DMA Design and Application for Non-Revenue Water Reduction in Canada

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ABSTRACT
The Halifax Regional Water Commission in Halifax, Nova Scotia, Canada has focused attention to district metered area (DMA) design and master metering implementation to identify water losses in a sector by sector basis. The high design standards in Canada promote system-wide redundancy and multiple feeder mains into discrete pressure zones. Oversized water mains and multiple feeds provide challenges to district metered areas, particularly when applied to minimum nighttime flows. District metered area design criteria, focusing on proper meter selection and leak detection response, was considered in Halifax. DMA design consideration includes peak day and fire flow demands, minimum nighttime flow velocities, redundant DMA source nodes, and water quality issues. Comprehensive DMA design improves sector metering, improved leak detection analysis, and priority response to lower overall leakage run time.

KEYWORDS
District metered area, DMA, flow analysis, Infrastructure Leakage Index, leak detection, master metering.

INTRODUCTION

The Halifax Regional Water Commission in Halifax, Nova Scotia, Canada has been active in developing district metered area analysis to determine leakage sectors and quantification and timing of water loss to prioritize leak detection crew response. The key focus in reducing water loss is the overall reduction in leakage "run-time". Although systems may experience a significant number of water leaks, the overriding factor in determining overall system non-revenue water loss is the duration of leak run-time. This process starts with the identification of the leak event. Accurate sector metering is required through the appropriate selection process for meter size and style to determine district metered area minimum night flows for leakage recognition and priority leak detection activities. Finally, sector metering is required to ensure that leakage reduction has occurred after the repair of identified leaks.

The three key elements in facilitating the reduction of non-revenue water includes the proper district metered area design to enhance leak detection response, accurate sector metering that allows flow analysis and leak quantification, and the utility's ability to respond quickly to locate and repair unreported water leaks in a district metered area.

Canadian System Attributes Effecting DMA Design

Most large water utilities in Canada require the water system design to include peak daytime water use (summer use) and fire flow requirements, as determined by the Insurance Advisory Organization in Canada. The overriding design parameter for distribution water mains is the fire flow demand. Peak day and fire flow requirements must be maintained with a minimum system pressure residual of 22 psi (15 m.). In Halifax, larger feeder main redundancy is specified to ensure that fire flow capacities are available even during repair activities of a main feeder supply to a system sector.

Other design criteria encourage system water main looping, and specify maximum flow velocities and multiple water source feeds to discrete pressure zones in the system. The effect of these design standards creates relatively low water flow velocities in the distribution system and larger feeder supply mains.

The district metered area design reflects this redundant source feed provision. Consequently, master metering at multiple source nodes further reduces available water flow velocities as a result of sharing sector feeds to more than one source connection. The master metering selection requires particular attention to ensure that the right meter is selected based upon system demands, water system capabilities, including number of source feeder mains, pipe size, pipe material, and SCADA interface issues for accurate water flow analysis.

METHODS

Approach to Pressure Zone and District Metered Area Design

The Halifax Regional Water Commission has 66 pressure reducing facilities and 10 water booster pumping stations located throughout its distribution area. Currently, there are 74 master meters located in these facilities and other discrete district metered areas without pressure regulating equipment. The approach to district metered areas in existing pressure reducing vaults must satisfy two conditions. These are the domestic / commercial normal daytime water demands and the minimum nighttime flows metered at DMA input facilities. In addition, each pressure reducing vault in this system provides a parallel high capacity fire flow size pressure reducing valve. The metering system design may include metering of domestic / commercial flows only, metering of both domestic and fire flow source feeds, or a metering of domestic only with a fire flow valve sensor to monitor metering bypass. A combination of these metering options is applied, as necessary, to provide the greatest value in master metering.

The district metered area is analyzed for meter selection by considering the system design capacity, customer consumption, and fire flow demands. As referenced earlier, there are typically two or more source nodes into each pressure zone that will be considered for master metering. The creation of a district metered area in existing systems was considered from the leak detection response perspective. It has been our experience that approximately 30 km of main can be surveyed by a leak team in one day by way of acoustic sounding of fire hydrants and valves. The goal of a DMA design target of 30 km can provide an optimum 24 hour response from leak identification to leak zone bracketing, and 48 hours for leak detection pinpointing of an unreported leak. This DMA criteria enables speedy leak identification and response to unreported leaks by a single leak detection team.

Each district metered area is monitored by our SCADA system and analyzed each day by reviewing the sector minimum night flows between 2 a.m. – 4 a.m. We benchmark the nighttime flows against best achievable to determine increases in nighttime flow rates through the addition of two or more of the DMA input source meters. Increases in nighttime flow rates are quantified and posted daily for management and leak detection team review. This information allows staff to estimate the "effective" water distribution main size that may be leaking.

The history of water main circumferential shear flow rates have been assessed over the years and are bracketed to water main nominal sizes to assist leak crews in prioritizing which mains will be surveyed first when leak quantification analysis has been completed. This technique facilitates leak crews in focusing early leak detection surveys to the most probable pipes leaking in the sector for early leak detection and pinpointing for repair.

DMA Meter Selection Analysis

The retrofit of existing pressure zones with district metering requires critical analysis to determine the "right meter for the right application". The proper selection of the appropriate metering device for DMA includes considerations for:

- Multiple water mains feeding the district metered area.
- Low velocities resulting from multiple feeds.
- Larger diameter pipe sizes resulting in lower water flow velocity.
- Retrofit issues, including pipe size and material, and location of meter installation.
- Domestic/commercial water demands and fire flow metering considerations.

The appropriate DMA meter selection should accurately capture the peak day and lower night flow rates. Low flow rates to 0.2 feet per second (0.06 metres per second) are generally accepted as target low flow velocities for meter selection, and within manufacturer's recommended operating ranges. In addition to low flow requirements, the district metered area domestic, commercial, and industrial water demands must be considered, as well as the number of source nodes to the DMA and nominal pipe sizes to select the appropriate meter size and style.

In existing meter vaults or pressure reduced facilities, master meter retrofitting may be difficult to achieve the recommended 10 pipe diameters of straight pipe before the meter, and 5 pipe diameters of straight pipe downstream of the meter position. In practice, DMA metering can be successful considering reduced straight pipe parameters before and after the meter position. This is particularly true with downstream fittings and bends which may be positioned very close to the discharge side of the water meter.

With installation of district water meters, the interface with SCADA systems becomes an important factor in determining minimum nighttime flow increments. The appropriate selection of the meter "scaling" factor to be displayed on your SCADA system should include the minimum nighttime flows and adequate resolution of incremental flow rate capability of the SCADA system interface with the district area master meter.

The Halifax Regional Water Commission has a radio communication system between DMA and pressure control facilities, and the regional Operations office / SCADA system. The resolution (incremental flow rate capability) of the SCADA system becomes an important consideration when analyzing minimum nighttime flow rates in a DMA for leakage identification. Maximum flow rate scaling may be compromised if monitoring accuracy has focused on the minimum nighttime flow resolution. However, from a DMA leakage assessment, the focus should be on minimum nighttime flow accuracy and metering / SCADA resolution, to correctly display nighttime flow rates for benchmarking analysis and leakage identification.

The system design requirements for domestic / commercial flows and fire flow capabilities present a number of metering options based upon the meter type, pipe size and flow velocities, and the aforementioned DMA criteria considerations. The Halifax Regional Water Commission assessed a number of metering options to capture the low and high flow demands within district metered areas, including size on size mag meters, reduced size mag meters for increased velocity, insertion mags, insertion and in-line turbines, compound meters, and transit time flow meters. The optimum meter choice depends upon all of the considerations of flow velocity, accuracy, and meter resolution required for low and high flow district metered area analysis. This utility has used a combination of all of the aforementioned meters and is proceeding with the assessment and trial installations of direct bury mag meters for new DMA creation in the existing system.

Responsive Leak Detection Investigation

The district metered area optimum size design target is for 24 hour response from determination of an unreported leak to leak location identification. Master metering within the sector can define the leak rate (flow rate) for staff response. The utility has applied an acoustic leak detection program that requires the sounding of all hydrants, and supplementary valves where hydrant spacing is inadequate, to create a "noise map" of the sector. Leak noises are documented with descriptors for presence or absence of noise, noise intensity, pitch, and other mechanical descriptors, such as pump and mechanical noise, and transformer interference are used to standardize the leak reporting during the sounding survey. An analysis of the leak map focuses surface leak detection within the loudest noise sector for further detailed analysis. This procedure has facilitated rapid leak identification for repair crew response. An effective monitoring program will track the occurrence of an unreported leak, leak run-time up to the pinpointing date, and track the leak repair crew response time to repair date.

The focus of district metered areas is the identification of unreported leaks, quantification of flow rate, projection of water main size, and responsiveness of leak detection teams to determine location. Known leak run-time will occur from the point of identification of an unreported leak, up to the repair date coordinated by the leak crews. Best-practice procedures will encourage the monitoring and tracking of the overall leakage run-time from time of leak occurrence to the time of leak repair, with emphasis on reducing the total leakage run-time. It is clear that best-practices in each of these areas yields superior results in reducing overall leakage run-time.

The Halifax Regional Water Commission comprises of three regional systems that were amalgamated into a new utility structure in 1996. Each of the three sub-systems have been analyzed and evaluated on the basis of the Infrastructure Leakage Index performance measurement. Best-practices of leak detection and district metered areas resulted in superior non-revenue water reduction approaching targeted levels.

RESULTS

Table 1: Regional ILI Trends and Targets, Corporate Goal: Economic Level of Leakage:

HALIFAX REGIONS RESULT	ILI 1999/00	ILI 2000/01	ILI 2001/02	ILI 2002/03	ILI 2003/04 12 Mo. Trend
CENTRAL	1.6	1.2	1.0	1.0	0.9
EAST	4.4	4.5	2.9	3.1	3.0
WEST	11.7	11.7	11.5	9.2	7.6
ENTIRE REGION	6.4	6.3	5.5	4.7	4.1

Infrastructure Leakage Index results of approximately 1.0 and 2.9 have been achieved in two of the three utility systems. The third system is undergoing a comprehensive district metered area implementation process, as described in this paper, to improve unreported leak occurrence, DMA creation for rapid leak zone identification, and improved leak detection and repair response.

CONCLUSIONS

It is clear that superior ILI performance indicators can be achieved through comprehensive sector metering, good SCADA analytical tools, responsive action to unreported leak identification, best-practice leak detection activities and repair. Accurate sector metering is critical to flow analysis and leak quantification to prioritize leak detection activities in the field. Overall, unreported leak run-time can be significantly reduced by priority leak detection response from district metered area monitoring, analysis, and responsive operations management to focus on leak detection and repairs. The focus of reducing overall unreported leakage run-time will yield superior leakage performance results using the IWA Infrastructure Leakage Index for system condition evaluation.