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BEST PRACTICE SUMMARY REPORT

February, 2008

Water and Wastewater

WATER LOSS MANAGEMENT – ADOPTING WATER LOSS MANAGEMENT STRATEGIES

Abstract:
The Cities of Ottawa and Sudbury have implemented a number of water loss management strategies to measure and reduce water loss in their systems. Strategies implemented include tracking water use, performing annual water balances to calculate water loss, active leak detection, district metering, night-time flow analysis, a bulk water strategy and pressure management.

Additional information regarding water loss management and the OMBI Water and Wastewater Expert Panel 2007 Business question for which this report has been written can be found in the Project Approach and General Water Loss Management Practices documents.

Practice Identification: Water and Wastewater

Case Study Municipality:

- City of Ottawa, City of Greater Sudbury

Municipal Profile:

Municipality	**City of Ottawa**[1]
Population	795,000
Water Distribution	2,700 km of watermains with 192,300 service connections, and 12 pump stations
Wastewater Collection	2,470 km of sanitary sewers, with a total of 181,635 sewer service connections, and 70 pump stations

[1] Municipal Profile is based on 2006 data

Water Treatment Plant	Population Served	Average Day Demand (ADD)
Britannia	795150	200 ML/day
Lemieux		143 ML/day
Wastewater Treatment Plants	**Population served**	**Annual Average Flow (AAF)**
ROPEC	786,130	460 ML/day

Municipality	**City of Greater Sudbury**[2]
Population	131,140
Water Distribution	895 km of integrated transmission and distribution system with 10 pump stations
Wastewater Collection	1237 km of sanitary sewers, with 75 pump stations
Water Treatment Plant	**Average Day Demand (ADD)**
Wanapitei WTP	31.08 ML/day
David Street WTP	13.24 ML/day
Inco Well No. 1	1.14 ML/day
Garson Well 1 & 3	0.69 ML/day
Falconbridge Well	0.24 ML/day
Levack Wells	0.59 ML/day
Onaping Wells (Owned by Falconbridge, Distribution Owned and Operated by City)	
Capreol Wells	2.51 ML/day
Valley Wells	10.17 ML/day
Dowling Wells	0.49 ML/day
Vermillion River WTP (Treated by Inco, distributed by the City)	
Wastewater Treatment Plants	**Annual Average Flow (AAF)**
Sudbury	56.98 ML/day
Azilda	2.95 ML/day
Chelmsford	4.87 ML/day
Coniston Pheasant	1.38 ML/day
Dowling	2.15 ML/day
Falconbridge	0.55 ML/day
Levack	0.98 ML/day
Lively	0.96 ML/day
Valley East	6.33 ML/day
Walden	2.71 ML/day

Key Words:

- Water Loss Management, Leak Detection, District Metering Areas (DMA), International Water Association (IWA), Water Audit, Non-Revenue Water

[2] Municipal Profile is 2006 Data

Related Benchmarking Goal(s):

- Operate a Reliable and Sustainable Water Infrastructure
- Meet Service and Performance Requirements at Sustainable Cost
- Environmental Protection

Related Performance Measures:

- Operating Cost ($000's) / Megalitre Treated Water
- Megalitres of Water Treated per 100,000 population
- Operating Cost of Water Distribution per km of Water Distribution Pipe
- Number of Watermain Breaks per 100 km of Distribution Pipe
- Average Day Utilization of Individual Water Treatment Plants
- Peak Utilization Rate of Individual Water Treatment Plants
- Litres of Non-Revenue Water per connection per day
- Cubic meters of non-revenue water per km per day (Transmission System)
- 5 Year Running Average Capital Reinvestment / Replacement Value
- Infrastructure Leakage Index (ILI)

Related InfraGuide Best Practices:

- Water Use and Loss in Water Distribution Systems

Description of Case Study

A. City of Ottawa

The City of Ottawa implemented their water loss reduction program in 2002 to focus on proactive management of lost and unaccounted for water. Statistics indicated that between the years 1984 and 2000 the "unaccounted for water" (UFW) for the City was 25% (% of Water Unaccounted For = [(Megalitres Water Treated – Megalitres Water Billed) / (Megalitres Water Treated)] * 100%). An internal audit was conducted and it was found that there were gaps in the overall proactive identification of water loss. In 2005, the focus of the water loss reduction program then changed to incorporate the American Water Works Association (AWWA) and International Water Association (IWA) Water Balance and Performance Indicators rather than UFW. A Water Loss Control Group was implemented and the IWA approach was adopted to calculate the City's annual water loss.

In 2006, the City's Water Loss Performance Indicators based on IWA and AWWA methodology were as follows (definitions for the water loss parameters can be found in the "General Water Loss Management" best practice summary report):

- Infrastructure Leakage Index (ILI) – 5.2
- Current Annual Real Losses – 63.63 ML/day
- Unavoidable Annual Real Losses – 12.12 ML/day
- Real Losses – 23.2 Million m^3 ($1.4 Million / year value at marginal water rate)
- Apparent Losses – 3.5 Million m^3 ($6.9M / year value at retail water rate)

The Cities original goal is to reach an ILI of 4 in three years; however, while significant progress has been made towards that end, it now looks as though further time will be required. Currently the City is refining the inputs for the Standard Water Balance, more focus will be spent to properly understand the Billing process, including the data roll-up, timing of reads (time-lag) and accounting for the unbilled authorized metered/unmetered water use. As well, additional information will be gathered surrounding the system input meters, including the timing of the calibrations and the locations for service water use and how this information is accounted.

In an effort to reduce the City's Infrastructure Leakage Index (ILI) the City has implemented many initiatives to contribute to its water loss management strategy. The City of Ottawa's water loss management strategy in addition to conduction annual water balances includes the following:

- Active leak detection
- Noise mapping, identification and characterization
- Automatic Meter Reading (AMR) pilot project
- Night flow analysis using DMA
- Implementation of ongoing water efficiency measures

To solidify water loss initiatives into one central unit, a leak detection team consisting of 2 field leak detectors and 1 supervisor joined the Water Distribution Unit in 2006.

Active Leak Detection

The City's Water Loss Management Strategy includes its Active Leak Detection program. The program was developed in an effort to reduce the City's Infrastructure Leakage Index (ILI) by reducing the run time of leaks. Active leak detection is a tool being used to identify leaks before they reach the surface. There are three steps to Ottawa's Active Leak Detection program. These steps include:

1. Awareness through acoustic noise survey
2. Location through pin-pointing and leak confirmation through excavation
3. Repair or Intervention

With the majority of watermain breaks occurring in ductile and cast iron watermains, leak detection staff have concentrated efforts to survey metallic watermains. In 2006, staff conducted 1191 investigations with 236 investigations generated from the Proactive Leak Survey alone. Of the 236 investigations, 40% required a repair of a leak on a watermain, service, valve or hydrant. As the active leak survey process is refined, the City believes that there will be greater number of watermain and service leaks found.

The leak surveys are conducted using acoustic equipment on all hydrants that are part of the metallic water system. The Son-I-Kit is used to record the noise intensity detected on hydrants throughout the distribution system as a numeric value on a scale of 1 to 100. Hydrants are tested and the results are manually recorded in the field and transferred to

the electronic maintenance management system. Results ranging from 40 to 100 are initially considered "high" values and will be revisited by a leak detector at another time to confirm the high noise intensity. Each day, 80 hydrants are surveyed using this active leak detection methodology. The City hopes to survey 100-120 hydrants per day once they become more familiar with the equipment and incorporate more efficient routing. The presence of secondary noises from transformers, gas mains, pumps, blow-offs and traffic is also noted and uploaded to maintenance management system. Based on noise intensity, hydrants are physically color coded for a noise map. Hydrants are also numerically numbered. The results of the field survey are loaded to the computerized maintenance management system.

The survey values are colour coded to indicate noise intensity or if there was secondary noise. The likelihood that a leak is present is higher in areas where a greater number of hydrants have a high noise intensity. There are plans to implement automated readers to enter the field data directly so that it can be uploaded at the end of the day. The uploaded data can be used to plan and map out pinpoint exercises to expedite the repairs needed.

A "leak detector" will return to sites where noise intensity was significant to investigate if the noise has remained high. For hydrants with a continued high noise, the leak detector pin points the location of any leak using a digital correlator, geophone and/or aquaphone. A cluster map is generated through using computer software (ArcGIS) and the spatial analyst function to assign numeric values to each hydrant contoured. The higher the value and the more spatially grouped the numbers, the more likely background shading will identify a cluster.

The first figure below indicates the results of an initial leak survey in pressure zone 2W2C. Each hydrant surveyed will have a numeric value assigned to it from 0-100. The second figure below illustrates a detailed view of a section of the 2W2C pressure zone. The red dots represent values of 40 and over from the Son-I-Kit were 11 clusters identified for detailed leak detection.

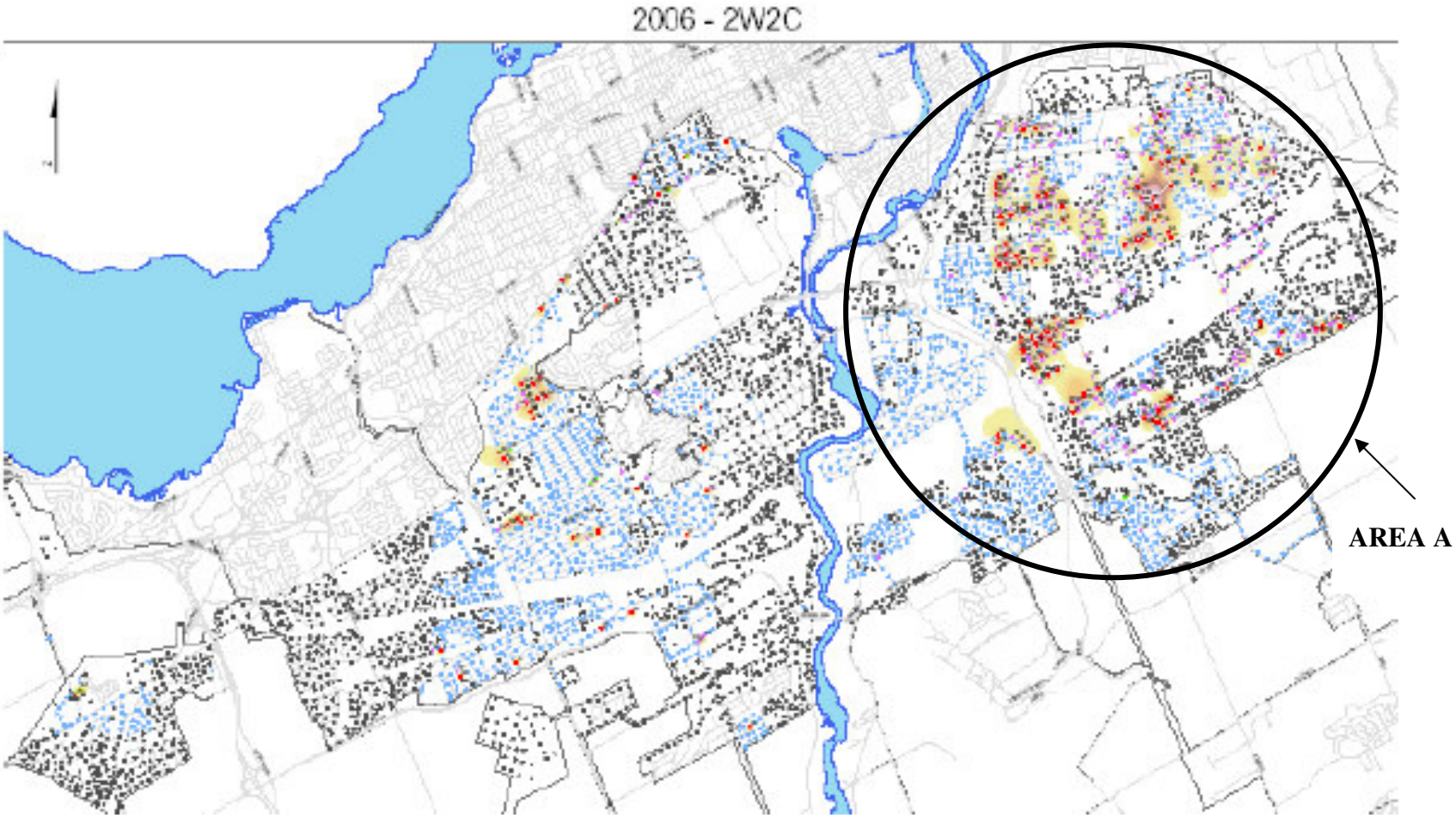

Figure: 2W2C Leak Survey Results

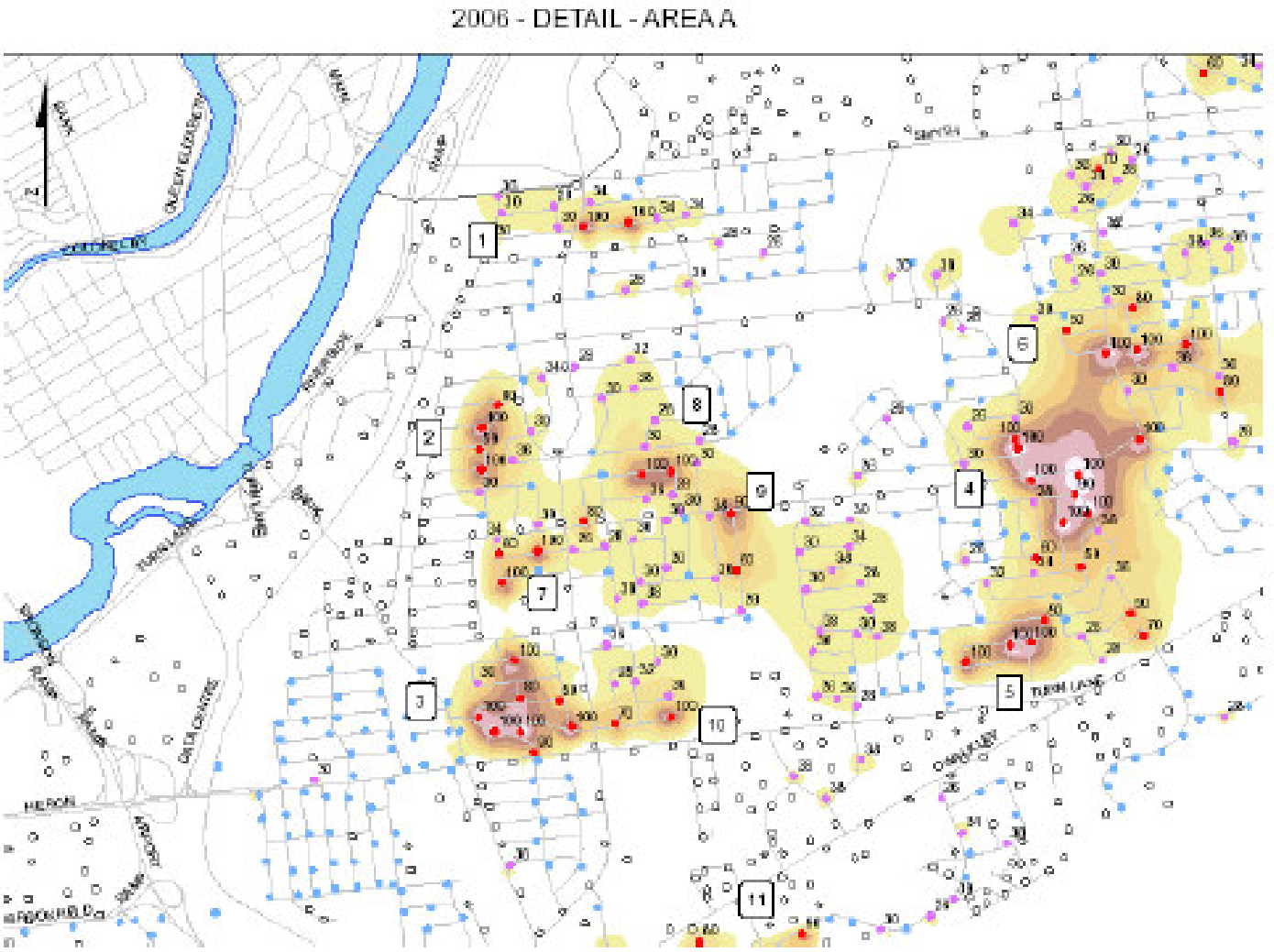

Figure: 2W2C 2006 – Area A

Leak detectors visited the 11 cluster areas to again listen to each hydrant. If the value was lower than 40, the new reading is uploaded into the maintenance management system. If the noise intensity remained high leaks were pinpointed and repaired. The table below indicates the success rate for the example area; 7 out of 11 clusters required intervention or repair.

Table: 2W2C Area A Findings

Cluster Number	Intervention type	Attributes
1	Broken main repaired	Unlined cast iron – 152 mm (6")
2	Broken main repaired	Unlined cast iron – 152 mm (6")
3	2 broken mains repaired	Unlined cast iron – 152 mm (6")
4	No leaks	
5	Broken main repaired	Cast iron – 152 mm (6")
6	No leaks	
7	Broken main repaired	Unlined cast iron – 152 mm (6")
8	Broken main repaired	Unlined cast iron – 152 mm (6")
9	Service post leak – private property	Lead service
10	Broken main repaired	Unlined cast iron – 152 mm (6")
11	No leak – pump noise	

Automatic Meter Reading (AMR) Pilot Project

The City of Ottawa has also developed an innovative pilot program using automatic meter reading (AMR) technology to improve the ability to account for leaks within the water distribution system, by enhancing and quantifying data gathered from district metered areas (DMA). The pilot program was used to provide night flow consumption data, identify daily consumption patterns, reveal the effectiveness of water efficiency measures, and test the reliability of meters. The program was spear headed in an effort to better quantify data obtained from district metered areas. It will provide insight into local water consumption patterns and help establish guidelines for to be applied to monitoring other areas.

Using the AMR pilot project, the City hopes to be able to more accurately quantify legitimate consumption volumes, excluding water losses, used for night flow analysis. The project will help clearly define their actual real losses by measuring actual consumption at every metered point in a DMA. Subtraction of confirmed metered use from the total metered flow entering a DMA provides leakage in the system. The method eliminates error in calculating the leakage based on standard legitimate use (excluding water losses) assumptions. The project will compare usage measurements with consumption use pattern assumptions to determine if usage assumptions are viable for representing usage in Ottawa.

Equipment requirements for the AMR pilot project included high resolution measurements (1 litre), synchronized read capabilities, and the ability to remotely transfer

read data. The AMR read technology was installed and meters were replaced or upgraded with meters and registers. The pilot area covered one square kilometer with 937 metered connections. Meters were read remotely by a passing utility vehicle fitted with a small wireless transceiver. With the installation of the AMR system, night flow testing and the establishment of usage patterns are being conducted. The meters provide data logging capabilities for the measurement of water consumed at specific times during a day. The AMR system is also being used for water billing for customers in the area.

The City of Ottawa's Automatic Meter Reading Pilot Project was featured in the September 2007 edition of *Environmental & Science Engineering Magazine* "City of Ottawa implements innovative AMR pilot program to curb distribution system leaks."

Night Flow Analysis and District Metered Areas (DMA's)

The International Water Association (IWA) water balance approach involves using DMA's to account for water loss. DMA's are defined boundaries that generally encompass 500-3000 households. Flow meters are strategically placed within the boundaries to measure the flow of water through the distribution systems into the area. DMAs can be used to identify significant leakage occurring in the system from background leakage and unreported bursts through night time flow analysis. Night time flow analysis involves calculating leakage based on the measured flow of water into the DMA at night and subtracting the legitimate consumption of water within the DMA during that time. The result provides the real losses in the system at night. The inflow measurement is made at night as the IWA best practice analysis of DMA flows requires the estimation of leakage when the flow into the DMA is at its minimum. The percentage of background leakage is largest at the minimum flow therefore the water loss is more apparent. This analysis is beneficial in determining leakage that has not reached the surface.

The City's water distribution system is broken down into 11 unique pressure zones and water moving in and out of each pressure zone is metered at remote stations. Ottawa has installed both permanent and temporary DMAs. There are three closed pressure zones each with up to 2000 connections and four communal well systems which are also monitored. Three temporary DMAs are tested two times a year and there are plans to add two or three additional sites in zones with higher pressures and a history of leakage.

As a result of the pilot Automatic Meter Reading (AMR) program initiated in 2006, the City has begun performing night flow testing in one pressure zone. They have recorded trends seen in night time flow using hourly flow downloaded to their SCADA system. Night flow consumption is tested by setting the real time clock in each register to record measurements at 2 a.m and 4.a.m. Night flow analysis was not conducted before as the City felt that the process relied too heavily on assumptions of legitimate use. With the AMR pilot program the City is more confident with the actual consumption readings.

An example of where night time flow analysis proved to be beneficial in determining leaks occurred when the City was performing night time flow work in a pressure zone,

monitoring approximately half of the 2,000 connections. The anticipated flow was higher than expected based on the number of connections, pressure, and main type. During a follow-up investigation with additional leak detection, a ten inch watermain break was found with water escaping into a nearby sewer. Once repaired, the night flow dropped by 792 m^3/day (174,216 gallons/day). Based on a review of SCADA reports, it was estimated that the break had likely been running for one year. At the marginal cost of water, this translates into a cost of $17,500.

Other water loss management initiatives

The City has also conducted water efficiency measures which included a toilet replacement program, the distribution of water efficiency kits, a high volume user process review and the installation of water efficient fixtures within Ottawa's Social Housing and City Retrofit Program.

A study to review the accuracy of large meters was also initiated in 2006. The results of the review indicated that 154 of the 234 meters reviewed were the inappropriately sized to provide accurate consumption readings; approximately 47% of water provided by the City was billed through these meters. Of the 154 meters recommended for downsizing, 80 were downsized; it was not possible to downsize the remaining 74 meters as recommended due to space/length restrictions for the existing installations. To prevent this in the future, the City has implemented a standard template to be used for meter installations so that if, in the future, the meter size does need to be replaced, there will be sufficient space to do so. The results of the review will help the City of Ottawa further refine their water balance, providing a more accurate picture of water loss in the system.

B. City of Greater Sudbury.

The City of Greater Sudbury has planned and implemented a number of initiatives concerning water loss management. In a 2003/2004 report delivered to council, it was indicated that the City's total Non Revenue Water (NRW) was 44% ([total volume of water produced – volume of billed water]/ total volume of water produced]. In order to reduce the amount of NRW, the City has since taken on a proactive approach to water loss management which has involved identifying the sources of NRW. The many water loss management initiatives that have been planned or implemented include the installation of magmeters to monitor flows from watermain flushing and swabbing programs, a bulk water strategy, district metering, a pipe freezing prevention plan, pressure management tactics and active leak detection. The restructuring and separation of the responsibility of water supply from roads operations was also undertaken as part of its water management strategy.

Bulk Water Strategy

The bulk water strategy currently being implemented involves restricting hydrant use by introduction bulk water stations with swipe card system. Currently, there are five designated hydrants for commercial bulk water users which are equipped with double check valves, control valves, and meters. A new rate structure will also be introduced.

Developers and municipal road sweepers are being encouraged to use the bulk water stations but there has been resistance. A corporate policy for reporting illegal use of hydrants is expected to help address the issue for staff and perhaps even the public.

Active Leak Detection

There are plans to implement district meter areas DMAs in old mining towns and older areas of the City core. There are numerous un-metered water supply transfer points within the system, especially in old mining areas and the City core, making the IWA water balance difficult to perform, the introduction of DMAs will help establish actual leakage levels.

Operations staff have taken part in active leak detection by sounding hydrants and valves for leaks during regular maintenance practices and during down times (operation staff operate in shifts 24/7). A small percentage of the system is sounded each year during hydrant maintenance, valve turning, manhole inspections, and any other opportunities that operation staff has to get out into the fields and sound valves and hydrants. Leaks are also investigated on the private side if they are reported. The repair of leaks for private property owners is the responsibility of the homeowners and is enforced when identified.

Watermain and Service Connection Break Prevention

Pipe freezing prevention has also been a focus in Sudbury with their cold winter climate. Customers are asked to run water during the winter months to help prevent freezing and watermain breaks. This practice is only applied in dead end areas, or areas with a history of watermain freezing. If records show that freezing has occurred on the private side, customers are billed and if freezing has occurred on the public side, customers are billed a flat rate during the period they are requested to run water for freezing prevention. This practice, while it does not directly reduce water loss, does have economic benefits; the practice helps to prevent watemain and service breaks that contribute to water loss, not to mention the cost and troubles related to locating and repairing breaks during the winter months.

Pressure Management

The City has also begun implementing pressure management by reducing pressure by 2pis by maintaining reservoirs at 1.5 metres below the level they have previously and normally been operated. With the lower pressure, the City has observed fewer breaks. While comparing the winter of 1995 to 2006, as they were similar winters, it was noted that in 1995 they had 400 watermain breaks and in 2006 they had 105 watermain breaks.

The City is now in the process of establishing and gathering the information that will be required to calculate water loss and the economic level of leakage (ELL). They have undertaken a formal review to ensure that all municipal accounts are being metered and are accounted for. Although there has not been any formal audit of the water distribution system, non-revenue water is believed to have been reduced to approximately 25-26%.

Benefits
In 2006, the City of Ottawa's active leak detection efforts helped identify 20% of watermain repairs. The active leak survey also identified 25% of service leaks. The proactive leak management approach allows for more efficient planning of resources as repairs can be scheduled in between other types of work while keeping overtime costs down. It also helps prioritize repairs and provide advanced notice of service interruption to customers. In addition, the Infrastructure Leakage Index (ILI) for the City of Ottawa was reduced to 5.2 in 2006 from 5.8 in 2005. There has been a reduction of real losses by 12% due to the active leak detection program.

In Sudbury, with the implementation of active leak detection and the installation of magmeters, the City has begun important steps in identifying the extent of leakage within their system. The planned implementation of DMAs will also contribute to this initiative and help distinguish areas with greater leakage than others. Although quantification of leaks repaired due to the active leak detection has not been reported it is an important practice in ensuring reduced water loss. The planning and implementation of water loss management initiatives has allowed the City to determine the next steps required to account for water loss and reduce leakage.

Efficiency
By implementing water loss management practices, both Ottawa and Sudbury are taking steps to quantify and reduce losses in their systems. Reducing losses is not only environmentally sound, it also results in savings for water treatment and pumping.

Effectiveness
As the City of Ottawa perfects their leak detection process they anticipate a greater percentage of water main and service leak repairs will be discovered and savings to continue to improve. Their leak detection approach also allows the City to schedule repairs in between other types of work, allowing prioritization and planned intervention to keep over-time costs down and provide advance notice of service interruptions to customers. With the adoption of the IWA methodology the City is tracking their performance. The City had an ILI of 5.8 in 2005 and 5.2 in 2006. They are targeting an ILI of 4.

Anecdotally, the City of Greater Sudbury has seen a diminished amount of breaks and believe the decrease in the overall system pressure has aided in this reduction. While comparing the winter of 1995 to 2006, as they were similar winters, it was noted that in 1995 they had 400 watermain breaks and in 2006 they had 105 watermain breaks.

Community or Environmental Outcomes
Repairing leaks in the distribution system before they significantly impact customers,increases overall customer satisfaction within the municipality. In addition, by reducing water loss, operators can make better use of available infrastructure, reduce energy consumption through reduced pumping requirements, decrease chemical consumption and lessen the processing loads on all of the water treatment systems.

Statutory Requirements
None

Replication of the Case Study
Water Loss has been adopted by the International Water Association (IWA) as a component of a systems total water balance. It is a best practice that should be adopted by all municipalities - municipalities that experience significant water loss, wish to identify inadequacies in their system before they pose a significant disturbance, or those that simply want to track water loss before it becomes an issue.

Supporting Documentation
InfraGuide has produced a best practice for Water Use and Loss in the Water Distribution System. InfraGuide's best practice uses the concepts developed by the IWA and AWWA to define the need to prepare a water audit, and describe the data requirements to allow for the proper creation of a water audit.

Leak detection is a component of the International Water Association's (IWA's) 'Best Practice' Standard Water Balance to eliminate Real Losses in the distribution system. More information on the IWA's Water Balance can be found on the IWA and AWWA websites.

Other OMBI Members that have implemented this practice:
Both the City of Thunder Bay and the Region of Halton have implemented Water Loss Management practices in the form of leak detection. Both municipalities' practices were reported for the OMBI 2006 business question pertaining to energy management – "Energy Management with Water Loss Control – Leak Detection." Please refer to the OCMBP or OMBI website for further information.

Region of York
The Region of York undertook a project to conduct water loss audits for each of the local municipalities as a component of their master planning. The Region intends on providing continued support to local municipalities by providing the local municipalities with the tools to perform regular water audits. Local municipalities were very interested in the results and keen to continue using the IWA methodology. The Region has also offered to assist local municipalities with data collection procedures, recognizing that some of the local municipalities have limited resources available to support the initiative. More work is required to pinpoint water loss issues, but the Region plans on conducting another program in 2008.

The benefits of the Region's approach are that leaks have been detected and found, and the process has been a means for meetings and discussions with local municipalities. The information sharing that occurs is important to how the Region operates. In conjunction with the water efficiency program "Water for Tomorrow", the Region has quantified a savings of 8.62ML/day throughout the Region and the predict that future efforts will yield an additional 23.4 ML/day

OMIB Water and Wastewater Participants

As a component of the 2007 OMBI Water and Wastewater business question, all participating municipalities conducted water balances of their systems. While some have been conducting water balances for a number of years, for others it was their first introduction to the IWA methodology. Conducting a water balance is a logical step to understanding the level of leakage in a system so that appropriate reduction measures can be made if or when necessary.

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