

## GIS Acoustic Mapping in Ottawa

**Kenneth J. Brothers, P.Eng.**

City of Ottawa Utility Services Branch, 110 Laurier Avenue West, Ottawa, Ontario, K1P 1J1 Canada,  
Ken.Brothers@Ottawa.ca

**Keywords:** Acoustic Noise Mapping, Active Leak Detection, Noise Clusters, Acoustic Survey, Leakage Run-time, ILI

In 2005, the City of Ottawa moved away from reporting water losses through unaccounted water percentages, to utilizing the IWA methodologies and performance measurements, including the Infrastructure Leakage Index (ILI) and reporting volumes and values of lost water in the system. The IWA Water Balance was also used to focus the attention to the various categories of water use, loss, and potential for recovery of lost water and additional revenues by undertaking a more rigorous assessment of the overall accounting of water in these areas.

The City of Ottawa water system incorporates 2,700 km of distribution and transmission watermains, providing drinking water and fire protection services to approximately 800,000 people in the metropolitan area.

The City calculated an ILI of 6.4 in 2005, after undertaking the Standard Water Balance. 263 litres per service connection per day of real losses were calculated from this water loss assessment in the system with an average pressure of 43 metres. This figure contrasts to the previously reported 25% Unaccounted For Water used in the past.

With a focus on reducing real losses, the City reviewed its Active Leak Control (ALC) program. The City was using a suite of noise correlators and electronic acoustic leak detection equipment to conduct broad system wide leak detection surveys. The City had recently implemented a systematic approach of ALC by utilizing noise correlation equipment to undertake both the survey and pinpointing activities of the program.

Through discussions with staff, it became apparent that the process of utilizing noise correlation equipment would take approximately 5 years to complete the comprehensive survey of the Ottawa system. This was based upon the staff resources available and in consideration of the extreme cold weather conditions during winter months during which the program could not cost effectively be implemented.

The water loss control team reviewed their equipment and procedures with the goal of reducing the leakage runtime by adopting the "Noise Mapping" procedure in the metallic pipe serviced areas. The Noise Mapping procedure can be applied to all rigid pipe, including cast iron, duct tile iron, copper, brass and asbestos cement systems. Acoustic noise mapping, and other sounding techniques, are not generally effective on PVC or elastic piping systems due to the limited transmission of leak noise propagation through this material.

To focus on where to implement the noise mapping procedure first, a bottom-up approach of the large sectorized metered zones in Ottawa was undertaken. The bottom-up approach comprised of assessing the night time flow rates in large sectors compared to the calculation of background losses for the system size, and an estimated 6% toilet/cistern use by population equivalence calculation, in night time use between 2:00-4:00 a.m. determined from a cistern size equivalent to the plumbing standards in the sector. This approach resulted in identifying 3 major zones that experienced much higher differences in calculated bottom-up water use loss compared to the night time system input flow to the sector. Not surprisingly, the real loss areas

were in those systems with the highest system operating pressure, located along the river front, and which also comprised of the oldest piping systems in the City.

The City leak detection staff were brought together to review and standardized the equipment to be utilized in the field for the acoustic noise mapping of the system. The equipment reviewed included high quality leak detection equipment, ground microphone sensors and standard equipment setup to ensure team-to-team consistency of acoustic noise mapping, and leak noise intensity documentation used in the pre-survey of above ground fire hydrants, valves and property isolation service valves.

The acoustic noise mapping procedure follows the standardized approach of acoustically sounding direct contact points on a metallic piping system to determine the presence or absence of system generated noises. Fire hydrants are typically spaced at 150 metres apart in North America, and provide excellent access points to the metallic piping systems to undertake acoustic soundings of the system to determine leaks on mains and services.

The acoustic procedure includes using ground microphones (transducers) and positioning these on top of fire hydrants, or valve keys, to provide the most direct access point to the metallic distribution system. The operator acoustically listens to the noise on the system and determines whether there is a presence of noise, and utilizes an acoustic "legend" to further describe the type of noise heard on the system. The standard legend that's applied in Ottawa includes:

1. Presence or absence of noise;
2. Intensity of noise (0-100 relative scale);
3. Mechanical noise on system;
4. Transformer noise;
5. Consumption Noise: Variations in noise intensity and pitch;
6. Pump noise; and,
7. High pitch noise: Typified a hydrant "seat" leak that is distinctively different than other system leak noises.

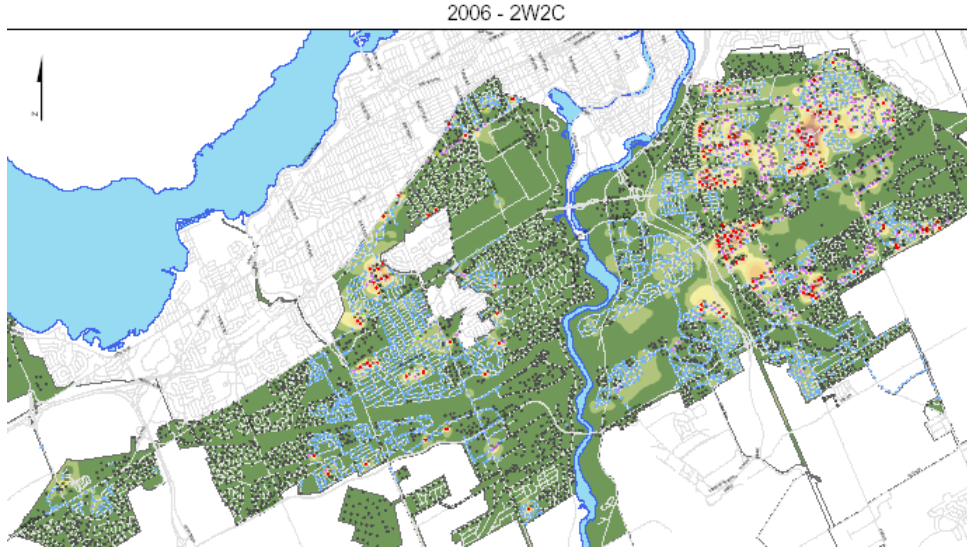
Utilizing this approach of acoustically sounding the equally spaced fire hydrants, or providing acoustic sounding points intermediate valves, the operator provides an acoustic array of information that determines the presence or absence of noise, and further characterization of noise by way of intensity and further descriptors to further assist the manager in assessing the potential type of leak, or leaks, monitored in the system.

With this information in hand, the operator can use a typical water plan of the system to graphically present the noise of each leak sounding while on route. This information can be transposed to a GIS and Excel spreadsheet system for further tracking of the repairs and leak detection recheck follow-up after repairs. On the GIS system, the plotting of the leak noise and intensity provides for a full view of the leak noise color pattern, which provides for a full graphic depiction of the leak noise for review and assessment to determine the number of potential leaks in the zone.

The City is currently using handheld computer devices to document other operational and maintenance information on fire hydrants, valves and other system information. The City will be implementing data capture devices to input the acoustic noise information directly down to palm held devices, which can be uploaded into the GIS system on a daily basis, without the further transfer information from hard copy sheets.

The aforementioned documentation of leak noises, and its presentation on system maps, can provide an overview of the “acoustic mapping” of noises heard through metallic systems. The intensity of noise has been scaled to a color scheme that shows the area of the noise plotted on the GIS mapping of the water system. With an

**Ottawa : Sector 2W2C: 1,240 km Metallic Pipe – Noise Mapping**



intensity provision, it can clearly see the rise and fall of leak noises as monitored throughout the system. The acoustic noise mapping technique provides a visual display of the potential leak locations, as well as multiple leaks that can occur within the cluster of leak noises that are monitored from the City distribution system. The use of color and the relative noise intensity figure posted to the attribute (hydrant or valve) provides for a detailed sonic view of the leak.

## Ottawa: Noise Intensity Clusters Demonstrate Multiple Leaks

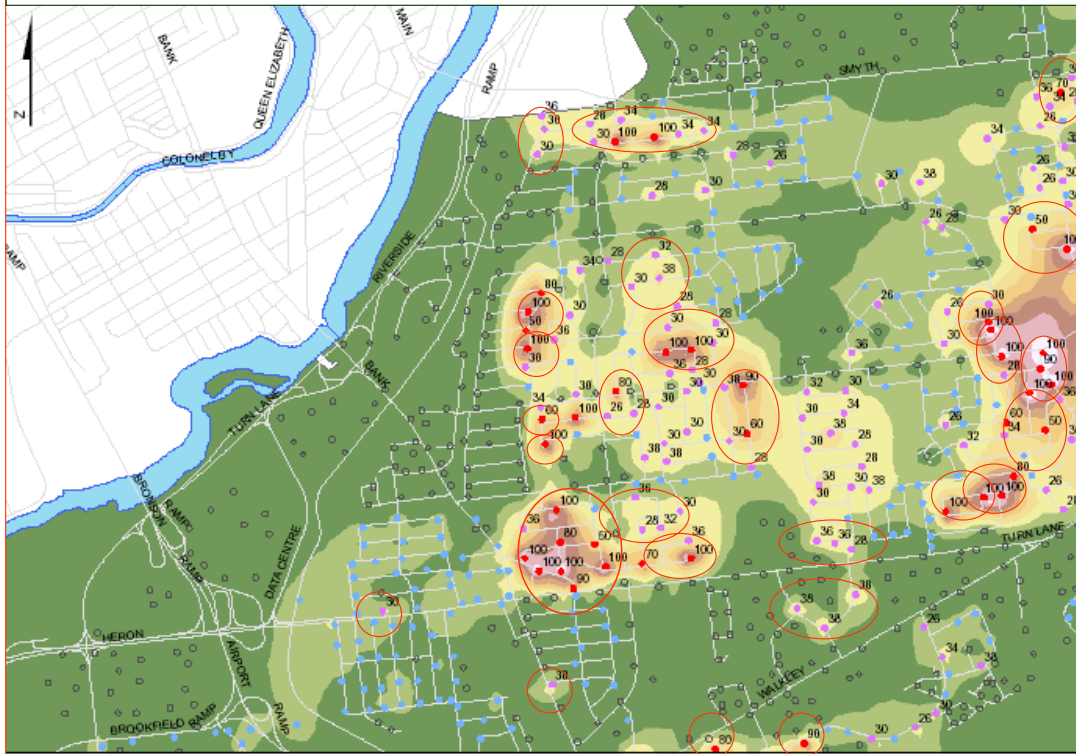


Figure #2

The Figure #1 depicts sector 2W2C comprising of 1,240 km of metallic pipe. Acoustic noise mapping was undertaken in this area and is seen on Figure #2, the GIS system plotted the acoustic noise intensities, with a variance in colour, to visualize the noise mapping and corresponding intensity of noises (leak noises) in the system. The lighter toned areas, along with the corresponding noise intensity figures, are plotted on the map. Upon review, it is evident that multiple leaks are occurring in clusters, through the assessment and profile of leak noise intensities in the various noise present areas. The noise intensity rises and falls, in groupings of high noise clusters. The corresponding reduction of noise in peripheral areas, illustrates that several leaks can be present over a very small area, and that the noises generated from each leak tend to overlap.

The acoustic noise mapping procedure, through a standardized equipment and documentation setup and description of leak noise intensity, clearly demonstrates that prior to any further leak investigation, that leak clusters (or multiple leaks) are present in many areas that have high losses. The acoustic noise mapping procedure can be used to focus pinpointing procedures for several leaks in a noise cluster area which can result in a greater number of leaks to be found and repaired more quickly than other active leak control programs and techniques. The acoustic noise mapping procedure can have a significant effect in reducing the overall leakage runtime of multiple leaks clustered in distribution systems of poor or in average condition.

The Ottawa system comprises of 1,900 km of metallic watermain. The initial survey of this system contemplated approximately a 5 year timeframe to cover the entire system. After review of the acoustic noise mapping system, staff had targeted approximately 18 months to complete the 1,900 km of metallic pipe. The process of

acoustic noise mapping started in April 2006 and the 1,900 km of main was completed in 9 months. It is anticipated that this timeframe can be reduced by another 3 months as leak crews become more confident and competent in the acoustic noise mapping procedure.

The City reduced real losses by 12% in the first year of Noise Mapping procedures. More importantly, unreported leak repairs increased to 20% of all main break repairs in 2006. It was also found that 40% of the noise clusters identified in the Noise Mapping procedure were found to have one or more leaks that were repaired. The City anticipates further improvements in the percentage of unreported leaks found in the system, and realize further reductions in the volume of water lost through the reduction in leakage run time.

The Infrastructure Leakage Index has also been reduced from 6.4 in 2005, to and ILI equals 5.2 in 2006. This decrease in real losses by 12% of the system input, is estimated at 3.1 million cubic metres per year of system input.

Based upon the City's extensive watershed area and access to the Ottawa River sustainable water supply, staff have targeted a short term goal of an ILI = 4.0. A further evaluation of an economic target level of leakage will be undertaken when this goal is achieved. The City's low marginal cost of water at 6.0 cents per cubic metre will have a bearing on the economic level of leakage calculated by the City.

## **Conclusions**

1. The acoustic noise mapping technique is a best practice for active leak control detection of unreported leaks on metallic or other rigid piping systems.
2. In systems with high leakage or infrastructure in average or poor condition, multiple leaks can occur in clustered areas.
3. Leak noises emanating from noise clusters provide an overlap and can be discerned through appropriate documentation of leak noises, intensity and noise characterization descriptions.
4. The plot of noise and intensity or a GIS format provides a successful diagnostic test to determine multiple leaks exist before pinpointing procedures and repairs occur.
5. The City of Ottawa has reduced its real losses by 12% in the first year of the noise mapping actively controlled technique, and completed system surveys in half the planned leak detection survey timeframe.