region	Ont.	√	included
31	Pickering	Ont.	√	included
32	Sudbury	Ont.	√	included
33	Thunder Bay	Ont.	√	included
34	Toronto	Ont.	√	included
35	Waterloo	Ont.		dnr
36	Windsor	Ont.	√	included
37	Thompson	Man.	√	included
38	Moose Jaw	Sask.	√	included
39	Saskatoon	Sask.	√	to NRC
40	Edmonton	Alta.	√	included
41	Fort McMurray	Alta.	√	included
42	Medicine Hat	Alta.	√	included
43	Red Deer	Alta.	√	included
44	Burnaby	B.C.	√	included
45	Kamloops	B.C.	√	included
46	Kelowna	B.C.	√	included
47	Langley	B.C.	√	included
48	Nanaimo	B.C.		dnr
49	New Westminster	B.C.	√	included
50	Penticton	B.C.	√	included
51	Port Coquitlan	B.C.	√	included
52	Prince George	B.C.	√	included
53	Richmond	B.C.	√	included
54	Surrey	B.C.	√	included
55	Terrace	B.C.	√	included
56	Yellowknife	N.W.T.	√	included

1) **dnr**: Did not respond; 2) **included**: means included in this survey; 3) **to NRC**: means results collected by the project team were given to NRC for their similar survey analysis

2.2 Survey Framework

The survey instrument was designed to obtain information about seven issues. Accordingly, the questionnaire had seven parts as follows:

- Part 1 dealt with *existing conditions* of linear water and sewer infrastructure (what municipalities know about the condition of their infrastructure);
- Part 2 dealt with *investigational* issues (how municipalities monitor and inspect piped infrastructure);
- Part 3 focused on *operation and maintenance* issues;
- Part 4 addressed *local repair* issues (involving both emergency repairs and planned regular maintenance activities);
- Part 5 dealt with *rehabilitation and replacement* of piped infrastructure;
- Part 6 focused on *modifications* to system design parameters; and,
- Part 7 asked for information on *pilot projects or trials* of new technology underway.

Section 3
Survey Results

3.1 Who Responded to the Survey

The survey and glossary of terms were sent by fax to 56 municipalities across Canada. Responses were obtained from 49 municipalities (see Table 1 on page 4), an 87.5 percent response rate, considered good for this type of detailed questionnaire.

In terms of size of municipality responding to the survey, 18 municipalities were below 50,000 in population, 11 municipalities were in the 50,000 to 100,000 range and 20 municipalities were above 100,000 population.

3.2 Existing Conditions

Part I of the questionnaire was designed to obtain inventory information on the water and/or sanitary sewer/storm sewer systems within each respondent's municipal jurisdiction, in terms of how many people are serviced, length of pipe network and its age.

Table 2 on page 7 summarizes the number of people connected to piped services (water, sanitary/combined sewers and storm sewers) and the length of each piped system, in kilometres, in the 44 municipalities reported on in this survey. The population of these 44 municipalities is 7.19 million — about 25 percent of the total Canadian population.

In terms of watermains, these municipalities serve a population of 4.43 million and have a total length of piping equaling 17,445 km. In terms of sanitary and combined sewers, they serve a population of 4.67 million and have a total length of pipe equaling 19,925 km. From the standpoint of storm sewers, a population of 2.14 million is serviced through a network of 10,443 km of piping[4].

The questionnaire also asked for information on the age of the piped infrastructure under each responding municipality's jurisdiction. **Figures 1 to 4** on pages 8 through 11 depict the age breakdown of the three piping categories — 1) watermains; 2) sanitary/combined sewers; and, 3) storm sewers — in 36 of the municipalities[5]. A review of the figures indicates that the Town of Aurora (Figure 2) just north of Toronto has the most recent water distribution infrastructure with 95 percent of its watermains being less than 30 years old (and with 65 percent being less than 10 years old).

At the other end of the spectrum, the Borough of East York (Figure 1) and the City of Toronto (Figure 2) within Metropolitan Toronto and the City of Sudbury (Figure 2) each have in excess of 70 percent of their watermains in the age category of 50 years or older (East York - 75 percent; City of Toronto - 89.7 percent; and Sudbury - 70 percent). In fact, 70 percent of the City of Toronto's watermains are 75 years or older.

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[4] The variation in population served by the three piped systems is a function of split jurisdictions between municipalities. Some provide all three services while others provide only one or two. In instances where there are two levels of municipal government, generally speaking, the upper tier is responsible for sewer and water, while the lower tier is responsible for storm sewers. There are exceptions to this rule.

[5] Eight municipalities who answered the questionnaire were unable to provide this information.

Table 2
Population Served and Pipe Lengths in Municipalities Responding to the Survey

Municipality	Prov.	Population Serviced			Length in Kilometres		
		Water	Sanitary	Storm	Water	Sanitary	Storm
Gander	Nfld.	13,400	13,400	13,000	64	60	56
Kings County	N.S.	500	4,500	7,000	20	125	u/a
Fredericton	N.B.	44,000	44,000	40,000	315	285	225
Jonquière	Que.	58,820	53,500	18,500	275	289	121
Rouyn-Noranda	Que.	26,990	26,990	2,712	117	117	60
Aurora	Ont.	30,000	30,000	15,000	150	1,064	78
Barrie	Ont.	n/a	60,000	u/a	n/a	250	110
Belleville	Ont.	15,000	n/a	n/a	178	n/a	n/a
Burlington	Ont.	n/a	n/a	90,000	n/a	n/a	450
Durham Region	Ont.	104,854	99,827	n/a	1,693	1,330	156
East York	Ont.	100,000	100,000	40,000	192	160	48
Halton Region	Ont.	305,000	303,000	n/a	1,424	1,275	n/a
Hamilton-Wentworth Region	Ont.	400,000	300,000	100,000	2,200	2,200	u/a
Kingston	Ont.	n/a	59,624	u/a	n/a	195	94
Kirkland Lake	Ont.	11,000	11,000	n/a	u/a	u/a	n/a
London	Ont.	300,000	300,000	u/a	768	1,760	1,520
North Bay	Ont.	50,000	u/a	u/a	140	110	90
North York	Ont.	560,000	560,000	360,000	1,385	1,300	1,500
Oshawa	Ont.	n/a	n/a	u/a	n/a	n/a	276
Ottawa-Carleton Region	Ont.	u/a	u/a	n/a	u/a	u/a	n/a
Peel Region	Ont.	612,000	568,800	n/a	u/a	u/a	n/a
Pickering	Ont.	n/a	n/a	u/a	n/a	n/a	162
Sudbury	Ont.	140,000	137,500	n/a	841	773	n/a
Thunder Bay	Ont.	95,000	93,000	91,000	665	488	232
Toronto	Ont.	522,000	522,000	522,000	1,225	1,198	923
Windsor	Ont.	n/a	180,000	90,000	n/a	950	259
Thompson (INCO)	Man.	n/a	u/a	u/a	n/a	u/a	u/a
Moose Jaw	Sask.	35,000	35,000	35,000	259	125	59
Edmonton	Alta.	n/a	627,000	475,200	n/a	2,550	1,810
Fort McMurray	Alta.	35,000	35,000	u/a	148	211	80
Medicine Hat	Alta.	45,890	49,690	u/a	314	269	131
Red Deer	Alta.	16,758	16,758	u/a	346	275	225
Burnaby	B.C.	160,000	n/a	n/a	655	n/a	n/a
Kamloops	B.C.	72,000	70,000	u/a	500	388	186
Kelowna	B.C.	26,000	60,000	u/a	580	331	175
Langley	B.C.	22,500	22,500	18,000	80	80	60
New Westminster	B.C.	45,000	40,000	5,000	185	170	42
Penticton	B.C.	30,000	25,000	25,000	u/a	u/a	u/a
Port Coquitlam	B.C.	41,000	41,000	41,000	154	151	155
Prince George	B.C.	54,600	50,600	35,000	393	330	199
Richmond	B.C.	143,212	120,000	120,000	614	421	368
Surrey	B.C.	295,000	u/a	u/a	1,600	1,170	1,030
Terrace	B.C.	4,000	4,000	1,000	107	78	66
Yellowknife	N.W.T.	16,000	16,000	u/a	62	42	14

n/a — Not applicable (other jurisdiction's mandate); u/a — Unavailable (information not provided)

Figure 1
Age of Piped Services

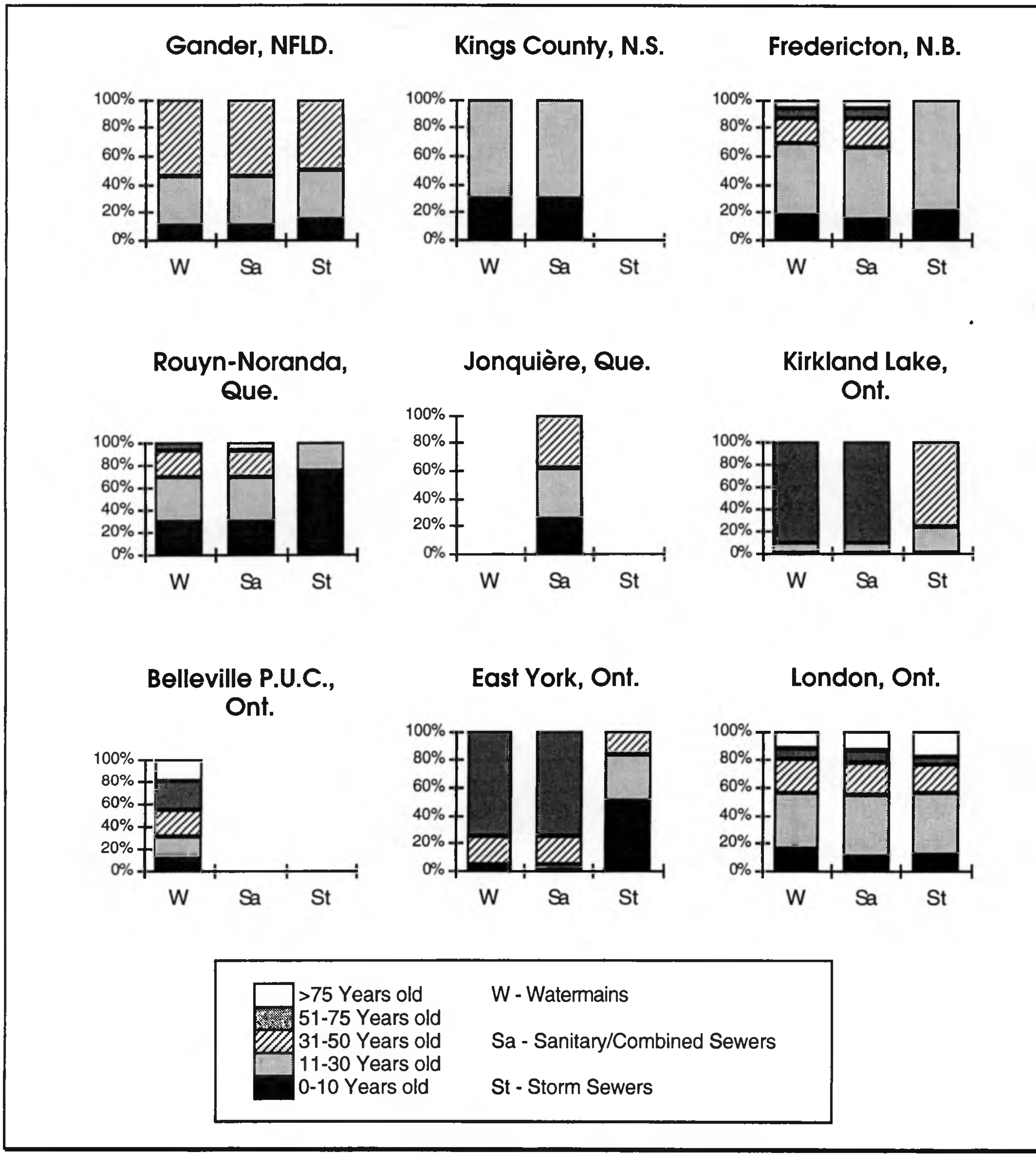


Figure 2
Age of Piped Services

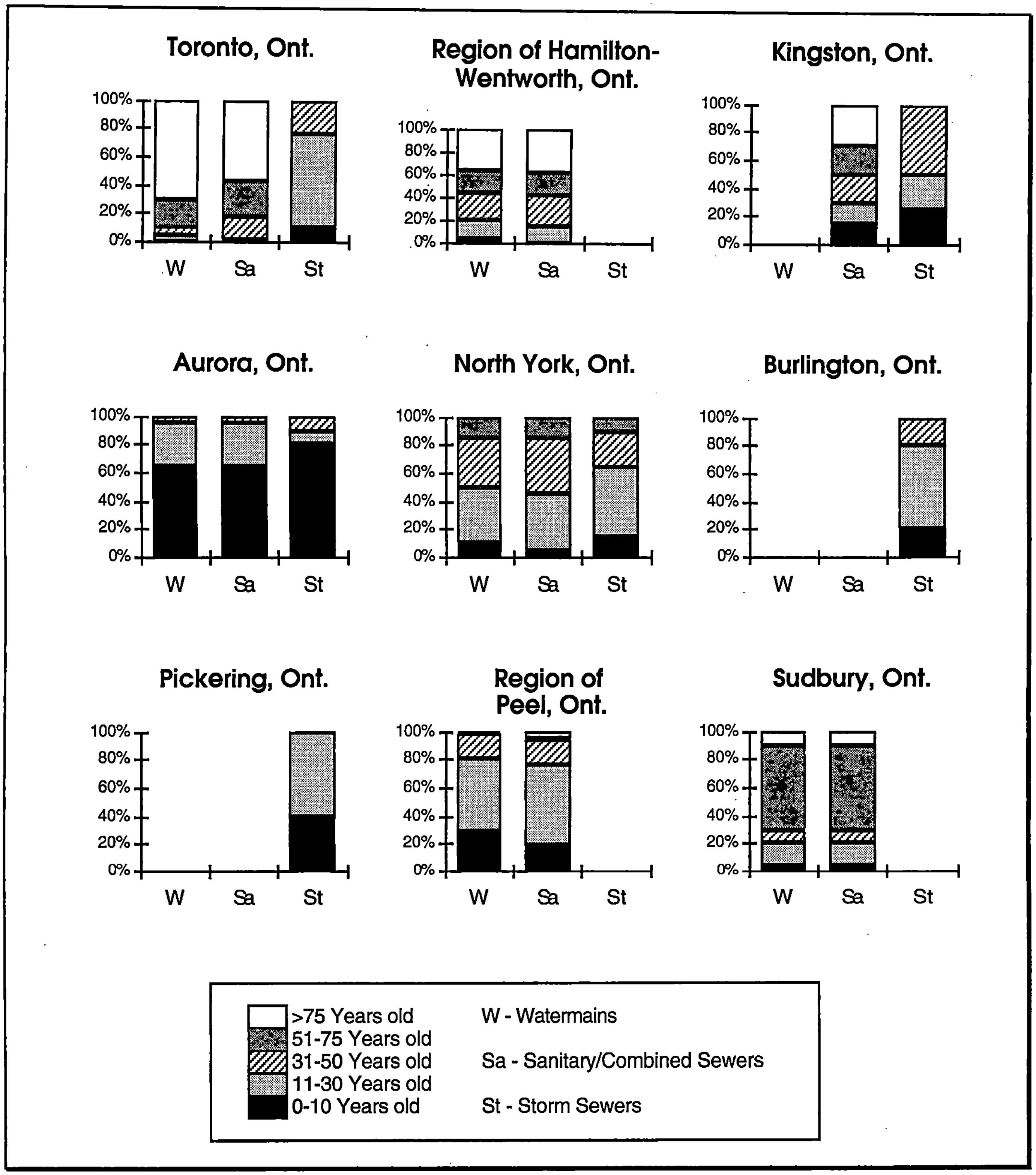


Figure 3
Age of Piped Services

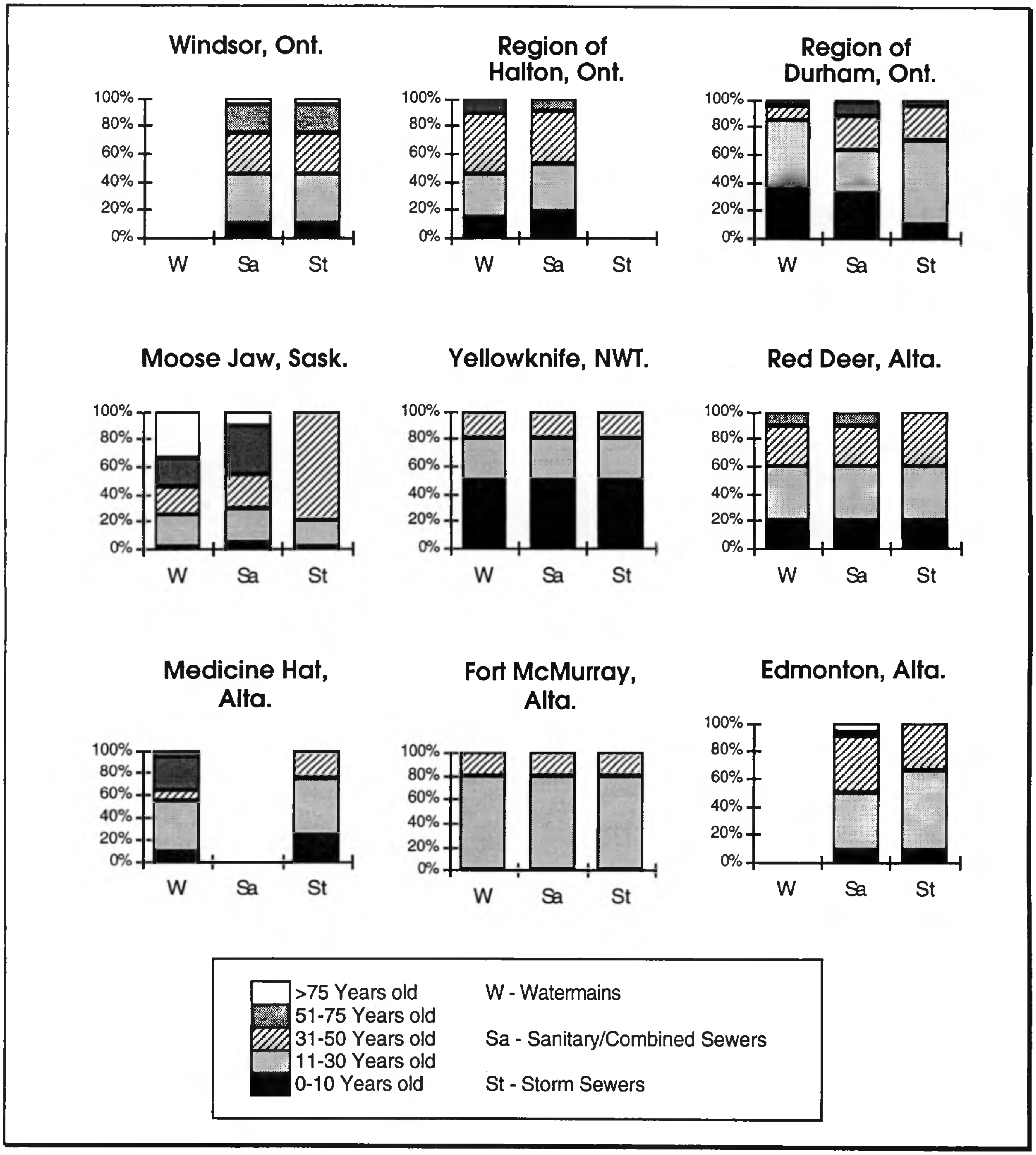
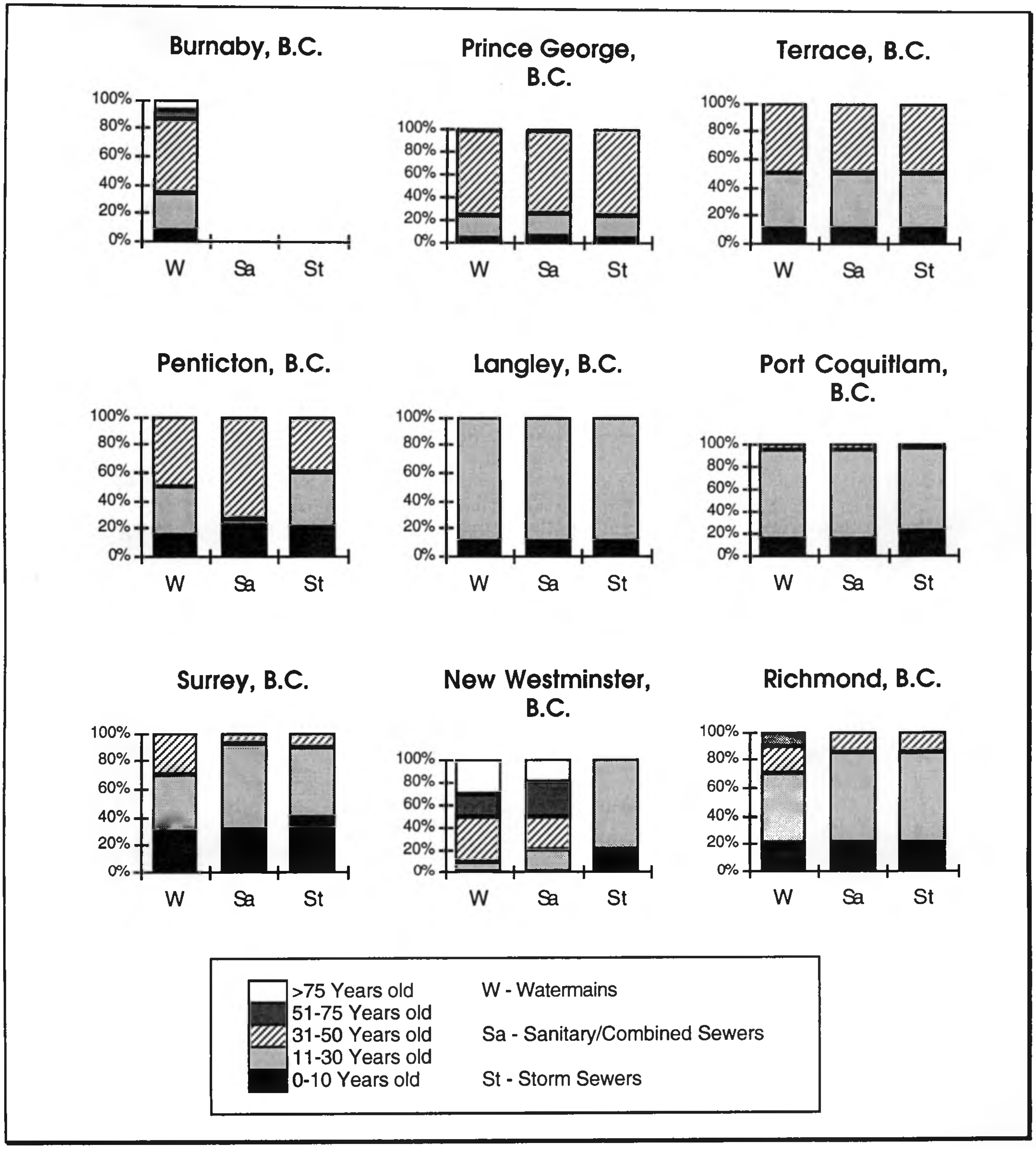


Figure 4
Age of Piped Services



3.3 Investigational Issues

Part II of the survey sought information on the methods municipalities use to monitor and inspect piped infrastructure within their jurisdiction. It also sought information on how municipalities use information obtained during monitoring and investigation of system conditions to plan for future piped service requirements.

3.3.1 Determining Pipe Conditions

Respondents were asked to select options from the following list (items in italics indicate terms included in the glossary accompanying the questionnaire). Respondents were free to select more than one option in most of the questions in the survey, unless otherwise noted.

1) External visual
2) *Closed circuit television (CCTV)*
3) *Sonar systems*
4) *X-ray*
5) *Corrosion pit analysis*
6) Cut-out section
7) *Ultrasonic*
8) Pressure loss flow testing
9) Other
10) Performed by other level of gov't
11) None of the above

As can be seen from a review of **Chart 1**, 84 percent of respondents reported using closed circuit television (CCTV), followed by 68 percent using external visual inspections; 39 percent each using cut-out section analysis and pressure loss flow testing; and 16 percent reported using corrosion pit analysis. Only 5 percent of respondents are using sonar systems while an additional 5 percent reported using internal visual ("other" — presumably the same as cut-out section analysis).

Chart 1 - Determining Pipe Condition

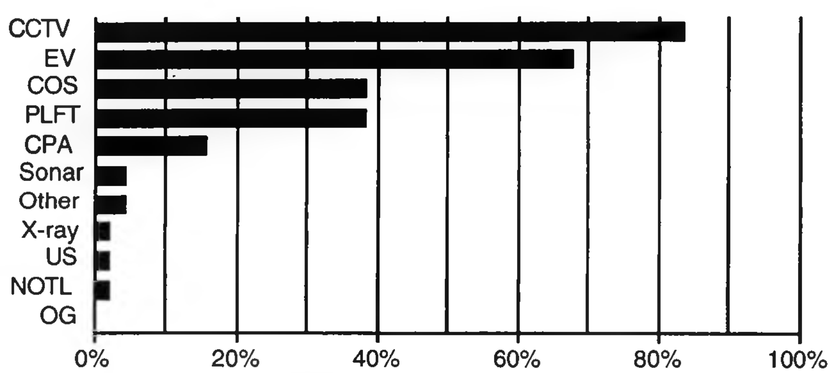


CHART 1 LEGEND: CCTV - closed circuit television; EV - external visual; COS - cut-out section; PLFT - pressure loss flow testing; CPA - corrosion pit analysis; US - ultrasonic; NOTL - none of those listed; OG - other government

3.3.2 Methods of Watermain Leak Detection

Respondents were asked to record, from the following list, which methods of watermain leak detection they employ.

1) Flow monitoring
2) *Tracer gas testing*
3) *Sonic leak detectors*
4) System metering
5) Other
6) Performed by other level of gov't
7) None of the above

Chart 2 indicates that 57 percent of respondents use sonic leak detectors to locate watermain leaks, followed by 36 percent who use system metering and 34 percent who use flow monitoring. Fourteen percent reported using "other" methods such as leakage at the surface, and related visual methods (ground subsidence).

No one reported using tracer gas testing, while seven percent of respondents indicated that they used none of the methods in the list, presumably relying on visual methods instead.

Chart 2 - Detecting Watermain Leaks

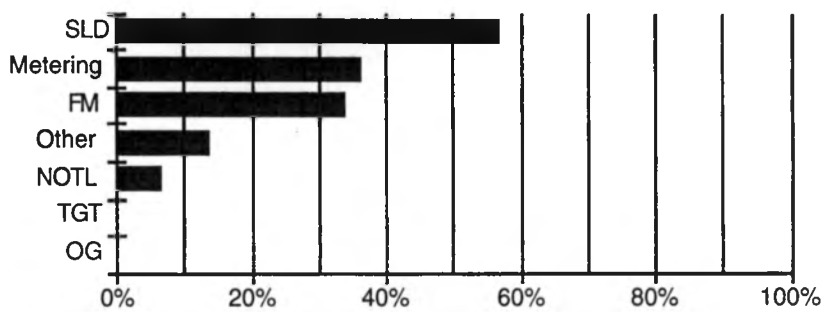


CHART 2 LEGEND: SLD - sonic leak detector; FM - flow metering; NOTL - none of those listed; TGT - tracer gas testing; OG - other government

3.3.3 Methods of Monitoring Pipe Capacity and Condition

The survey asked respondents to indicate what methods their municipality uses to monitor pipe capacity and condition within sanitary and storm sewers and/or watermains, selecting from the following:

1) Flow meters
2) Fire hydrant flow testing
3) Records of pipe failures
4) Records of consumer complaints
5) Assessment of condition during repairs
6) Weir/flume (open channel) flow meters
7) *Corrosion coupons*
8) Other
9) Performed by other level of gov't
10) None of the above

Chart 3 demonstrates that respondents are relying on a wide variety of techniques to monitor pipe capacity and condition. Eighty-nine percent of respondents reported assessing overall pipe condition during routine repairs, 75 percent use records of pipe failures, 73 percent use fire hydrant flow testing, 66 percent use records of consumer complaints, 64 percent use flow meters, and 20 percent use corrosion coupons. Eighteen percent reported using weir/flume flow meters and 11 percent reported using "other" techniques such as surge monitors, CCTV and hydraulic calculations and computer network analyses.

Chart 3 - Monitoring Pipe Capacity and Condition

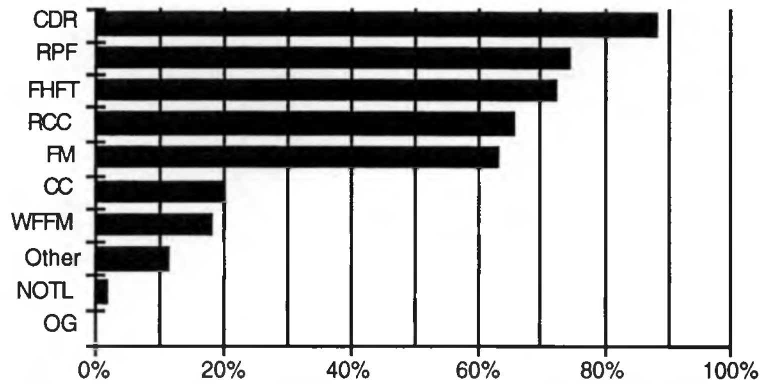


CHART 3 LEGEND: CDR - condition during repairs; RPF - records of pipe failures; FHFT - fire hydrant flow testing; RCC - records of consumer complaints; FM - flow meters; CC - corrosion coupons; WFFM - weir/flume flow meters; NOTL - none of those listed; OG - other government.

3.3.4 Methods of Locating Watermains

Respondents were asked to document what methods their municipality employs to locate watermains. The list of options included the following.

1) Test excavation
2) *Electromagnetic induction (EMI)*
3) *Ground probing radar*
4) Other
5) Performed by other level of gov't
6) None of the above

Chart 4 indicates that 61 percent of respondents reported using test excavations to locate watermains, followed closely by 57 percent who reported using electromagnetic induction (for locating mains made out of metal). Five percent reported using ground probing radar (for determining the location of plastic and cement pipes) while 20 percent relied on existing records ("other" category).

Chart 4 - Locating Watermains

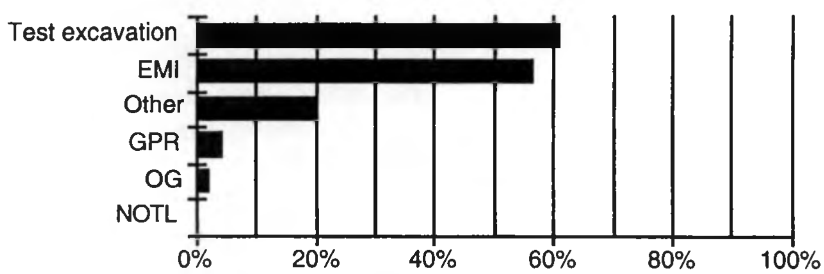


CHART 4 LEGEND: TE - test excavation; EMI - electromagnetic induction; GPR - ground probing radar; OG - other government; NOTL - none of those listed

3.3.5 Methods of Planning for Future Upgrades

This section of the questionnaire concluded with a question about how municipalities plan for future upgrading to their piped infrastructure. The list of options included:

1) Flow capacity testing
2) Pressure testing
3) Inventory of watermain/sewer maintenance records
4) Infiltration/inflow analysis
5) By age of pipe
6) By condition of pipe
7) Geographical Information Systems
8) Water inventory & maintenance base (*WIMS*)
9) Sewer inventory & maintenance data base (*SIMS, SAM*)
10) Stormwater computer modeling (*SWMM, SAM*)
11) Water and sewer rate software
12) Hydrology Modeling (*OTTHYMO*)
13) Hydraulic Modeling (*EXTRAN*)
14) Other
15) Performed by other level of gov't data
16) None of the above

Chart 5 shows that 78 percent of respondents rely on an inventory of watermain/sewer maintenance records as a diagnostic tool in planning for future system upgrading, followed by the condition of the pipe (73 percent of respondents); age of the pipe (59 percent); flow capacity testing (57 percent); analysis of infiltration/inflow data (50 percent); and, pressure testing (39 percent of respondents).

Chart 5 - Planning for Future Upgrading

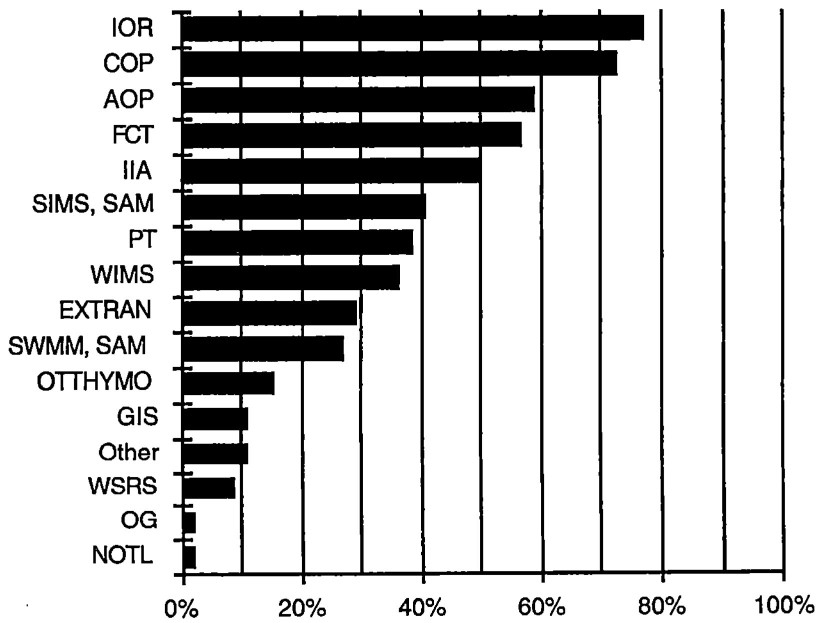


CHART 5 LEGEND: IOR - inventory of records; COP - condition of pipe; AOP - age of pipe; FCT - flow capacity testing; IIA - infiltration/inflow analysis; SIMS/SAM - sewer inventory and maintenance data bases; PT - pressure testing; WIMS - water inventory and maintenance data bases; EXTRAN - hydraulic computer model; SWMM/SAM - stormwater computer modeling; OTTHYMO - hydrology modeling; GIS - geographical information systems; WSRS - water and sewer rate software; OG - other government; NOTL - none of those listed

Several respondents reported using a selection of proprietary computer software packages to assist in planning for future system upgrades. These included sewer inventory management systems (SIMS) and sewer analysis models (SAM), reported by 41 percent of respondents; water inventory management systems (WIMS), reported by 36 percent of respondents; extended transport (EXTRAN) subsurface drainage modeling, reported by 30 percent of respondents; and, hydraulic modeling (OTTHYMO) of urban and rural catchment areas, reported by 16 percent of respondents.

3.4 Operations and Maintenance Issues

Part III of the questionnaire sought information on the methods, technologies and practices municipalities currently use in the day-to-day operation and maintenance of the infrastructure under their jurisdiction.

3.4.1 Types of O & M Activities

Respondents were asked to select options from the following list. More than one option could be selected.

1) Flow capacity testing
2) Exercise valves
3) Bacteriological/water quality testing
4) Wastewater quality testing
5) *Pigs*
6) *Hydro-cleaning*
7) *Swabbing*
8) Leak detection (watermains)
9) Pressure testing (watermains)
10) Sewer flushing
11) *Sewer rodding*
12) Hydrant flushing
13) Bench testing of water meters
14) Catch basin vacuum cleaning
15) Street sweeping
16) *Cathodic protection*
17) Other
18) Performed by other level of gov't
19) None of the above

Chart 6 reveals a striking range of tools and techniques available to municipal works employees which are used on a regular basis to carry out ongoing operation and maintenance requirements. The most popular techniques include: sewer flushing (89 percent of respondents); catch basin sump pump cleaning (89 percent); hydrant flushing and street sweeping (each at 77 percent of respondents); bacteriological/water quality testing (75 percent); activation of exercise valves (73 percent); capacity flow testing (55 percent); wastewater quality testing (52 percent); cathodic protection and bench testing of water meters (each at 45 percent of respondents); sewer rodding (41 percent); hydro-cleaning (39 percent); and, leak detection on watermains (36 percent).

Respondents who selected any of the above categories were asked to indicate the frequency with which the activity was undertaken. With respect to sewer flushing, those who reported carrying out this activity identified frequencies ranging from daily to every eight years[6]. Twenty-four percent reported undertaking this activity on an annual basis, 12 percent as required, 10 percent every two years, 5 percent every 5 years, 5 percent every 6 months, 5.5 percent every 3 years, 5.5 percent every 4 years, 5.5 percent daily, 2.5 percent every 7 years, 2.5 percent every 8 years, and 7.5 percent variable. Fifteen percent of respondents to this category indicated no frequency figure.

[6] The way this question was asked may have generated some confusion in the way it was answered. For example, it is assumed that those who responded that sewer flushing was occurring daily meant that, on any given day, the activity was being undertaken somewhere in their system.

Chart 6 - Types of O & M Activities

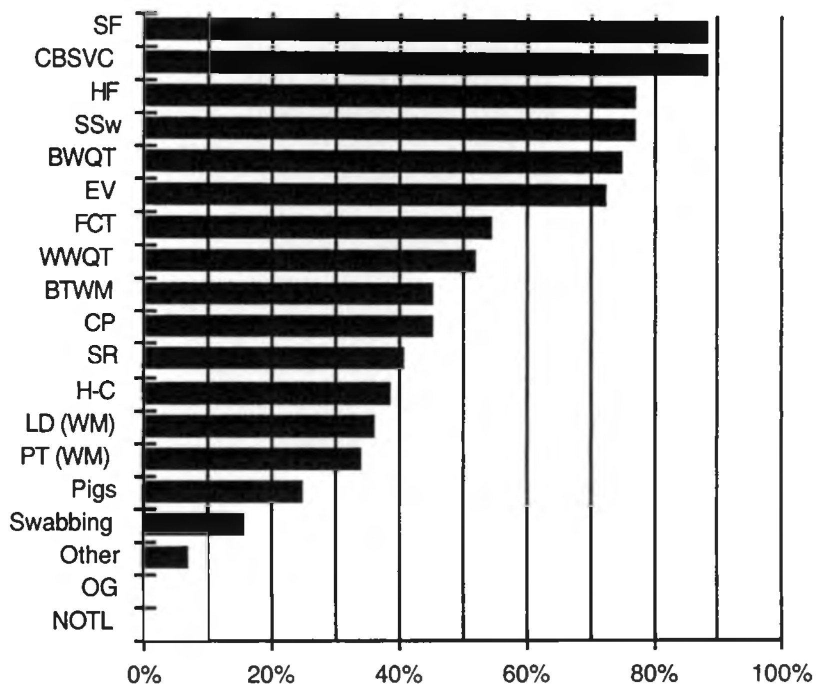


CHART 6 LEGEND: SF - sewer flushing; CBSVC - catch basin sump vacuum cleaning; HF - hydrant flushing; SSw - street sweeping; BWQT - bacteriological water quality testing; EV - exercise valves; FCT - flow capacity testing; WWQT - wastewater quality testing; BTWM - bench testing of water meters; CP - cathodic protection; SR - sewer rodding; H-C - hydro-cleaning; LD (WM) - leak detection (watermains); PT (WM) - pressure testing (watermains); OG - other government; NOTL - none of those listed

3.5 Types of Local Repairs

Part IV of the questionnaire sought information on the methods municipalities currently employ in conducting *small scale* repairs to water and sewer services under their jurisdiction, involving *emergency repairs* and *planned regular maintenance* activities.

3.5.1 Types of Repair Activities

Respondents were asked to select options from the following list. More than one option could be selected.

1) Excavate and replace
2) *Repair clamps*
3) *Grout sealing*
4) *Manhole rehabilitation liners*
5) *Reaming and chemical sealing*
6) *Resin injection*
7) *Keyhole technology*
8) *Internal sleeves*
9) Defrosting frozen services
10) Other
11) Performed by other level of gov't
12) None of the above

Chart 7 shows that conventional repair technology is the option of choice in most situations involving repairs. Fully 100 percent of respondents to the questionnaire have used excavation and replacement techniques in the past five years. In addition, 82 percent have used repair clamp technology, followed by: grout sealing (64 percent of respondents); internal sleeve technology (34 percent); resin injection and reaming and chemical sealing (both reported by 27 percent of respondents); keyhole technology (14 percent); and, manhole rehabilitation liners (7 percent of respondents). Nine percent of respondents reported using other technologies or repair activities including: insulating lines; utilizing heat trace services; rebuilding pumps and employing full length trenchless technologies.

Chart 7 - Types of Repairs

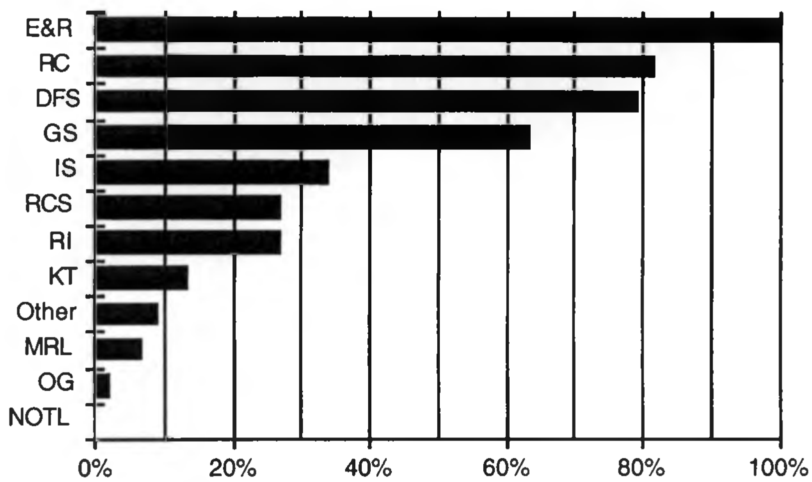


CHART 7 LEGEND: E&R - Excavate and replace; RC - repair clamps; DFS - defrost frozen services; GS - grout sealing; IS - internal sleeves; RCS - reaming and chemical sealing; RI - resin injection; KT - keyhole technology; MRL - manhole rehabilitation liners; OG - other government; NOTL - none of those listed

3.6 Rehabilitation and Replacement

Part V of the questionnaire dealt with the methods municipalities currently employ in the large scale rehabilitation or replacement of piped services within their jurisdiction. The section was subdivided into three parts: 1) in-situ *rehabilitation* of existing pipe with linings; 2) in-situ *replacement* of existing pipe; and 3) no-dig *directional drilling* involving new pipe systems.

3.6.1 In-Situ (No-Dig) Rehabilitation Techniques

This question asked whether the respondent had any experience using any of the following in-situ (no-dig) *rehabilitation* techniques applied to *existing* inground pipes, manholes and/or chambers. Respondents were asked to select options from the list on the following page. More than one option could be selected.

1) *Sliplining*
2) *Swaglining*
3) *Roll-down lining*
4) *Thread-jointed pipe*
5) *Romo-lining*
6) *Interlining*
7) *Fold and form lining*
8) *Spiral lining*

9) *Inverted, cured-in-place pipe lining*
10) *Sprayed epoxy resin lining*
11) *Sprayed cement mortar lining*
12) *Robotic cutters for service laterals*
13) Other
14) Performed by other level of gov't
15) None of the above

As indicated in **Chart 8**, the respondents have developed some (limited) experience or exposure to in-situ, no-dig technology to rehabilitate water and sewer lines. Thirty-four percent reported having used inverted, cured-in-place pipe (I-CIPP) lining in the past five years, followed by: robotic cutters for service laterals (32 percent of respondents); sliplining (30 percent); fold and form lining (20 percent); sprayed cement mortar lining (20 percent); swaglining (7 percent); roll-down lining (7 percent); thread-jointed pipe (7 percent); spiral lining (7 percent); sprayed epoxy resin lining (5 percent); and, interlining (2 percent of respondents).

Under the "other" category, 7 percent of respondents reported using such techniques as link pipe, pipe bursting and a proprietary resin lining product.

What is interesting to note is that nearly one-third of the respondents reported having *no experience* with any of the in-situ rehabilitation techniques listed in the questionnaire. This suggests that concerns about liability and proof of performance are still major barriers to the broader uptake of these new technologies.

Chart 8 - In-Situ Rehabilitation Techniques

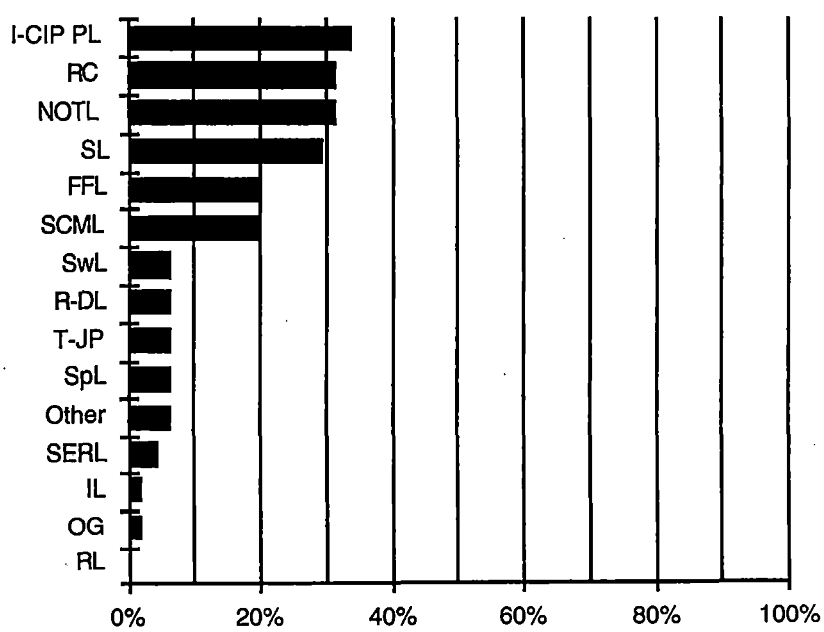


CHART 8 LEGEND: I-CIPPL - inverted cured-in-place pipe lining; RC - robotic cutters for service laterals; NOTL - none of those listed; SL - sliplining; FFL - fold and form lining; SCML - sprayed cement mortar lining; SwL - swaglining; R-DL - roll-down lining; T-JP - tread-jointed pipe; SpL - spiral lining; SERL - sprayed epoxy resin lining; IL - interlining; OG - other government; RL - romo-lining

3.6.2 In-Situ (No-Dig) Replacement of Existing Piped Services

This question asked whether the respondent had any experience using any of the following in-situ (no-dig) *replacement* techniques applied to *existing* inground services. Respondents were asked to select options from the following list. More than one could be selected.

1) *Small diameter displacement/ compaction drilling*
2) *In-situ pipe jacking/bursting*
3) *Small diameter hydro-jet drilling*
4) Microtunneling
5) Other
6) Performed by other level of gov't
7) None of the above

Chart 9 shows that only a handful of municipalities have any direct experience with no-dig replacement technologies. For example, only 14 percent of respondents have used in-situ pipe jacking or bursting. Eleven percent of respondents reported having experience with small diameter displacement /compaction drilling followed by: microtunneling (9 percent); small diameter hydro-jet drilling (7 percent); and, under the "other" category, two proprietary products (5 percent) which are actually more commonly used in rehabilitation circumstances. Fifty percent of respondents reported having no direct experience with any of the technologies listed.

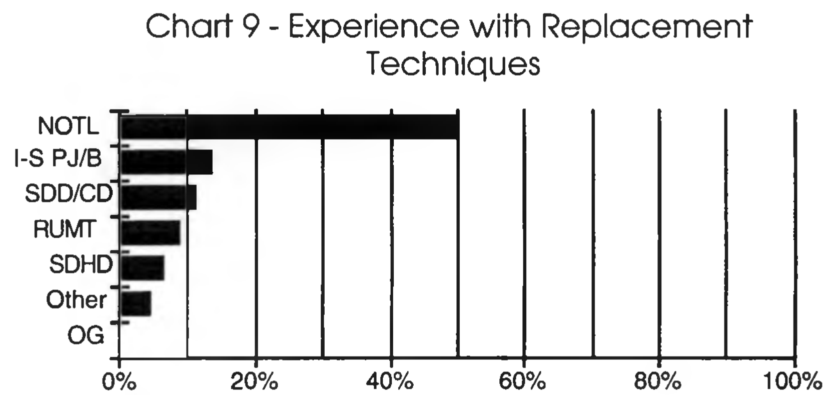


CHART 9 LEGEND: I-S PJ/B - in-situ pipe jacking/bursting; SDD/CD - small diameter displacement/compaction drilling; RUMT - replacement using microtunneling; SDHD - small diameter hydro-jet drilling; OG - other government; NOTL - none of those listed

3.6.3 In-Situ (No-Dig) Installation of *New* Piped Services

This question asked whether the respondent had any experience using any of the following in-situ (no-dig) techniques applied to *new* inground services. Respondents were asked to select options from the following list. More than one option could be selected.

1) *Horizontal boring (auger method)*
2) *Horizontal boring (slurry method)*
3) *Small diameter pneumatic rotary air drilling*
4) *Large diameter directional drilling*
5) *Microtunneling*
6) *Pipe jacking*
7) Conventional tunneling
8) Other
9) Performed by other level of gov't
10) None of the above

A review of **Chart 10** indicates that 41 percent of respondents have some experience with the auger method of horizontal boring or drilling, followed by: pipe jacking (34 percent); conventional tunneling (27 percent); small diameter pneumatic rotary air drilling (9 percent); microtunneling (9 percent); large diameter directional drilling (7 percent); and, pneumatic tunneling and directional boring (5 percent) listed under the "other" category. Two percent of respondents (one municipality) reported having used the slurry method of horizontal boring. Twenty-three percent of respondents indicated having no experience with any of the options on the list.

Chart 10 - Experience with No-Dig Techniques

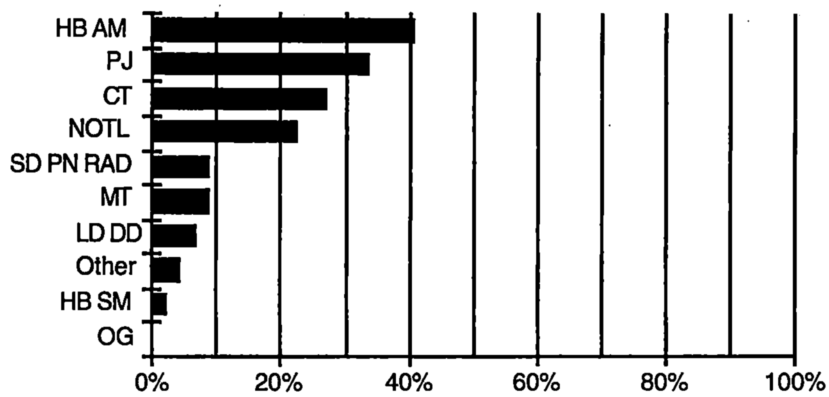


CHART 10 LEGEND: HB AM - horizontal boring (auger method); PJ - pipe jacking; CT - conventional tunneling; SD PN RAD - small diameter pneumatic rotary air drilling; MT - microtunneling; LD DD - large diameter directional drilling; HB SM - horizontal boring (slurry method); OG - other government; NOTL - none of those listed

3.7 System Modifications

Part VI of the questionnaire asked for documentation about sanitary and storm sewer modifications or improvements — involving either management systems or technology — which municipalities had exposure to in the previous five years.

3.7.1 Types of Sanitary/Combined Sewer System Modifications

Respondents were ask to list types of sanitary/combined sewer system modifications or improvements they may have undertaken in the past 5 years. They were asked to select options from the following list. More than one option could be selected.

1) Combined sewer overflow (CSO) retention tanks/tunnels
2) Combined sewer separations
3) Supervisory Control and Data Acquisition *(SCADA)* monitoring
4) Automated Mapping/Facilities Management *(AM/FM)* data bases
5) *Stormwater disconnection bylaws*
6) Home water metering program
7) Other
8) Performed by other level of gov't
9) None of the above

Chart 11 shows that 43 percent of respondents are using computerized monitoring systems such as SCADA (Supervisory Control and Data Acquisition), while 30 percent are using some sort of computerized mapping data base referencing system such as AM/FM (Automated Mapping/Facilities Management).

Thirty-four percent reported their municipalities are engaged in combined sewer separation programs and home water meter installation programs, stormwater disconnection bylaws (27 percent of respondents), or CSO (combined sewer overflow) retention tank/tunnel construction (25 percent).

Eleven percent of respondents reported using none of the items on the list. Those who referenced the "other" category were, in fact, noting either combined sewer separations or standard detention tanks and pipes (5 percent).

Chart 11 - Types of Sewer Modifications

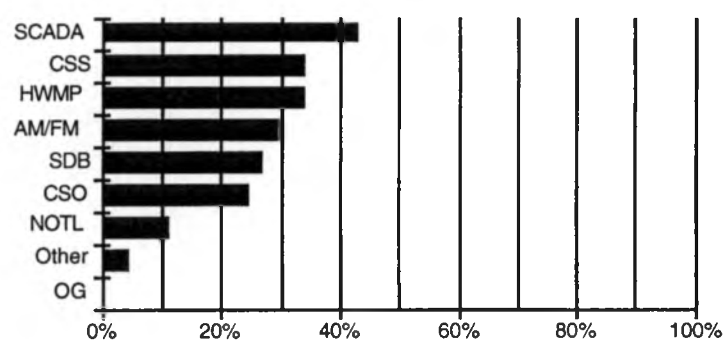


CHART 11 LEGEND: SCADA - supervisory control and data acquisition monitoring system; CSS - combined sewer separations; HWMP - home water meter program; AM/FM - automated mapping/facilities management system; SDB - stormwater disconnection bylaws; CSO - combined sewer overflow retention tanks/tunnels; OG - other government; NOTL - none of those listed

3.7.2 Types of Storm Sewer System Modifications

Respondents were ask to list types of storm sewer system modifications or improvements they may have undertaken in the past 5 years under the following categories: 1) source control; 2) conveyance control; and, 3) end of pipe. They were asked to select options from the following list. More than one option could be selected.

1) Source Control

1) *Cisterns*/soakaway pits
2) *Permeable pavement*
3) Other (specify)
4) Performed by other level of gov't
5) None of the above

2) Conveyance Control

1) *Vortex separator*
2) *Oil/grit separators*
3) *Grassed drainage swales*
4) Pervious pipe
5) Other
6) Performed by other level of gov't
7) None of the above

3) End of Pipe

1) *Stormwater disinfection* (ozone, UV)
2) Sand filters
3) Infiltration basins
4) *Detention ponds/marshes/wetlands*
5) Other
6) Performed by other level of gov't
7) None of the above

In terms of source controls, **Chart 12 a** indicates that 20 percent of respondents reported having some experience with cisterns and soakaway pits while only one respondent reported using permeable pavement. In addition, under the "other" category, there were three additional items registered (flow restriction hydro brakes, box culverts with debris collection sumps, and downspout disconnection/sump pumps/lot regrading (all mentioned by one respondent). Perhaps most significantly, 52 percent of respondents recorded that they had no experience with any of the items on the source control list.

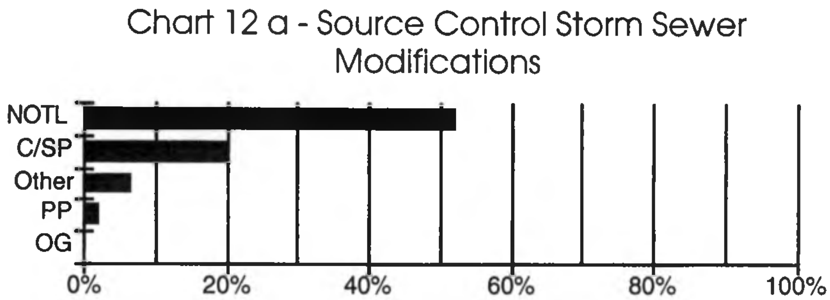


CHART 12 a LEGEND: C/SP - cisterns/soakaway pits; PP - permeable pavement; OG - other government; NOTL - none of those listed

In terms of conveyance control, **Chart 12 b** shows that about 30 percent of respondents are using grassed drainage swales, 18 percent are using oil/grit separators, 18 percent are using pervious pipe, and 14 percent are using vortex separators. In addition, 41 percent reported having no experience with any of the items on the conveyance control list.

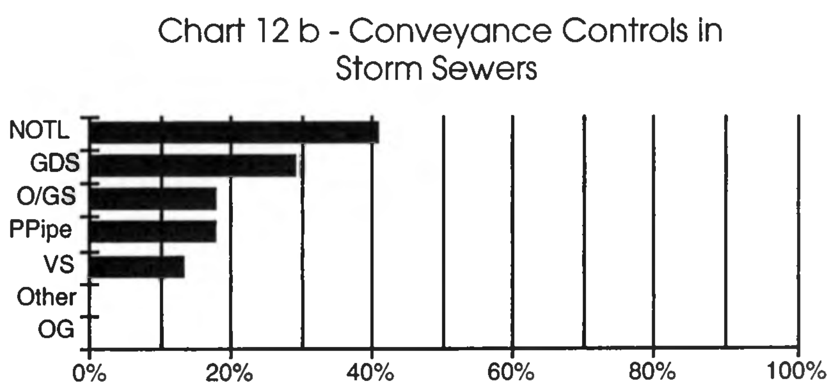


CHART 12 b LEGEND: GDS - grassed drainage swales; O/GS - oil/grit separators; PPipe - pervious pipe; VS - vortex separator; OG - other government; NOTL - none of those listed

End of pipe information is depicted in **Chart 12 c**. Forty-three percent of respondents reported having experience with detention ponds, marshes or similar wetlands as a method of dealing with storm water treatment. Only 5 percent reported using infiltration basins. "Other" techniques reported by three respondents were: diversion to sanitary sewers, energy displacement boulders and sedimentation ponds. Thirty-four percent of respondents reported having no direct experience with any of the applications on the list.

Chart 12 c - End of Pipe Storm Sewer Modifications

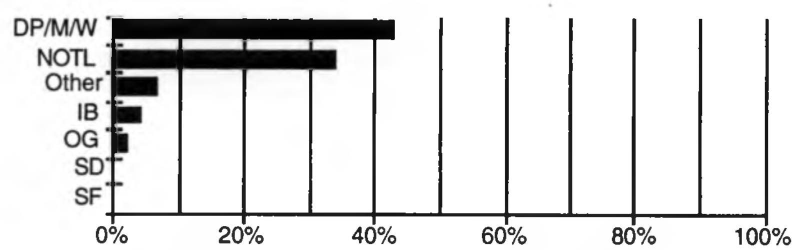


CHART 12 c LEGEND: DP/M/W - detention ponds/marshes/wetlands; IB - infiltration basins; SD - stormwater disinfection; SF - sand filters; OG - other government; NOTL - none of those listed

3.8 Pilot Projects or Trials Underway

Part VII of the questionnaire was open ended and was designed to obtain information on any pilot projects respondents had undertaken involving piped services. None were referenced or offered by any of the respondents. This section also sought information on procurement policies and alternative servicing standards for new development, etc.

3.8.1 Sewage Conveyance Alternatives

Respondents were asked to report on municipal experience with alternative methods of sewage conveyance to traditional gravity systems. Respondents were invited to select from the list below.

1) *Pressure sewers*
2) *Vacuum sewers*
3) Small diameter, variable grade gravity sewers
4) Other
5) Performed by other level of gov't
6) None of the above

Chart 13 indicates that 43 percent of respondents have had direct experience with pressure sewers, followed by small diameter variable grade gravity sewers (34 percent), and vacuum sewers (7 percent). The chart also reveals that 34 percent of respondents have had no direct experience with the items on the list.

Chart 13 - Alternative Sewage Conveyance

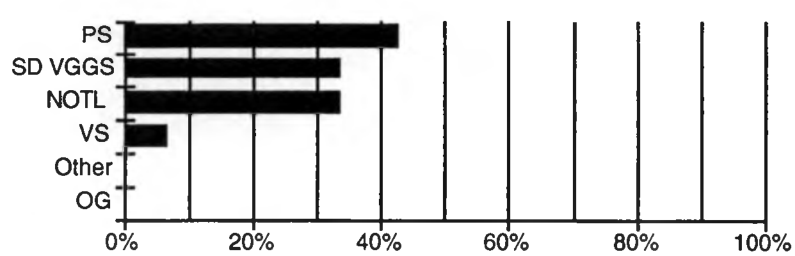


CHART 13 LEGEND: PS - pressure sewers; SD VGGS - small diameter variable grade gravity sewers; VS - vacuum sewers; OG - other government; NOTL - none of those listed

3.8.2 Decision-Making About New Technologies

Respondents were ask to indicate which of the criteria on the following list are used in making decisions about new technologies.

1) Price
2) Durability
3) Availability
4) Proven in other municipalities
5) Legal acceptance
6) Provincial standards

Chart 14 reveals that 91 percent of municipal respondents are more likely to adopt new technologies if they have a proven track record in other municipalities. Other key influencing criteria are: price (82 percent of respondents); durability (68 percent); availability (61 percent); coverage of the technology by existing provincial standards (59 percent); and, legal acceptance (41 percent of respondents).

Chart 14 - New Technology Selection Criteria

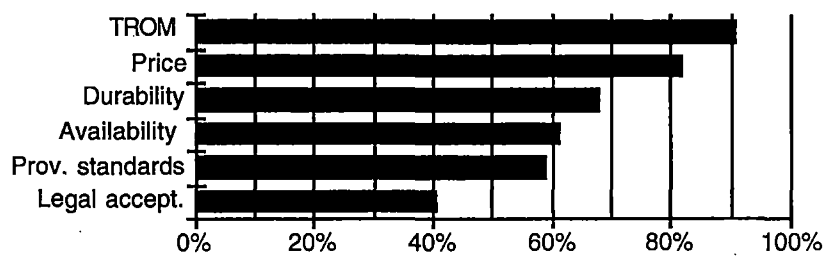


CHART 14 LEGEND: TROM - track record in other municipalities

In a related area, the questionnaire sought information on whether procurement policies used by municipalities establish minimum performance standards as a way to limit municipal exposure when adopting new technologies. Fifty-nine percent of respondents answered in the affirmative to this question while 25 percent answered in the negative. An additional 11 percent indicated that it would depend on the technology.

The survey also sought information on whether procurement policies considered lowest first cost or life-cycle costing in the case of new technology. Forty-three percent of respondents indicated that life-cycle costing was a key determining factor while 27 percent reported that lowest first cost was important. A further 23 percent indicated that such decisions would depend on the technology in question.

Section 4
Case Studies

A component of this project included the development of a series of case studies of municipal experience with innovative infrastructure renewal technology. Once the initial survey results were analysed, a series of case study candidates were shortlisted and the survey respondents were contacted to obtain more detailed information on their experience with innovative technologies.

Six case studies were developed, each conforming to a two-page reporting format. These case studies are contained in Appendix 3. The case studies cover the following infrastructure categories (with technologies in parenthesis):

- Case Study 1 – leak detection (sonic leak detection)
- Case Study 2 – corrosion protection (cathodic protection)
- Case Study 3 – no-dig spot repair (resin injection)
- Case Study 4 – sewer relining (fold and form lining)
- Case Study 5 – no-dig structural rehabilitation (mini-annulus liner)
- Case Study 6 – no-dig pipe installation (microtunneling)

Each two-page case study in Appendix 3 is organized around the headings of: technology, application context, rationale for use of the technology, results, costs, savings, availability, and contact person to obtain more information.

It should be emphasized that the case studies which were selected for this project were designed to give the reader a sampling of activity in each of the six main subject areas of the survey. They provide only a brief overview of the technique or application. The interested reader is encouraged to get in touch with the municipal contact, listed with each case study, for more detailed information.

During the process of shortlisting candidate municipalities for the development of the case studies, an interesting dilemma emerged. The commitment to a particular innovative rehabilitation technique that was identified (or inferred) in the completed questionnaires was not always confirmed by the follow-up, in-depth telephone interviews.

Apparently, while selected municipalities are prepared to assume the role of "early adopter" of new technologies, they prefer to wait several years for enough performance, operation and maintenance data to accumulate before committing on a massive scale to a particular new technology or application. In effect, many municipal forays into innovative infrastructure renewal techniques might be more accurately termed *pilot projects*.

This "proceed with caution" attitude on the part of municipal infrastructure professionals is understandable. For example, not all of the candidate case studies which were shortlisted reported positive results from using new technology. Further, one of the case studies reported in Appendix 3 (Case Study 4) describes the experience of the City of London, Ontario with a no-dig fold and form relining of a clay sanitary sewer.

The City had no previous experience with this relining technique and so, in 1993, elected to use this rehabilitation as a test of the technology. The case study notes that the City had disappointing results with the installation of the liner. The liner was torn in one location which required additional repairs and several service laterals were missed. In another location, a service lateral was cut through the pipe wall where one did not exist, causing spillage of backfill into the sewer.

London engineers intend to canvas other municipalities to determine their success rates with this technology. It is encouraging to note that, despite the problems encountered with this test application, the City stills believes that, ultimately, the liner technology will be lower in cost than conventional rehabilitation techniques involving excavation. If the technology has advanced enough in the eyes of the department, they will attempt another trial.

The other five case studies report successful applications of innovations which, generally speaking, provided the level of service expected at a lower cost than conventional practices. However, even in the case of successful applications of new technologies, many municipalities will likely proceed with caution until enough performance data is accumulated to justify further investment in alternative technology.

The desire to proceed with caution, even when a generally positive result is obtained with new technology, may explain the hesitation of several candidate municipalities who made the case study short list to "go public" with their examples. Several reported that they had used sliplining or resin injection techniques but had returned to conventional practices, such as excavation. They indicated this was a pragmatic approach which would allow enough monitoring to take place before changing over practices entirely to the new technology.

The continued caution or skepticism on the part of municipal infrastructure professionals concerning innovative technology points to several barriers which must be addressed in any discussion about the diffusion of innovation into the municipal infrastructure marketplace.

However, before the implementation of newer technologies takes place, administration practices must be changed to encourage their use. For instance, treating municipal water and sewer departments more like a regulated utility, such as is done for electric, gas, telephone, cable and related telecommunications services, would be a step in the right direction.

Using utility accounting practices would help ensure that a reserve fund is in place to rehabilitate and replace the system when needed. With such a fund in place, the municipality is in a much better position to entertain new technologies and practices, and to proceed in a proactive manner with a properly planned and budgeted repair and replacement strategy, rather than having to react to crises as they occur.

Before effective principles of utility accounting and financing can be applied in the context of municipal water and sewer infrastructure, it will be necessary to close the loop that currently exists in many municipalities between the provision of water and sewer services. In many municipal jurisdictions in Canada, one department or agency, such as a PUC, provides water services, while a different department is responsible for sewage collection and treatment. This often results in the costs of sewage collection and treatment being effectively hidden from the consumer.

The ensuing discussion may also assist the reader in interpreting the results of the survey and the case study material.

Section 5
Discussion

5.1 Overview

The results of this survey, as well as the case study material, can be interpreted in a number of ways. While interpretation of the results of the survey, and of the case studies, will be left to the reader, the survey and case studies do show that municipal interest in and experience with innovative infrastructure renewal technology is growing, albeit, slowly.

For example, Chart 6 on page 17 shows that, while nearly 90 percent of respondents reported using conventional sewer flushing as a method of cleaning sewers, about 40 percent have used sewer rodding or hydro-cleaning. Further, about 25 percent have used pigs and about 15 percent have used swabbing for cleaning watermains.

Chart 7 indicates that conventional technology — excavation and repair — is still the option of choice for most municipalities when it comes to repairs. However, internal sleeves, resin injection and reaming and chemical sealing have been used by between 25 to 35 percent of respondents. Further, keyhole technologies have been used by about 15 percent of respondents.

Chart 8 shows that respondents have had limited experience with in-situ, no-dig technology to *rehabilitate* water and sewer lines, but that about a third of the respondents have reported some experience with cured-in-place pipe liners, robotic cutters, and sliplining.

Chart 9 reveals that a much smaller percentage of respondents have had any direct experience with no-dig alternatives as a method of *replacing* water and sewer lines. For example, only about 15 percent reported using pipe jacking and less than 10 percent reported any experience with microtunneling and small diameter directional drilling.

As far as no-dig installations of *new* piped services go, Chart 10 shows that less than 10 percent of respondents have reported experience with directional drilling or microtunneling. However, 40 percent did report having used the auger method of horizontal boring, while about 35 percent reported having used pipe jacking.

5.2 Interpreting the Results

Drawing any conclusions from these results will vary, depending on the perspective of the reader. To the layperson, the numbers might seem disappointing. To the entrepreneur carving out a niche in a developing industry, the numbers could be considered encouraging. To the unionized contractor in the Greater Toronto Area (GTA), the numbers may be seen in a different light[7].

As one moves from the use of non-destructive investigative methods at one end of the innovation spectrum through the operation, maintenance and repair fields to the actual large scale rehabilitation and replacement of municipal infrastructure, the rate of uptake of, and experience with innovative technology or practices diminishes.

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[7] For example, most open-cut contractors in the GTA are unionized, whereas most trenchless technology contractors are non-unionized. The preference on the part of GTA contractors for conventional technologies and practices may be more a function of the perceived need to ensure job security, rather than any substantive concerns about the efficacy of new technologies.

For example, while nearly 85% of respondents reported using closed circuit television (CCTV) — a technique which has been in use for 30 years — to determine the condition of sewers, only about 35% reported using internal sleeves to repair problems encountered. Further, only about 30% reported using any of the currently available sliplining techniques to rehabilitate pipe sections — techniques which have been in use for over 20 years — while fewer than 15% reported any experience with in-situ pipe jacking or bursting. And, finally, less than 10 percent reported any experience with microtunneling.

The reason for these figures may have a lot to do with perceptions of risk associated with the new technologies. At the investigational end of the spectrum, the risk of new technology, such as CCTV may be perceived to be low compared to the benefits — better diagnostic capabilities. CCTV has a longer history, municipalities have become familiar with it, and its output — colour video pictures — is very compelling. In other words, CCTV may be a fairly easy sell to the political decision makers. In addition, the investment is low and few, if any, issues of liability are involved, as much of the work can be contracted out. If the remote camera platform malfunctions, a manufacturer's warranty limits the liability of the contractor conducting the investigations as well as that of the municipality.

At the other end of the infrastructure spectrum — the large scale replacement or renewal of sewer and water lines — a whole different set of variables are at play. The level of investment can be in the millions of dollars and the level of uncertainty is much higher. The perceived risk may be higher as well and few municipalities appear willing to assume the liability associated with this risk. The bottom line is that cost effective and proven infrastructure alternatives may not be adopted due to this perception of higher risk.

Why is this? Why do municipalities view innovation with such caution and reserve? The answers may be found within the complex system of checks and balances by which municipal infrastructure is designed, financed, constructed, operated and maintained.

5.3 Financing/Cost Recovery Issues

Until recently, very few municipalities demonstrated the political will to impose full cost pricing to recover the true costs of providing municipal services. Instead, the historical tendency has been to price their services, e.g., for water supply and sewage treatment, at a level which is perceived to be acceptable to the municipal consumer, rather than at the true cost of providing the service. This statement applies equally well to garbage collection and recycling as it does to the provision of sewer and water services. In addition, few municipalities have the mandate or authority to create proper reserve funds to replace infrastructure components which have reached the end of their service life.

Chronic underfunding creates its own viscous cycle resulting in a kind of "crisis management" in which only the latest line break gets repaired or replaced. Waiting until an infrastructure component fails does not create the best environment within which to entertain innovative alternatives.

Further, chronic underpricing of water and the availability of senior government subsidies have worked to distort the relationship between what the customer pays for the service and what the true cost is in providing the service. On top of this, senior level funding for system repairs and rehabilitation is being drastically scaled back. This condition is forcing many provinces and municipalities to rethink their infrastructure accounting practices.

For example, the province of Ontario is currently reviewing the whole process whereby municipalities finance and replace sewer and water systems. A 1991 study prepared for the Ontario Ministry of Municipal Affairs[8] noted that present accounting practices for Ontario municipalities do not allow them to depreciate sewer and water systems, or show them as an asset on their balance sheets. If they were able to do this, it would create an opportunity to generate reserve funds, through a depreciation allowance, for the future replacement of the asset.

However, a move to this kind of accounting practice in Ontario — which is, essentially a move to utility accounting methods — even if it were approved by the Ontario Municipal Board, would need two additional changes to support it: 1) a move to institute full cost pricing/user pay schemes; and, 2) aggressive implementation of demand management programming to cushion the expected significant per household price increases associated with full cost pricing[9].

5.4 Design Issues

The design of municipal roads, water and sewer infrastructure requires specialized expertise which most municipal corporations do not retain on staff. Instead, they rely on engineering consultants to provide these services. These consultants usually respond to a tendering process which is inimical to innovation or the introduction of new technology. As a recent study by CMHC points out[10], the winning bid, on price alone, is invariably the one which can demonstrate the most proficiency in the tried and true practices and procedures of the past.

In this environment, the proponent who promotes an innovative approach is at a distinct disadvantage. The municipal decision makers will likely have limited knowledge of, experience with, or faith in the innovative technology. Or, alternatively, they may have experience which was unfavourable. The bottom line is that the deck is stacked against alternative or innovative solutions to infrastructure design and O&M problems.

5.5 Legal/Jurisdictional Issues

To embrace innovation in any substantive way is to imply that the current way of doing things — the status quo — is no longer effective. This is an admission that many municipal engineers, as well as municipal solicitors and consulting professional engineers, are not eager to accept.

Along with innovation comes uncertainty, risk, liability concerns and the fear of prosecution in the courts if a new system fails to perform as specified. And, as the above-noted CMHC study points out, "the legal representatives and insurers for each party are quick to encourage the shedding of responsibility, risk and liability by that party [following the maxim] if there is any risk associated with the project, let it rest with someone else."

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[8] *Background Study on the Pricing of Water and Sewer Services*, prepared for the Ministry of Municipal Affairs by Marshall, Koenig & Associates, March 1991.

[9] In the study referenced in footnote 8, annual per home charges of $1,000 or more for water and sewer services were identified in some extreme cases.

[10] *A Sythesis of Technical Research and its Potential for Application in Linear Infrastructure Renewal*, written by CH2M Hill Engineering Ltd. for CMHC, 1994.

On the subject of risk and liability, a recent Supreme Court of Canada decision[11] will make the diffusion and uptake of innovation even less attractive to municipalities. Until recently, municipalities in Canada could use the defense of *statutory authority* in the event that a public work, such as a sewer, failed or otherwise created a public nuisance. All the municipality has to prove is that the failure was not due to any negligence on their part.

In the Supreme Court of Canada decision, a majority of the panel of judges reasoned that, if the legislation authorizing the work is *mandatory* (i.e., directs the municipal authority to construct certain works according to plans and specifications in a particular location for a specific purpose), then any nuisance caused by the failure of the work (in the absence of negligence) is *also* deemed to be authorized and the municipality can claim the defense of statutory authority.

However, if the legislation is *permissive* (i.e., gives the municipal authority broad *discretion* as to how and where to build the works), then it must exercise that discretion "with due regard for private rights." In the case referenced in the footnote (which involved a flooded basement caused by a blocked municipal sewer), the majority decision of the judges panel went against the municipality because the enabling legislation was permissive, not mandatory (i.e., the defense of statutory authority was unavailable to the municipality).

Unfortunately, the case is not as clear-cut as it seems. Two members of the five-member majority decision, although deciding against the municipality, arrived at this decision by a completely different route. In essence, they determined that the municipal defense of statutory authority was irrelevant in this case.

They reasoned that the provision of a service by a public utility is likely to result in inevitable incidences of failure leading to property damages and related nuisances. If the damage or nuisance is diffuse in its effect and only has a non-specific effect which impacts on the whole community (such as a closed beach due to a combined sewer overflow causing high bacteriological counts), then the municipality should not be held liable.

However, in this case, the occurrence was an isolated and infrequent event which inflicted heavy material damage on a single victim. The two judges concluded that, to deny the claim would have the effect of visiting a disproportionate share of the costs of the beneficial service on the homeowner who suffered the damage.

The bottom line, according to the author of the report, is that even if the enabling legislation had been mandatory, the defense of statutory authority no longer exists in law. The author goes on to cautioned that this decision will cause virtually all municipalities in Canada to have sobering second thoughts about innovative technologies to repair or rehabilitate municipal water and sewer systems.

5.6 Economic Barriers

In terms of economics, municipal stakeholders currently place an over-emphasis on capital costs in tendering procedures. As the 1994 CMHC study referenced in footnote 10 points out, if longer-term operation and maintenance factors were factored into a tendering process placing more emphasis on performance rather than prescriptive elements of the project, then many of these new technologies would be able to compete on a level playing field.

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[11] *Tock et al vs. St. John's Metropolitan Area Board and the Defense of Statutory Authority*, presented by R.S. Caswell, Q.C., P. Eng., in summary of proceedings to *Innovative Techniques for Rehabilitating Sewer Systems*, University of Toronto Faculty of Applied Science & Engineering Seminar, Nov. 1994

In this survey, 43 percent of respondents reported that life-cycle costing was a key selection criteria in their tendering documents while only 27 percent reported that lowest first cost was important.

As things presently stand, the current method of comparing costs between or among systems places innovative technologies at a disadvantage. They may offer little in the way of a price advantage and may initially be more expensive. Factoring in operational and maintenance and life cycle costing considerations is a start. However, if other social and environmental externalities are factored into the equation, then the true costs of each technology option are revealed.

For example, Union Gas and Centra Gas in Ontario now employ directional drilling as a non-invasive method of negotiating most watercourses during pipeline construction. This trenchless technology solved many environmental regulatory compliance problems for the utilities such that Centra eventually decided to purchase its own equipment, rather than rely on third party contractors. When broader environmental costs (and breach of compliance citations from regulatory agencies) were factored into the equation, directional drilling was chosen as the most cost-effective way to go.

Much the same argument can be made for the use of directional drilling and related no-dig technologies in water and sewer rehabilitation. Further, in addition to the environmental benefits of no-dig technologies for water and sewer rehabilitation, other benefits in built-up areas include less disruption to traffic and the public, little or no subsidence problems, reduced incidences of damages to existing services and improved worker safety.

5.7 Regulatory Issues

One of the biggest obstacles to the more widespread adoption of innovative technologies relates to lack of familiarity within regulatory agencies about many of the new technologies available. Additionally, there are few accepted standards in place affecting materials and methods of installation.

To the extent that construction codes, standards and regulations follow rather than lead innovation, this should come as no surprise. As municipalities are usually the party held responsible after a municipal work is completed, they look to published and accepted standards as a way to reduce risks and liability in the provision of services. In the absence of these legal safety nets, it comes as no surprise that many municipalities are reluctant to accept the assurances of private sector entrepreneurs who claim their innovative technology is better than current practices.

As pointed out elsewhere, municipal stakeholders are arguably the most conservative risk takers in the urban infrastructure field. They will do anything to avoid the liability associated with taking risks. This philosophy has stood them in good stead for the last 100 years. Only in the face of very rapid technological change and recent government rejection of deficit financing is this philosophy beginning to change.

All levels of government should be stimulating and supporting the writing and discussion of alternative standards covering materials and construction/installation methods for these new technologies. The National Research Council's Infrastructure Laboratory is well positioned to lead this initiative and is, in fact, developing a National Technical Guide for Urban Infrastructure which will, among other things, identify a series of best practices involving innovative techniques for the repair and rehabilitation of sewers and watermains.

The need for a fundamental rethinking of the way municipalities control and guide development is also needed and, in this respect, the Province of Ontario has begun the process of establishing alternative development standards.

Starting with the Sewell and Crombie Commissions in the early 1990's, the province has begun to challenge the post-war urban development paradigm of large lot, single family detached, single use, automobile-dependent land use planning. It culminated in the 1994 publication of a guideline document which explores the planning and infrastructure implications of alternative development standards[12].

The document represents a small, incremental step in the right direction towards reinventing the way municipal planning and engineering interact in creating built form. A similar rethinking is long overdue on the role of innovative infrastructure renewal in the delivery of cost effective municipal services.

5.8 Privatization/Ownership Issues

As long as the municipality remains the ultimate owner or operator of the infrastructure component being built or rehabilitated, the rate of uptake of innovation is not likely to change, for all of the reasons outlined above.

In recent years, all levels of government have been exploring the role that private sector partners might be able to play in the provision of a whole range of government services: from garbage collection and the operation of sewer and water systems at the municipal level; to the design, construction and operation of highways at the provincial level; even to the design, building and operation of federal prisons.

Exploring partnerships with the private sector is a logical trend that has been underway for the last decade as senior levels of government have moved to reduce transfer payments and shift responsibilities for the provision of services to the municipal level of government which is closest to the user of the service.

CMHC has developed an overview of the theory and practice of public-private partnerships which provides a series of case studies and an overview of the advantages and disadvantages of various partnership models[13]. It points out that such arrangements can result in the more efficient and less costly delivery of a whole range of government services.

In many respects, such partnerships have existed formally and informally for over a century in Canada, starting with the financing and construction of the Canadian Pacific Railway in the 1880's. For well over 40 years, municipalities have relied on private developers to design and build sewer collectors and water distribution mains in subdivision developments. And, more recently, several municipalities have begun to privatize or lease infrastructure components such as water purification plants and wastewater treatment plants to private operators.

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[12] *Making Choices: Alternative Development Standards*, Prepared by Marshall Macklin Monaghan Ltd., Berridge Lewinberg Greenberg Ltd., and REIC Ltd. for Ontario Ministries of Housing and Municipal Affairs, 1994.

[13] *Public-Private Partnerships: Theory and Practice* Summary Report prepared by IBI Group for the CMHC *Workshop on Municipal Infrastructure and Housing*, March 1995.

Depending on the partnership arrangement — whether the private sector builds, owns, leases or operates the facility — this trend can create several advantages (as well as disadvantages) for the municipality and may become a contributing factor to the more rapid uptake of innovative infrastructure technology in the future.

In the case of the private sector building and/or operating a wastewater treatment plant, the most obvious advantage for the municipality is that it downloads the responsibility for the financing, maintenance, repair and, in some cases, the staffing of the facility. In the case of a privately operated sewage treatment plant, an additional advantage for the municipal corporation is the shedding of responsibility to meet discharge requirements. The downside is that the municipal corporation also foregoes the revenue stream from water sales it previously enjoyed.

The private sector is thus able to operate the facility according to the first principles of utility financing, treating the facility as an asset with depreciation allowances and the chance to systematically maintain and upgrade the facility. The ability to take advantage of new technology is also more likely to occur if the partnership model has also shifted the responsibility for liability to the private sector.

As more public-private partnerships are developed, the interest in and uptake of innovative infrastructure rehabilitation and repair technologies can be expected to increase.

5.9 Information Dissemination

Many of the respondents to this survey complained that there was no readily available outlet or recognized source of information on who is doing what in the infrastructure innovation field. A recent study conducted by CMHC[14] on the information needs of municipalities has shown that colleagues in other municipal jurisdictions are a key source of information on innovation and that the experiences and practices of other municipalities have a strong influence on municipal decision-makers[15].

A component of the information dissemination study referenced in footnote 14 included a focus group session. The purpose of the focus group was to obtain feedback on the draft study report and to provide a forum in which municipal infrastructure professionals could meet to discuss ways and means to overcome the information dissemination barriers identified in the report. In one key area — the use of computers and computerized information networks — the focus group participants indicated a willingness to accelerate the use of this information dissemination technique.

It was agreed within the group that the *Internet* information network is likely to be the best long-term vehicle for the dissemination of topical, current information on all municipal issues, including all aspects of infrastructure renewal (from financing and construction to operation, maintenance, repair and rehabilitation issues).

The CMHC focus group suggested that the Intergovernmental Committee on Urban and Regional Research (ICURR) might be able to provide a web site on the Internet which could act as a one-window gateway or main index to all municipal services, starting from the generic and subdividing down to the specific. In this way, ICURR could then offer its web site to all the other municipal information providers (CMHC, Federation of Canadian Municipalities (FCM), Association of Municipalities of Ontario (AMO), Canadian Water

[14] *An Assessment of Municipal Infrastructure Information Needs* prepared by REIC Ltd for the CMHC *Workshop on Municipal Infrastructure and Housing*, March 1995.

[15] This was part of the rationale used for including the case studies in this present report.

and Wastewater Association (CWWA), Transportation Association of Canada (TAC), American Water Works Association (AWWA) and the Canadian Public Works Association (CPWA), among others) as a kind of on-line Internet clearinghouse[16].

An alternative option that was suggested would see discussion groups attached to specific issues on an Internet web site bulletin board where interested parties could quickly access the information they are trying to find or, alternatively, state their problem and see if there are any "hits" offering solutions. This discussion group could act as a kind of gateway itself, plugging browsers into other sources of information, such as references to other municipalities (case studies), other networks, or publications and reports.

The Internet is not currently capable of providing topical information on municipal infrastructure issues, especially in the area of innovative techniques and applications for the renewal and rehabilitation of sewer and water systems. The quality and quantity of information currently available on municipal infrastructure renewal on the Internet is not good. However, as information providers such as those listed above begin to develop and use the Internet for information dissemination and business development purposes, this situation will change quickly.

The capability already exists for individuals to communicate directly via e-mail, either on or off the Internet. What is missing is the mechanism for individuals interested in infrastructure renewal techniques to find each other and exchange information on the Internet. Within the next three to five years — and quite possibly sooner — it is likely that infrastructure professionals will be able to subscribe to a bulletin board service or drop into a web site location and interact directly with municipal colleagues who have hands-on experience with the type of innovative application they are considering. This in turn will speed the introduction and uptake of new technology.

In the meantime, there are several computerized networks, data bases, and information clearinghouses which offer up-to-date information on a wide range of municipal infrastructure issues, including innovative rehabilitation techniques[17]. Among these is the Canadian Municipal Environmental Directory developed by Public Technology Canada.

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[16] If ICURR is to assume this role, it must expand its client base to include technically oriented urban infrastructure readers. At present, the typical users for ICURR's services are planning professionals.
[17] These dissemination techniques are profiled in an appendix to the report referenced in footnote 14.

Section 6
Conclusions

Findings from this survey indicate that **the interest in innovative municipal infrastructure renewal is growing, but needs further stimulus to accelerate diffusion of innovation into the marketplace**. This interest is being driven by a combination of enlightened self interest and the trend, on the part of all levels of government, to pursue fiscal responsibility and reduce deficits. It appears likely that these factors will accelerate the interest in and experience with innovative forms of renewal and rehabilitation. But, as this study has shown, there are still a cluster of barriers which must be overcome if the introduction of this new technology is to proceed in an orderly and predictable manner.

The findings suggest **there is a need to accelerate the uptake of new technology**. Users and providers of municipal water and sewer services must develop a better understanding of the true cost of providing these services. Most consumers tend to undervalue the water and sewer services they receive, as municipalities tend to underprice virtually all services (such as sewer and water, and garbage collection). This is done in a misguided attempt to keep taxes and user fees from rising.

The study findings, together with other work, indicate that **virtually all municipalities, especially older ones with aging water and sewer systems, utilize accounting practices in which fees and taxes raised neither reflect the true cost of providing the service, nor the cost of replacing components which have exceeded their service life**. Under such conditions, municipalities are often forced to engage in a kind of "infrastructure renewal triage" where only the most serious and immediate problems get attention. **This approach to sewer and water maintenance is inimical to the orderly and effective introduction of new technology**.

A move towards full cost accounting practices will be necessary. This is likely to be the only way to relate the use of a given service to the actual cost of providing the service. All users of water and sewer services must develop this understanding and participate in this potentially difficult transition.

A necessary precursor to implementing full cost accounting practices is universal water metering. In a recent survey of municipal water conservation programs conducted for ICURR[18], nearly a third of the responding municipalities reported having less than 50 percent of their customers metered. Nearly 15 percent reported no residential metering of any kind.

Concurrent with the introduction of full cost accounting practices must come an array of demand management and related conservation measures, the purpose of which would be to cushion the impact of higher per unit costs for water and sewer services. An additional benefit of demand management programs, if they are designed and implemented effectively, is the opportunity they offer cash-strapped municipalities to defer the need for costly expansions to water supply and sewage treatment infrastructure.

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[18] *Canadian Municipal Water Conservation Initiatives*, by R. Scott, D. Moore and D. Waller, Technical University of Nova Scotia conducted for the Intergovernmental Committee on Urban and Regional Research (in progress) 1995.

From this study, the authors have further concluded that:

- Treating municipal water and sewer departments more like a regulated utility, such as is done for telephone, cable and related telecommunications services, would hasten the diffusion of new rehabilitation and repair technologies into the marketplace. Requiring water and sewer utilities to adopt utility accounting practices in their financial reporting would help ensure that a reserve fund is in place to rehabilitate and replace the system when needed.

- Increasingly, municipalities will be exploring user-pay options and, to the extent that provincial legislation permits, a movement towards the principles of utility accounting. Consumers accept this method of providing telecommunications services; they understand and accept the underlying accounting principle which provides them with these essential services — pay only for the services you use.

- Before effective principles of utility accounting and financing can be applied in the context of municipal water and sewer infrastructure, it will be necessary to close the loop that currently exists in many municipalities between the provision of water and sewer services. In many municipal jurisdictions in Canada, one department or agency provides water services while a different department is responsible for sewage collection and treatment. This often results in the costs of sewage collection and treatment being essentially hidden from the consumer[19].

- The current trend towards reducing hidden subsidies and transfer payments from senior levels of government to municipalities should continue. In Ontario, this is already underway. The Ontario Clean Water Agency is now making municipal capital grants for sewer and water system expansions conditional on the completion of system optimization studies first, including detailed demand management plans which demonstrate alternative ways to accommodate new growth.

- The lack of currently recognized codes and standards for new infrastructure materials and installation practices is often identified as a key factor contributing to municipal skepticism about new technology. This must change to pave the way for accelerated uptake in new technology. Not surprisingly, due to the slow and cumbersome process by which standards are developed, existing codes and standards are usually out of step with developments in the marketplace.

- To address this problem, the National Research Council should continue in its efforts to develop and introduce its proposed National Technical Guide for Urban Infrastructure. This would accelerate the development and promulgation of testing protocols and standards covering the design, fabrication, installation and maintenance of innovative sewer and water renewal technologies.

- On the subject of growth and development, there is a need for more public education on the benefits of alternative development standards. The public must come to accept, for example, that a grassed drainage swale that floods occasionally is an acceptable alternative to a dedicated storm sewer which is more costly to build while providing essentially the same level of performance and service.

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[19] For example, in the survey of municipal water conservation programs conducted for ICURR, referenced in footnote 18, 25 percent of respondent municipalities reported that the costs of sewage collection and treatment were "recovered" through property taxes, rather than through the water billing process. Until this loop is closed, cost accounting practices will always work to undervalue and underprice the true cost of providing clean, potable water.

- Several of the public-private partnership models involving the construction, operation and rehabilitation of municipal infrastructure need to be explored, documented and disseminated in more detail. As greater experience with public-private partnerships develops, the interest in and uptake of innovative infrastructure rehabilitation and repair technologies can be expected to increase.

- As mentioned earlier, while several municipalities responding to this survey were prepared to assume the role of "early adopter" of new technologies, they also prefer to wait several years for enough performance, operation and maintenance data to accumulate before committing on a massive scale to a particular new technology or application. In effect, many municipal forays into innovative infrastructure renewal techniques might be more accurately termed *pilot projects*.

- In addition to documenting municipal experiences with innovative technology and practices, more effective methods of disseminating this information must be found. Municipal infrastructure professionals have indicated that the experiences of other municipal colleagues are a major source of information which they use in making decisions about new technology.

- CMHC can play a pivotal role in this information dissemination process. Working with the Intergovernmental Committee on Urban and Regional Research (ICURR), which it helps fund, CMHC should be exploring how to use existing technology transfer mechanisms (print media and workshops in particular), as well as emerging mechanisms (such as the Internet) to hasten the adoption of innovative infrastructure renewal technology and practices.

- Better information incorporating Canadian examples of municipal experience with innovative infrastructure renewal, will go a long way to removing many of the barriers noted above. This will, in turn, accelerate the uptake and introduction of cost-effective alternatives to conventional infrastructure repair, renewal and rehabilitation practices.

- Municipalities also need to develop a better understanding of the role that water demand management can play in optimizing sewer system design and operation. For example, properly designed and implemented water efficiency programs can reduce sewage flows and hydraulic loadings and more than offset the loss in sewer line carrying capacity which result from several sewer relining techniques.

- It has been demonstrated in this and other surveys just how important current, up-to-date information on alternative practices is to municipal infrastructure professionals. More case studies which document and explore the experiences of other Canadian municipalities are likely to be a strong factor which will encourage more municipalities to take up the innovation challenge. CMHC could consider sponsoring a series of workshops on innovative technologies — perhaps in collaboration with NRC — where municipalities would have the opportunity to present case studies on their experiences with technological innovations. At this forum, NRC could present and discuss their proposed National Technical Guide for Urban Infrastructure and manufacturers, through a trade show venue, could showcase their technologies.

- CMHC could also consider identifying and promoting innovative infrastructure research priorities within the national community college and university system and with the Montreal-based Centre for Expertise and Research on Infrastructure in Urban Areas (CERIU).

- And, finally, the authors recognize that this study, plus the closely related study on the condition of municipal infrastructure conducted by the National Research Council (see footnote 1), represents only a starting point. A methodology has been developed to survey municipal experience with infrastructure renewal techniques. A number of issues have been identified which represent key barriers to the more rapid diffusion of innovation into the marketplace. Other stakeholders in the private and public sectors will need to build on this study and determine how to overcome these barriers and thus hasten the introduction of better performing, more cost effective technologies into the municipal infrastructure marketplace.

Appendix 1

Survey Questionnaire

CMHC Infrastructure Renewal Questionnaire

Please fill-in the information on this page and fax this page only to: Infrastructure Renewal Questionnaire, 15,010 Yonge St., Aurora, Ontario L4G 1M6. The fax number is 905-841-6744. The information on this page will be used to co-ordinate the phone interview phase of the project (refer to cover letter).

Municipal Office (please give name):______________________________

Municipal Address:______________________________

Name of Respondent:______________________________

Title of Respondent:______________________________

Phone/Fax Number:______________________________

Total Municipal Population:______________________________

If your municipality does not provide either water distribution and/or sewage collection/treatment service(s), please provide details on the authority or agency which provides the service(s) by filling in the information below.

Services Not Provided By Your Jurisdiction

Name of Municipality Providing *Water Supply/Treatment* Service

____

Name of Municipality Providing *Water Distribution* Service

____

Name of Municipality Providing *Sewage Treatment* Service

____

Name of Municipality Providing *Sewage Collection* Service

____

Introduction

The focus of this questionnaire and survey is on inground piped services: watermains, sanitary sewers and storm sewers. The questionnaire is organized around seven categories of municipal water and sewer capabilities and activities: 1) Existing Conditions; 2) Investigational Issues; 3) Operations and Maintenance; 4) Local Repair; 5) Rehabilitation and Replacement; 6) Modifications; and 7) Pilot Projects/Trials Underway. These categories are explained and discussed in more detail in the body of the questionnaire.

Included with the questionnaire is an annotated glossary of *selected* technologies and terms used in the survey, cross-referenced by question number. Terms in the questionnaire which appear in *italics* are defined in more detail in the glossary.

Part I — Existing Conditions

This section of the questionnaire is designed to establish inventory information on the water and/or sewer/storm sewer systems within your jurisdiction, in terms of how many people are serviced, length of pipe network and its age. If the information is not known, indicate 'n/k'.

a) How many people are connected to the water and/or sewer network?

1) Water:________________
2) Sanitary/Combined Sewer:________________
3) Storm Sewer:________________

b) What is the total length of each piped system, excluding service connections?

1) Water:________________
2) Sanitary/Combined Sewer:________________
3) Storm Sewer:________________

❑ km ❑ mi

c) What is the approximate age of the network? (Use % <u>or</u> length for the various categories)

1) Water:

0 - 10 yr________________
11 - 30 yr________________
31 - 50 yr________________
51 - 75 yr________________
> 75 yr________________

❑ % ❑ km ❑ mi

2) Sanitary/Combined Sewers:

0 - 10 yr________________
11 - 30 yr________________
31 - 50 yr________________
51 - 75 yr________________
> 75 yr________________

❑ % ❑ km ❑ mi

3) Storm Sewers:

0 - 10 yr________________
11 - 30 yr________________
31 - 50 yr________________
51 - 75 yr________________
> 75 yr________________

❑ % ❑ km ❑ mi

Comments:____

Part II — Investigational Issues

This section of the questionnaire deals with the methods your municipality currently employs to monitor and inspect piped infrastructure under your jurisdiction. It also addresses the basis by which your municipality plans for future piped service requirements.

a) How do you determine: 1) overall pipe condition; 2) remaining pipe wall thickness; and 3) extent of internal deposits?

1) External visual ❑
2) *Internal closed circuit television (CCTV)* ❑
3) *Sonar systems* ❑
4) *X-ray* ❑
5) *Corrosion pit analysis* ❑
6) Cut-out section ❑
7) *Ultrasonic* ❑
8) Pressure loss flow testing ❑
9) Other (specify)____________ ❑
10) Performed by other level of gov't (specify) ______________ ❑
11) None of the above ❑

b) What methods of watermain leak detection do you employ?

1) Flow monitoring ❑
2) *Tracer gas testing* ❑
3) *Sonic leak detectors* ❑
4) System metering ❑
5) Other (specify)____________ ❑
6) Performed by other level of gov't (specify) ______________ ❑
7) None of the above ❑

c) How does your municipality currently monitor pipe capacity and condition within sanitary and storm sewers and/or watermains?

1) Flow meters ❑
2) Fire hydrant flow testing ❑
3) Records of pipe failures ❑
4) Records of consumer complaints ❑
5) Assessment of condition during repairs ❑
6) Weir/flume (open channel) flow meters ❑
7) *Corrosion coupons* ❑
8) Other (specify)____________ ❑
9) Performed by other level of gov't (specify) ______________ ❑
10) None of the above ❑

d) What methods do you employ to locate watermains?

1) Test excavation ❑
2) *Electromagnetic induction (EMI)* ❑
3) *Ground probing radar* ❑
4) Other (specify) ____________ ❑
5) Performed by other level of gov't (specify) ______________ ❑
6) None of the above ❑

e) How do you plan for future upgrading to your piped infrastructure?

1) Flow capacity testing ❑
2) Pressure testing ❑
3) Inventory of watermain/sewer maintenance records ❑
4) Infiltration/inflow analysis ❑
5) By age of pipe ❑
6) By condition of pipe ❑
7) Geographical Information System (specify) ___________________ ❑
8) Water inventory & maintenance data base (*WIMS*) (specify) _______ ❑
9) Sewer inventory & maintenance data base (*SIMS, SAM*) (specify) ___ ❑
10) Stormwater computer modeling (*SWMM, SAM*) (specify) ________ ❑
11) Water and sewer rate software (specify) ___________________ ❑
12) Hydrology Modeling (*OTTHYMO*) (specify) ________________ ❑
13) Hydraulic Modeling (*EXTRAN*) (specity) ____________________ ❑
14) Other (specify) ____________ ❑
15) Performed by other level of gov't (specify) ___________________ ❑
16) None of the above ❑

Comments: ____

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____

Part III — Operations and Maintenance

This section of the questionnaire seeks to establish the methods your municipality currently employs in the day-to-day operation and maintenance of infrastructure under your jurisdiction.

a) What type of O & M activities does your municipality undertake and at what frequency?

1) Capacity flow testing (Frequency:__________) ❑
2) Exercise valves (Frequency:__________) ❑
3) Bacteriological/water quality testing (Frequency:__________) ❑
4) Wastewater quality testing (Frequency:__________) ❑
5) *Pigs* (Frequency:__________) ❑

6) *Hydro-cleaning* (Frequency:__________) ❑
7) *Swabbing* (Frequency:__________) ❑
8) Leak detection (watermains) (Frequency:__________) ❑
9) Pressure testing (watermains) (Frequency:__________) ❑
10) Sewer flushing (Frequency:__________) ❑
11) *Sewer rodding* (Frequency:__________) ❑
12) Hydrant flushing (Frequency:__________) ❑
13) Bench testing of water meters (Frequency:__________) ❑
14) Catch basin sump vacuum cleaning (Frequency:__________) ❑
15) Street sweeping (Frequency:__________) ❑
16) *Cathodic protection* ❑
17) Other (specify) ____________ ❑
18) Performed by other level of gov't (specify) ______________ ❑
19) None of the above ❑

Comments:____

____

____

Part IV — Local Repairs

This section of the questionnaire deals with the methods your municipality currently employs in conducting *small scale* repairs to water and sewer services under your jurisdiction. This section applies to both *emergency repairs* and *planned regular maintenance* activities.

a) What types of repairs do you currently undertake or have experience with in the past 5 years?

1) Excavate and replace ❑
2) *Repair clamps* ❑
3) *Grout sealing* ❑
4) *Manhole rehabilitation liners* ❑
5) *Reaming and chemical sealing* ❑
6) *Resin injection* ❑
7) *Keyhole technology* ❑
8) *Internal sleeves* ❑
9) Defrosting frozen services ❑
10) Other (specify) ____________ ❑
11) Performed by other level of gov't (specify) ______________ ❑
12) None of the above ❑

Comments:____

____

____

Part V — Rehabilitation and Replacement

This section of the questionnaire documents the methods your municipality currently employs in the large scale rehabilitation or replacement of piped services under your jurisdiction. The section is subdivided into three parts: 1) in-situ *rehabilitation* of existing pipe with linings; 2) in-situ *replacement* of existing pipe; and 3) no-dig *directional drilling* involving new pipe systems.

a) Is your municipality using any of the following in-situ (no-dig) rehabilitation techniques applied to *existing* inground pipes, manholes and/or chambers?

1) *Sliplining* ❑
2) *Swaglining* ❑
3) *Roll-down lining* ❑
4) *Thread-jointed pipe* ❑
5) *Romo-lining* ❑
6) *Interlining* ❑
7) *Fold and form lining* ❑
8) *Spiral lining* ❑
9) *Inverted, cured-in-place pipe lining* ❑
10) *Sprayed epoxy resin lining* ❑
11) *Sprayed cement mortar lining* ❑
12) *Robotic cutters for service laterals* ❑
13) Other (specify) ____________ ❑
14) Performed by other level of gov't (specify) ______________ ❑
15) None of the above ❑

b) Has your municipality had any experience with the following in-situ (no-dig) replacement techniques of *existing* piped systems?

1) *Small diameter displacement/compaction drilling* ❑
2) *In-situ pipe jacking/bursting* ❑
3) *Small diameter hydro-jet drilling* ❑
4) Replacement using microtunnelling ❑
5) Other (specify) ____________ ❑
6) Performed by other level of gov't (specify) ______________ ❑
7) None of the above ❑

c) What no-dig techniques are you currently employing for installing *new* piped systems?

1) *Horizontal boring (auger method)* ❑
2) *Horizontal boring (slurry method)* ❑
3) *Small diameter pneumatic rotary air drilling* ❑
4) *Large diameter directional drilling* ❑
5) *Microtunnelling* ❑
6) *Pipe jacking* ❑

7) Conventional tunneling ❑
8) Other (specify)____________ ❑
9) Performed by other level of gov't (specify)______________ ❑
10) None of the above ❑

Comments:____

____

____

Part VI — Modifications

This section of the questionnaire documents other modifications or improvements your municipality has undertaken, or is planning in the near future, involving piped services.

a) What other types of sanitary/combined sewer system modifications or improvements have you undertaken in the past 5 years?

1) Combined sewer overflow (CSO) retention tanks/tunnels ❑
2) Combined sewer separations ❑
3) Supervisory Control and Data Acquisition *(SCADA)* monitoring systems ❑
4) Automated Mapping/Facilities Management *(AM/FM)* data bases ❑
5) *Stormwater disconnection bylaws* ❑
6) Home water metering program ❑
6) Other (specify)____________ ❑
7) Performed by other level of gov't (specify)______________ ❑
8) None of the above ❑

b) What other types of storm sewer system modifications or improvements have you undertaken in the past 5 years?

1) Source Control

1) *Cisterns*/soakaway pits ❑
2) *Permeable pavement* ❑
3) Other (specify)___________ ❑
4) Performed by other level of gov't (specify)_____________ ❑
5) None of the above ❑

2) Conveyance Control

1) *Vortex separator* ❑
2) *Oil/grit separators* ❑
3) *Grassed drainage swales* ❑
4) Pervious pipe ❑
5) Other (specify)___________ ❑
6) Performed by other level of gov't (specify)_____________ ❑
7) None of the above ❑

3) End of Pipe

1) *Stormwater disinfection* (ozone, UV) ❑
2) Sand filters ❑
3) Infiltration basins ❑
4) *Detention ponds/marshes/wetlands* ❑
5) Other (specify) ___________ ❑
6) Performed by other level of gov't (specify) _____________ ❑
7) None of the above ❑

Comments: ____

____

____

Part VII — Pilot Projects/Trials Underway

This section of the questionnaire is open ended and is seeking information on any pilot projects your municipality has undertaken or is planning to undertake involving piped services. Areas of interest include any of the trenchless technologies identified earlier in this questionnaire and any other aspect of infrastructure renewal, such as trials involving new backfilling materials, insulated backfills, new design tools, procurement policies and alternative servicing standards for new development, etc.

a) How does your municipality make decisions about which new technologies to select?

1) Price ❑
2) Durability ❑
3) Availability ❑
4) Proven track record in other municipalities ❑
5) Legal acceptance ❑
6) Provincial standards ❑

b) Do your procurement policies establish minimum performance standards to ensure that new technology will perform as intended?

1) Yes ❑
2) No ❑
3) Depends on the technology (specify) ___________________ ❑

c) Are your procurement policies based on lowest first cost or life cycle costing considerations?

1) Lowest first cost ❑
2) Life cycle cost ❑
3) Depends on the technology (specify) ___________________ ❑

d) What alternative types of sewage conveying systems has your municipality installed or assumed responsibility for in the past five years?

1) *Pressure sewers* ❑
2) *Vacuum sewers* ❑
3) Small diameter, variable grade gravity sewers ❑
4) Other (specify)______________ ❑
5) Performed by other level of gov't (specify)________________ ❑
6) None of the above ❑

e) Please provide as many examples as possible of pilot projects or trials your municipality has undertaken or is planning to undertake involving piped services? Please indicate how your municipality defines the term 'pilot' in this context.

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Appendix 2

Glossary of Questionnaire Terms

This glossary contains a selection of terms appearing in the Canada Mortgage and Housing Corporation Questionnaire on *Municipal Experience with Infrastructure Renewal.*

Numerical headings in the glossary correspond to specific sections in the questionnaire in Appendix 1.

An Annotated Glossary of Infrastructure Renewal Terminology

Prepared for the Research Division of Canada Mortgage and Housing Corporation

Annotated Glossary of Terms

Part I — Existing Conditions

(no glossary items identified)

Part II — Investigational Issues

Question II a

- *Closed Circuit Television (CCTV):*
  A method of remote sensing using miniature television cameras with high powered lights. The rig can be self-propelled or winched through sewer lines and watermains and produces black and white or colour pictures viewed on a monitor.

- *Sonar Systems:*
  An acoustic method of remote sensing which is used in overloaded sewers or undrained watermains, where CCTV and other visual techniques are hampered by poor visibility. The results are displayed on a screen with different objects depicted in different colours.

- *X-ray:*
  A method similar to CCTV except that x-rays are utilized to survey the internal conditions of piping and the resulting images are displayed on a black and white monitor.

- *Corrosion Pit Analysis:*
  A method by which a section or sections of pipe are surveyed for pitting. The resulting analysis of the section(s) is used to infer the condition of the rest of the pipe section.

- *Ultrasonic:*
  A method of determining pipe wall thickness, used to evaluate the extent of corrosion or buildup of deposits in sewer lines and watermains. It uses a bullet-shaped device, often called a 'pig', which is placed inside and propelled through the pipeline. The time differential between the ultrasonic waves bouncing off the inner and outer walls of the pipe is converted into thickness by an on-board computer.

Question II b

- *Tracer Gas Testing:*
  Smoke canisters are released into a sewer line and the smoke appearing at the surface is used to locate these breaks. Tracer gas techniques using helium are also very effective in locating leaks. The helium is lighter than air and will rapidly rise to the surface where a helium sensor can locate the seepage.

- *Sonic Leak Detectors:*
  The most common method of determining watermain leaks, this method uses highly sensitive microphones and electronic frequency filters. Because the sound produced by a leak is different from that produced by normal flow, this to enables the user to 'hear' leaks in a pipeline and determine their location.

Question II c

- *Corrosion Coupons:*
  A method for measuring general corrosion in watermains. A rack of pre-cut and pre-weighed coupons made of the same material as the distribution pipe is suspended in the water flow for up to 120 days, after which it is removed, cleaned and reweighed to determine the corrosion rate.

Question II d

- *Electromagnetic Induction (EMI):*
  A method of locating metal pipes and cables by inducing a magnetic field in the conduit through a small generator which is then detected by an aerial. The use of two aerials can also establish the depth of the buried pipe.

- *Ground Probing Radar:*
  Used in conjunction with EMI, this method bounces electromagnetic pulses off objects, the pulses then being received by an aerial. Useful in locating plastic and cement pipes, this method cannot locate metallic objects.

Question II e

- *WIMS:*
  Water Inventory Management System: A software program which inventories existing watermains. Useful in planning, administration and management.

- *SIMS:*
  Sewer Inventory Management System: A software program which inventories existing sewer lines. Useful in planning, administration and management.

- *SAM:*
  Sewer Analysis Model: A software program which uses dynamic routing to evaluate and design storm piping systems.

- *SWMM:*
  Stormwater Management Model: A software program which uses dynamic routing to evaluate and design storm piping systems.

- *OTTHYMO:*
  Hydrologic Modeling software: An analytical tool used in the analysis of drainage characteristics of urban and rural catchment areas.

- *EXTRAN:*
  Extended Transport: A dynamic analytical tool used in the analysis of subsurface pipe and channel systems.

Part III — Operations and Maintenance

Question III a

- *Pigs:*
  Pigs are typically bullet-shaped and made of polyurethane foam of various grades and flexibility. Pigs are inserted in fire hydrants or in manholes where they are used to remove most of the hardened encrustations in a pipe. Pigs are propelled by the flow in the pipe.

- *Hydro-Cleaning:*
  This system uses high pressure water jet nozzles to dislodge deposits and debris from inside pipelines. The pressure propels the nozzle through a section of the pipeline, after which it is pulled back, drawing with it all the debris as it moves.

- *Swabbing:*
  This method uses swabs made of polyurethane foam of differing densities and abrasiveness which are inserted through manholes or fire hydrants. Swabs are not as hard as pigs and are used for the removal of any loose sediments, soft scales and slime in the pipe. Swabs are and are flexible enough to negotiate a 90° bend and are propelled by the flow in the pipe.

- *Sewer Rodding:*
  This method of pipe cleaning uses a flexible, mechanically rotated metal 'snake' to dislodge or breakup obstructions in pipes that cannot be removed by pigging or swabbing. The 'snake' is inserted through manholes or fire hydrants.

- *Cathodic Protection:*
  This technique reduces corrosion rates in pipes. Direct current — generated either by a galvanic cell or fed into the electrolytic cell from an external source — enters the pipe surface (or other structure), thus making the metal or structure a cathode. The resulting current flowing into the protected structure or pipe overcomes any currents that might be created by naturally occurring corrosion cells, in which the structure or pipe would be an anode.

Part IV — Local Repairs

Question IV a

- *Repair Clamps:*
  This method requires exposing pipe joints that are leaking and attaching repair clamps from the exterior. Clamps may be used on the inside of piping, depending on the pipe diameter.

- *Grout Sealing Systems:*
  This method forces chemical grout material into faults from a remote location. It uses pumps and sealing packers in conjunction with video observation equipment.

- *Manhole Rehabilitation Liners:*
  This process allows no-dig pouring of rehabilitation concrete, and offers corrosion protection for the newly formed manhole.

- *Reaming and Chemical Sealing:*
  This process uses a remote controlled rig which is propelled through the pipeline to scrape the internal walls clear of debris while creating a rough surface for application of a chemical sealant. The sealant is applied at locations of infiltration or exfiltration to prevent undermining of the soil substrate.

- *Resin Injection:*
  Controlled by CCTV, this structural repair and waterproofing technique injects epoxy resin into damaged areas of a pipeline. A tube is wrapped around a repair head and either pushed or pulled to the damaged area where it is inflated to fit snugly against the pipewall. Resin is then injected on both sides of the tube and is forced out through the pipe into the soil. After the resin cures for about 2 hours, the head is removed.

- *Keyhole Technology:*
  This pipeline maintenance technique involves excavating a small hole, about a foot in diameter, using either a vacuum excavator, an air knife (compressed air nozzle and vacuum) or an air badger (rotating auger and vacuum). The repair is then undertaken from the surface using long-handled tools

- *Internal Sleeve Systems:*
  This system is used for spot repairs on pipe diameters ranging from 150 to 2800 mm. Stainless steel sleeves are used for diameters between 150 to 600 mm. The sleeve, wrapped in PE foam and with a pneumatic sewer plug, is pulled into location over the damaged area using CCTV, after which the plug is inflated, locking the sleeve in place. For diameters between 600 and 2800 mm, PVC sleeves are used.

Part V — Rehabilitation and Replacement

Question V a

- *Sliplining:*
  Generic term referring to several lining techniques which reduce diameter but create a smooth inside surface that can result in improved flow characteristics. Applications include *swaglining, roll-down lining, segmented lining, romo lining, interlining, fold-and-form lining and spiral lining* (all describe in more detail, below). Newer sliplining techniques minimize the reduction in pipe wall thickness.

- *Swaglining:*
  This application uses continuous pressure-rated PE pipe which is reduced in diameter by pulling it through a preheated swaging die and into the pipe. Once inserted, the tension is released and the pipe slowly assumes its original dimensions, tightly fitting against the host pipe. No annular space treatment is necessary.

- *Roll-down lining:*
  Similar to swaglining, this system uses a liner material which is diameter-reduced without applying heat by drawing the liner pipe through a cold rolling machine, after which it is winch-pulled into place. Medium and high density PE can be reduced up to 10 per cent, expanding without damage to integrity.

- *Thread-jointed pipe lining:*
  This system employs hydraulically pushing or winching short interlocking sections of plastic pipe through manholes and into place. A lock joint converts the short lengths into one continuous pipe. A flowable cement grout injected into the annular space can be used to create a composite pipe. This system does not normally require pumping or bypass.

- *Romo-lining:*
  This sliplining technique is used for the rehabilitation of non-circular profile sewers using moulded PE profiled pipes. The sections are butt-fusion welded in the manhole or shaft and winched through from manhole to manhole. Although the cross-sectional area is reduced, as with other segmented liner systems, the smoother pipe surface increases flow velocity.

- *Interlining:*
  This method isolates the waterproofing and the structural functions of sewer repair. Waterproofing is obtained by a flexible sheath through which the structural lining is then installed. The annular space between the waterproofing and the structural lining is then filled with grout. Prior to grouting, a bag is inserted through the structural liner sections and inflated to align the sections and prevent the ingress of grout at the pipe joints.

- *Fold and Form Lining:*
  These are thermo-mechanically folded polyethylene (PE) pipe winched in place and reformed under steam pressure. The pipe arrives flattened into a U-shape and coiled into a long continuous piece; steam softens and inflates the pipe, so that it tightly fits against the existing pipe, thus eliminating annular space problems. A derivative of the above uses extruded, folded polyvinyl chloride (PVC) liner which is rounded using a steam-propelled device.

- *Spiral Lining:*
  This application helically winds PVC liner strips into a tube, which is then fed directly into the sewer or pipeline. It can be used inside a sewer manhole, and can be expanded after insertions to fit snugly against the existing pipe. Sometimes uses solvent cement to seal the seams. Some spiral liners do not expand inside the pipe and require grouting of the annular space.

- *Inverted (Cured-in-Place Pipe) Lining*
  This system lines the walls of existing pipelines with a hardened synthetic fibre tube. The tube is inserted in a soft, collapsed condition, after which it is turned inside out by either water or air pressure. This inversion process forces the lining tightly against the pipe walls and eliminates annular space grout requirements.

- *Sprayed Epoxy Resin Lining:*
  This system is used to repair short lengths of damaged and cracked pipe, previously cleaned and dried. A lining machine is winched through the pipeline, splitting open two hoses in the process, and drawing equal quantities of resin and hardener.

- *Sprayed Cement Mortar Lining:*
  In this application, a mortar mix is pumped to a head which rotates at high speed and which uses centrifugal force to apply the mortar to the walls.

- *Robotic Cutters for Service Laterals:*
  This is a remotely controlled technique for re-opening service laterals after various sliplining and other no-dig rehabilitation applications have been undertaken. It integrates video cameras, computers and compact robots. These machines are operated from the surface by a skilled worker.

Question V b

- *Displacement Drilling:*
  This is a generic term referring to a series of small diameter directional drilling methods which replace the existing pipe or conduit with a new pipe within the same right-of-way or alignment. It includes pipe bursting and enlargement. Jack hammer piercing tools and other hydraulic machines are inserted along the existing pipe, pulverizing it and simultaneously inserting a similar sized or larger than original sized replacement. These methods require excavations for service connections, tie-ins and hydrants. The associated vibration can damage other utilities in close proximity.

- *In Situ Pipe Bursting:*
  This displacement method uses radial force to break out and enlarge an existing pipe, making room to install a new one along the original alignment. Works for 50 - 600 mm pipes.

- *Small Diameter Hydro-jet Drilling*
  Jetting nozzles are aligned on one side of the steering head of drill rods. A mixture of water and drilling mud, usually bentonite, is ejected from the nozzles. When the drilling rods are rotated, they will travel in a straight line. When the rods are not rotated, the jets will form a void on one side and the rods will steer in that direction.

Question V c

- *Horizontal Boring (Auger Method):*
  The auger is driven from an entrance pit. As the auger proceeds, pieces are added to it and the spoils are simultaneously removed. Once the auger reaches the exit pit, it is removed and the pipe is installed. Typical diameters range from 100 to 2100 mm, with driving lengths up to 180 metres.

- *Horizontal Boring (Slurry Method):*
  This method differs from the auger method in that it uses drill bits and tubing instead of cutting heads and augers. A slurry is used to keep the drill bit clean and aid in removing the spoils. Once the drill tubing is removed, the pipe is installed.

- *Small Diameter Pneumatic and Rotary Air Drilling:*
  These directional drilling techniques are similar in operation but are steered differently. The pneumatic application contains a piercing head with a transmitter to relay its position and depth. The steering head is tapered on one face and maintains a straight line while rotating. Steering is accomplished by pushing the head without rotation, in which case, the head follows the direction of the alignment of the taper. Steering of the rotary air application occurs by differential rotation of the drill head and drill stem.

- *Large Diameter Directional Drilling:*
  Similar in operation and control to small diameter applications, above.

- *Microtunnelling:*
  Holes drilled using remote-controlled, laser-guided boring methods that do not require personnel entry in the bore; concrete, fibreglass, steel or clay pipe is then inserted in the bore.

- *Pipe Jacking:*
  See displacement drilling under V b, above.

Part VI — Modifications

Question VI a

- *SCADA:*
  Supervisory Control and Data Acquisition systems are computerized control and monitoring systems used to determine the status and condition of pipeline systems via remote telemetry. All the information is fed electronically to a central control location for display and interpretation.

- *AM/FM Management Systems:*
  Automated Mapping/Facilities Management database systems usually incorporate two computer applications: Computer assisted drafting design (CADD) and database management (DBM). These database management systems offer complete mapping information covering the location, description and age of all pipeline components.

- *Stormwater disconnection bylaws:*
  These bylaws result in the removal of building downspout and other precipitation flows from all sewer flows.

Question VI b

- *Cisterns:*
  Tanks or chambers of variable capacity which allow capture of precipitation runoff from roofs and related structures. Typically, a cistern takes up all or part of a basement room. The water they retain can be used for non-potable indoor uses such as washing and bathing, for lawn and garden watering, or for gradual, on-site stormwater catchment/infiltration.

- *Permeable pavement:*
  Permeable pavement is an alternative to conventional pavement, whereby runoff is diverted through a porous asphalt layer and into an underground stone reservoir, where it then infiltrates into the subsoil.

- *Vortex Separator:*
  A cone-shaped piece of equipment installed in-line in sewers to separate solids from liquid by centrifugal force, using the speed of the incoming liquid and forcing it into a vortex action.

- *Oil/Grit Separators:*
  An underground retention system (ie., multichamber tank, Stormceptor™, etc.) designed to remove heavy particulates and absorbed hydrocarbons.

- *Grassed Drainage Swales:*
  An earthen conveyance system in which pollutants are removed from urban stormwater by filtration through grass and infiltration through soil.

- *Stormwater Disinfection:*
  Disinfection is carried out through chlorination-dechlorination, ozonation or ultraviolet light banks.

- *On-site detention pond, marsh, or constructed wetlands systems:*
  A series of pools of water that remove pollutants from stormwater through wetland uptake, retention and settling. Detention ponds may be designed to remain 'dry' between storm events or have a permanent pool of water or create suitable conditions for the growth of marsh plants and the support of wildlife.

Part VII — Pilot Projects/Trials

Question VII d

- *Pressure Sewers:*
  A pressurized sewer system is characterized by a number of pumped, small diameter inlet points and a single outlet point, typically draining to a gravity sewer or treatment plant.

- *Vacuum Sewers:*
  A vacuum sewer system consists of a central vacuum source and a gravity vacuum interface valve which maintains the sewer system in a vacuum. The valve permits a sewage slug and a measured volume of atmospheric air to enter the system so that the pressure difference between the atmosphere and the sewage system propels the sewage slug towards a collection tank where it is pumped to a treatment plant.

Appendix 3

Case Studies

CASE STUDY NO. 1

Technology

➢ Sonic Leak Detection

Applications

➢ Leak Detection Technology for Ductile Iron/ Cast Iron Underground Piping

Introduction

The City of Fort McMurray has a ductile iron/ cast iron based watermain system. In the early development of the City during the oil sands boom, the ductile iron watermains were backfilled with native material that was extremely corrosive. Ductile iron watermains were corroding out in as little as nine years and the City had to address about 70-90 breaks per year. In 1994, 40 breaks were recorded.

Rationale for Use of the Technology

Due to the high frequency of watermain breaks, lack of as-builts from the early years and the City of Fort McMurray having a frost penetration depth of about 9-11.5 feet between November and June, an inexpensive and accurate method of locating leaks was required.

The Region has bought two types of sonic leak detection equipment and has trained four of their 'pipemen class' personnel to operate them. The leak detectors are manufactured in England and Japan.

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➢ Results

Sonic leak detection is currently being used with a reasonable rate of success in the City of Fort McMurray/Region of Wood Buffalo.

During the winter of 1995, sonic leak detection was utilized to find a watermain break that was responsible for flooding the basement of the Royal Bank building in the City of Fort McMurray.

Sonic leak detection found what was believed to be the leak close to the building in question. Excavation was done at the location indicated and running water was found. However, the leak was not at this location. The water from the leak had travelled from the break along an abandoned line to the Royal Bank building.

By tracing the path of the abandoned line, sonic leak detection was used again about 15 feet away from the original excavation. The leak was found there. With the aid of sonic leak detection, the leak was discovered, repaired and put back in service in 14.5 hours.

This example also illustrates how the interpretation of the data provided by the equipment is important. The Region has found that due to the thick frost level, water from a leak will travel considerable distances at great depths. The equipment will pick up flowing water but not necessarily at the leak location.

➢ Costs

The sonic leak detection equipment was purchased by the Region of Wood Buffalo in 1991 for a cost of about $25,000.00.

➢ Savings

Traditional methods of leak detection rely on the appearance of water at the surface. In Fort McMurray, a deep frost line often forces water from leaks to travel long distances before surfacing. As such, excavation at the location where the water surfaces is both an expensive and not very accurate method of locating leaks.

The sonic leak detection technology permits the Region to save on both excavation costs, down time of the watermain and inconvenience to the customer.

➢ Availability

The two types of sonic leak detection equipment owned by the Region are:

Correlator MicroCorr 4 Super (Electronic)
Palmer Environmental Services
Norfolk, England

Fuji-Sanyo Co. Ltd.
Sonic Leak Detector

Notes

Technology

- Cathodic Protection

Applications

- Corrosion Protection of Underground Ductile and Cast Iron Watermains

Introduction

The City of Thunder Bay has used cathodic protection for the past 20 years in limited areas. Since 1992 the City has been committed to install cathodic protection on all new ductile iron watermains, metallic fittings, hydrants, and service connections installed and any existing cast iron watermains that are exposed during any excavations. Further, the City of Thunder Bay has targeted four specific areas where existing ductile iron watermain will be cathodically protected as the frequency of breaks is substantially greater than in other areas.

Rationale for Use of the Technology

The increased use of cathodic protection came to the forefront in 1992 when it was noted that a stretch of ductile iron water main installed in 1970-71 along Highway 61 had experienced between 40-50 watermain leaks since its installation. These leaks have been attributed to external corrosion.

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It was debated whether to replace the entire ductile iron watermain with a PVC watermain or install cathodic protection.

At the time, the City of Thunder Bay did not permit the installation of PVC watermain. However, the City had previous successful experience with cathodic protection. A 20 year old steel watermain protected by cathodic protection had recently been inspected and found to be structurally sound. Only the zinc anodes needed to be replaced.

The City determined that they could cathodically protect the existing ductile iron line based on their previous positive experience with cathodic protection at a cost saving of 50%.

➢ Results

The 25 year old ductile iron watermain along Highway 61 has had only one leak since the cathodic protection was installed and it was not related to corrosion.

➢ Costs

The City of Thunder Bay has budgeted $100,000 per year out of their water works rehabilitation and replacement budget.

➢ Savings

While no hard numbers are available, the City is confident that the money being spent yearly on cathodic protection is justified because they have twenty to twenty five year old pipes that they do not have to replace.

To install the sacrificial anodes (zinc or magnesium) involves augering down to the pipe and then attaching the anodes by welding.
This process is both cheaper than replacing the existing pipe and further savings are also experienced from decreases in the amount of future leaks.

The sacrificial anodes installed are designed to last a minimum of 25 years.

➢ Availability

The cathodic protection system and consultation is readily available to the City through two Ontario companies. The City of Thunder Bay has had previous good working relationships with Corrosion Services and Corrosion Intervention.

➢ Notes

Technology

- ➢ Resin Injection

Applications

- ➢ No-dig spot repair

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Introduction

Since 1992, the City of London has used resin injection to do spot repairs on concrete and clay sanitary sewers. These sewers are typically in excess of 50 years of age (and have failed due to improper installation practices such as poor or improper backfilling).

The City of London has a yearly video contract with an independent firm. Every year selected sanitary sewers are video taped using CCTV platforms and a report issued. The sanitary sewers video taped in a given year are chosen on the basis of where the City plans to do road rehabilitation work and where maintenance crews have identified possible problems. By reviewing the video tapes and the associated report, repair locations are identified and are grouped as either requiring internal repair or repair requiring excavation.

In 1995, a contract was tendered for the internal repair of about 140 locations in various sanitary sewers. The Contractor provided a bid to repair the various locations which included video taping the locations after the repairs were completed. The Contractor was free to choose the method of rehabilitation. Three bids were received. The two lower bids proposed using resin injection technology and a third proposed using liner technology.

Rationale for Use of the Technology

In 1995, the lowest bid proposed to use the Amkrete resin injection method.

The Amkrete method utilises an inflatable bladder that is winched to the repair location and centered. Two separate hoses run the two part resin to the bladder, where they mix and are applied to the repair location until it is filled. After about an hour of hardening, the bladder is removed and the repair location is video taped to ensure the repair is complete.

➢ Results

No sanitary sewers rehabilitated by resin injection have been video taped since their repair, although plans are underway to have this done.

➢ Costs

The cost for the 140 repair locations 1995 internal repair contract was about $164,000.

The cost to repair the various locations ranged depending on the diameter of the pipe to the type of repair. The lowest cost for a certain repair location was $1000.

➢ Savings

As with other no dig technologies, the main benefits are not having to incur excavation costs and the elimination of inconveniences relating to excavation.

It was found on this contract that the resin injection savings over liner technology ranged from $150.00 to $350.00 per repair depending on the size of sewer and type of repair.

➢ Availability

Based on the number of quotations received for resin injection projects, it appears that there are several Contractors in the Windsor and Toronto area that can do this type of work.

Notes

CASE STUDY NO.4

Technology

➢ Fold and Form Lining

Applications

➢ Lining of Gravity Sewers to Re-establish Structural Integrity

Introduction

In 1993, the City of London relined a 90 m long section of 250 mm clay sanitary sewer that was buried under Dreaney Avenue. The sewer was installed in the mid-1940s.

Rationale for Use of the Technology

The City of London had investigated internal lining technology as a no dig rehabilitation technique and wished to apply it as a test on a suitable sanitary sewer pipe. The sanitary sewer under Dreaney Avenue was selected due to the number of fractures that were present on the pipe (about 20 fractures over the section needing repair) and because the pipe still retained its cross sectional profile and was otherwise structurally sound.

The above mentioned sewer rehabilitation project was put to tender in 1993 noting the requirement for an internal liner. Two bids were submitted and the Contractor proposing the fold and form liner was the lowest bid. The other bid was for in-situ liner technology.

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Fold and form liners are about 8 mm to 15 mm thick and are pulled into the pipe in a deflated state. The installation of the liner is done under flow conditions. Once the liner is placed in the correct position, it is inflated with steam. The liner then takes the shape of the pipe and is allowed to cool.

Following the cooling period, a robotic cutter is used to cut out the service laterals. Prior to the installation of the liner, a steel tape and camera are used to measure the location of the service laterals. Once the liner is installed, the service lateral locations are confirmed by noticeable dished areas in the liner.

➢ Results

The installation of the liner created several major problems and, as a result, the City of London has no plans to proceed with any other liner projects in the near future. Before this technology is used again, the City will canvas other municipalities to determine their experience and success rates with liner installation projects. Also, the City will investigate whether this technology has advanced enough since this project to warrant another trial.

The liner was ripped in one location during installation (possibly as it was pulled against a projection from a service lateral) and had to be repaired. Several service laterals were missed due to operator error and, on one occasion, a service lateral was cut where there was none which resulted in the introduction of backfill into the sewer.

The sanitary sewer in question was video taped in 1995 and the liner appeared to be in good condition. However, there were four locations at service laterals that were cut in improperly that showed backfill entering the pipe where the cutter damaged the laterals.

It is planned to address the four deficient locations again in late 1995. Previous attempts to repair the four locations have failed. The status of the sanitary sewer in question has been graded by the City of London as fair (good being the highest grade).

➢ Costs

The tendered price was about $22,000.00 and the project duration was to have been about five days. Due to deficiencies, the Contractor took 2 or 3 additional days to complete the works.

➢ Savings

This project did not result in any cost savings to the City. Two years after the project was completed, the City is still trying to repair four deficient locations. The City has had to video tape the sewer again to ascertain the status of the liner at the problem locations. Subsequently, several excavations were undertaken to repair the liner.

While this relining technique did create a smoother pipe surface which reduced frictional losses, the City did not consider this to be a major benefit, as this was a minor line.

➢ Availability

Liner technology is readily available.

➢ Notes

Technology

➢ Mini-annulus (Tight fitting liner)

Applications

➢ No-dig structural re-hab of a watermain

Introduction

The Regional Municipality of Halton (RMOH) utilized mini-annulus technology (similar to swagelining technology except the liner diameter does not have to be decreased by heating) on two sections of watermain in 1993-94. The two sections of 40 year old 300 mm diameter cast iron watermain were located in the Derry Road area. The first section was from Bronte Road to Tremaine Road and the second section was from Tremaine Road to Bell School line. A total length of 2.9 km was rehabilitated.

Rationale for Use of the Technology

This watermain had experienced 40 breaks at its joints in a ten year period from 1982 to 1992. It provided about 20% of the Milton water supply as well as feeding the Milton Hospital.

In December 1992 a council resolution was passed requiring that the Public Works Department advance its plans by approximately two years and replace the watermain in question.

This caused budgetary constraints as the moneys allocated for this replacement (estimated cost of $800,000) would not be available in time for the required construction period.

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The importance of the watermain as a water supply conduit compounded by it traversing a major roadway required that the watermain be out of commission for a maximum period of two weeks and that no or minimal traffic disruption result.

It was believed that, by using the mini-annulus method, the project could be completed in the desired time, with minimum interruptions and for approximately 60% of the cost of open cut construction.

The composition of the watermain was also such that some sections of the watermain had a smaller inside diameter than others due to: (1) a heavier class cast iron pipe had been used under a railway crossing; and (2) some sections had previously been repaired by replacing the cast iron main with PVC watermain (about 40 areas).

In addition, it was necessary that the liner be a fully structural pipe not gaining any of its strength from the host cast iron pipe, to satisfy RMOH watermain design criteria.

A butt fused High Density Polyethylene (HDPE) SDR17 liner was selected. It had the required dimensions and smoothness to provide a tight structural lining that could deliver the necessary ultimate flow characteristics.

➢ Results

Benefits resulting from using the mini-annulus technology were:

1. Lower construction costs.
2. No traffic interruption.
3. Survey costs were almost totally eliminated as the design was based upon 'know points' such as valve chambers.
4. Design and drafting time was reduced as design drawings were schematics of the existing main produced on letter sized paper.
5. Approvals time was reduced due to work proceeding as a rehabilitation project instead of new construction. This was especially useful where the watermain traversed railway properties.

Few problems were encountered due to the watermain being ideal for mini-annulus technology (the main had few service connections). It is expected that mini-annulus technology would be less advantageous in a watermain with several service connections as each service would have to be excavated and connected to the new liner.

The mini-annulus technology is expected to be very durable, lasting from between 25 to 50 years, with no breakages or related failures.

The rehabilitation of the watermain resulted in a reduction of the internal pipe diameter from 300 mm to 247 mm. The town expected to obtain flow improvements brought about by the smoother liner but was more concerned that the reduced diameter not exceed the pump manufacturer's mimimum pipe diameter requirements, which it did not.

➢ Costs

The cost for the first section of watermain rehabilitation was $246,346 including Engineering, Contract Administration and construction. The cost for the second section was $320,800.

➢ Savings

The cost for the mini-annulus project was compared against the cost for open cut construction around the same time period.

The open cut construction cost was determined by deciding upon a per meter cost for the same size PVC pipe as the lined pipe. From this unit cost, a price to install the watermain only was determined. The installation of the watermain only was estimated to be 90% of the total cost of the tender to give a very conservative number. 20% more was added for Engineering and Contract Administration, based upon prior experience.

It was determined that the mini-annulus project was completed at around 53% of the cost for open cut on the first section and 66% of the cost for the second section. This represents a savings of about $384, 000 total for the two sections.

➢ Availability

The technology is simple enough that any contractor in the sewer and watermain business would be able to learn the application details quickly. Four bids were received for the above mentioned project.

➢ Bibliography

Project Design and Contracting, Piper, Steven, February, 1995.

Technology

➢ Microtunneling

Applications

➢ No-dig piping installation

Introduction

The installation of 430 m of 750 mm diameter storm sewer on Keele Street was required in order to remove storm flows from an existing combined sewer and divert these flows to an existing storm trunk sewer.

Rationale for Use of the Technology

Keele Street is an arterial road with heavy traffic which crosses under a Toronto Transit Commission subway bridge just north of Bloor Street West. At the initial design stage it was determined that tunneling would be required for the section of the storm sewer that crosses Bloor Street West because of the heavy traffic and because the road crosses under the TTC bridge.

The total length of storm sewer to be installed by tunneling was 91 m.

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Geotechnical investigation revealed that the soil conditions were poor and that the water table was above the crown of the sewer for most of the length.

The contract was tendered in June 1990. The Tenderers were instructed to utilize any of the following three alternatives:

1. Open cut — except for the 91 m specified to be tunneled.

2. Conventional tunneling — mining, tunnel machine.

3. Microtunneling.

Eight tenders were received. The lowest bid received proposed the use of microtunneling for the entire project. Of the remaining tenders, one other proposed to use microtunneling and the rest proposed to use traditional tunneling or a combination of traditional tunneling and open cut.

➢ Results

The contract commenced October, 1990 and was completed on schedule and on budget in April 1991.

A Iseki, Uncle Mole Microtunneling machine was used. It utilized a slurry system for spoil removal.

The average speed of the excavation was 76 mm a minute and the maximum daily production was 10 pipe sections or 23 m. A total of three headings were used with the longest one being 155 m.

Microtunneling provided a substantial savings in pavement cut repairs. Also, by using microtunneling, minimal disruption to the underground occurred and, therefore, no voids or loss of ground were created. Therefore, no settlements formed.

As expected, disruption to traffic was reduced because only one lane was occupied at any time. Neighbourhood disruptions were also minimized because: access to all driveways was maintained; noise levels were kept relatively low; no heavy excavating equipment was required other than to dig the access shafts; truck traffic was reduced due to the reduced amount of excavated material required to be hauled away; and no dewatering pump was required. In addition, job safety was improved and interference with other utilities was reduced.

Some downtimes occurred due to winter conditions causing the freezing of the slurry system and moisture to develop in the cable connectors.

➢ Costs

The contract price was just under $1 million.

➢ Savings

In addition to microtunneling being the low bid, a savings of $60,000 was calculated for repairs that were not required to cut pavement.

➢ Availability

The Contractor on this project S. McNally & Sons Limited obtained an Iseki, Uncle Mole Microtunneling Machine.

While the availability of microtunneling machines was not considered by the City as it was not part of their scope, the Contractors involved in tunneling work would be more familiar with the specific types and their efficiencies.

➢ Bibliography

Keele Street Microtunneling Project, Dennis, Tim.

➢ Notes