Integrating biofiltration into existing water plants

Mobile district metering cuts water losses

Modernizing WWTPs to prepare for growing populations

Improving ammonia removal from petrochemical plant wastewaters
This is the final installment in a series of articles published in ES&E Magazine relating to the Ontario-wide leakage testing program using mobile district metered area testing.

The article “Municipalities wanted for new water loss testing project” in ES&E’s April 2019 issue introduced the project. This was followed by “Mobile district metered area testing helps cut watermain leak losses” in ES&E’s February 2020 issue, which presented initial results.

The field-testing component of the project is now complete. The results have been compiled and a final report will be available later this year. This article presents the key findings of the project and the resulting benchmarks that can be used by utilities as performance indicators.

This project involved the development and deployment of a mobile testing unit to directly measure the minimum night flow (MNF) into temporary and predominantly residential district metered areas (DMAs), which are relatively small, isolated sectors of a water distribution network.

It also measured the pressure-leakage dependency of flow in the DMAs. Owing to the predictability of human behaviour and resulting water consumption patterns, the MNF is a reliable indicator of potential leakage and can help inform whether more efforts are needed to locate and repair meaningful leaks.

The project involved a total of 20 DMAs across eight municipalities in Ontario and was a resounding success. Additional data, curated to the same standard as applied for this project, was provided from one of the municipalities that recently conducted a pilot DMA study to help strengthen the benchmarking exercise.

The article in the April 2019 issue of ES&E Magazine presented a case study from one of the early test sites where a leak of 4.4 L/s was discovered and repaired. Resulting savings were impressive: 139,000 m$^3$ of annual water savings; $426,000 of annual financial savings; and 102 MWh in terms of annual energy savings.

This singular result largely contributed to the project receiving the Professional Engineers Ontario – York Chapter’s 2020 Engineering Research Project of the Year Award and, in conjunction with York Region, the Ontario Water Works Association Water Efficiency Committee’s 2021 Award of Excellence (Public Sector).
ted excessive flows, suggesting high leakage or other forms of water (and energy) wastage, while the results from the other test sites were used to help establish the benchmarks representing “healthy” systems discussed below.

For each of the DMAs, key information was obtained to help characterize the results, such as:
- Energy consumption drivers, including the overall lift and distance from the source water to the DMA.
- Demand drivers, such as the numbers of residential connections and units, population estimates and watermain lengths.
- Historical average consumption data as well as land use information.

For the most part, much of this information was readily available from the participating municipalities through their GIS and billing databases. To estimate DMA population, an algorithm (using Python) was developed to overlay the test area boundaries on 2016 census data, enabling the extraction of population data following appropriate filtering processes.

This technique was applied with success and yielded the strongest correlation for benchmarking purposes. The plots shown in Figure 1 provide the benchmarking results for the (centralized) 60-minute moving average MNF value (MNF60) based on the residential unit count, the number of residential connections and the population.

Each of the plots segregates the data between the “healthy” DMAs (in blue), “leaky” DMAs (in orange), and provides the derived benchmark values (broken grey lines) for each performance indicator.

While correlations were also conducted for watermain length and the ratio of MNF60 to the average annual billed demand, these indicators were found to be somewhat less reliable than those offered in Figure 1.

Additional discourse on these particular results will be presented in the final report, as well as the dissertation of one of the authors, both of which are available publicly on the project website. For practical purposes, it is often instructive and useful to consider several performance indicators when assessing the health of a particular DMA.

For each of the test sites, the participating municipalities received a detailed test report which, in addition to presenting the DMA characteristics and field measurements, provided an economic evaluation to give a sense of the degree of investment that may be warranted based on the degree of leakage identified and the value thereof.

Figure 2 provides a graphical representation of the annual value of excess leakage, as indicated by the size of each bubble. These are relative to the annual volume of the excess leakage and the marginal cost of water to the municipality for all sites with MNF rates exceeding the established benchmark value. The colour of the bubbles similar to the above represents “healthy” DMAs (in blue) and “leaky” DMAs (in orange).

Unsurprisingly, the highest values of leakage occur when both the leakage amount and the cost of water are relatively high. This graphic illustrates the impact of the wide disparity in the marginal cost of water among the municipalities where testing occurred.

The lowest costs occur for municipalities that draw and treat water from abundant surface sources. Conversely, the highest costs occur for municipalities that rely on purchasing imported water from neighbouring jurisdictions.

Somewhat concerningly, the value of lost water for one of the “leaky” test sites is very low due to the low marginal cost of water for the municipality in question. This may lead to a lack...
of financial motivation to actively seek and repair leaks.

Raw financial costs alone, however, are not the only costs borne by society. In addition to the obvious waste of water that has been extracted from the natural environment and treated, it is also instructive to look at the energy implications of leakage. The largest part of water utility energy consumption is typically attributable to pumping.

Figure 3 provides a similar graphical representation, although the results show a stronger correlation between the amount of leakage (x-axis) and the energy consumption (size of bubbles). This is due to the smaller disparity in the embedded energy in the water, which is a function of how high the water is lifted from the source, as well as the distance it needs to travel from the source to the customer.

Of course, both the financial and energy implications are only components of an overall theme of responsible stewardship of both natural resources and infrastructure assets.

One municipality contributed advanced metering infrastructure (AMI) data to the project, which assisted in further dissecting the basic components of the MNF, being legitimate consumption and leakage.

Further deployment of AMI or similar technologies to record granular consumption data at hourly (or sub-hourly) frequencies allows for deeper analyses of consumption characteristics that can further improve estimates of excess leakage, lending an increasing degree of confidence in the results.

That said, this project has demonstrated that there is often a clear distinction between generally "healthy" DMAs and those that are "leaky," such that the latter represent the low hanging fruit which can be most affordably addressed for meaningful performance improvements.

As these practices continue to evolve with municipalities and practitioners become increasingly proficient and sophisticated, the additional accuracy afforded from widespread DMA and AMI adoption can be expected to assist in identifying and dealing with smaller leaks, as well as the emergence of new leaks.

With this project now complete and the concept of mobile DMA testing proven, the method is available for replication and commercialization. The benchmarking results can be used for any DMA configuration, whether temporary or permanent, utilizing the mobile unit or otherwise. The results obtained through this project can assist in providing an objective and reliable basis for assessing DMA performance and determining whether any deeper examinations (e.g., leak detection) or other interventions (e.g., pressure management) are worthwhile.

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