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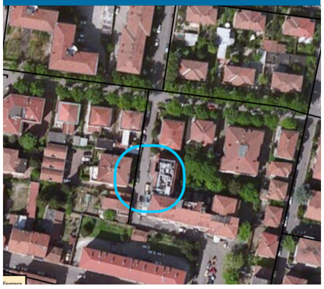
SUMMARY



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EDITORIAL

Leadership

Daniel Nicolae

A discussion about leadership involves various risks. Like any new word in the Romanian language that is not sufficiently well explained, meanings are varied, depending on the interlocutor and the space where it is used.

On the other hand, excessive use of the word with its wrong meaning, can lead interlocutors in awkward situations, sometimes even embarrassing.

The Romanian Dictionary says about "LEADERSHIP" that is a "leading position. (<Ro. Leadership) ", a definition that is a deeply flawed and can lead to a false conclusion.

John Maxwell said that leadership is influence, nothing more, nothing less.

The premise that leadership is linked to the position within a company, how high you are in an organization or what is your organizational formal authority is wrong. We all know weak leaders who had good positions and very good leaders who had no function. Robin Sharma says that leadership is rather a state of mind, a way to live your life day by day. Leadership is a process, not a position. But while the parallel between manager and leader is not hard to do, in recent years more and more people notice differences.

"People have the potential to be leaders in any position, but a manager regardless of his position, may not have the necessary skills to build relationships between people and thus to be a good leader" explains Jim Bagnola.

Leadership means people and their dynamics. It means to start making a change and help the development of others.

To be a leader in the XXIst century is not necessarily a formal function. A leader is recognized though different qualities.

In the most complex book related to leadership, in my opinion, "The 5 levels of leadership," John Maxwell shows that in everyone's life there are 5 stages of leadership, explaining how you can deepen each level, so you get to have a larger influence in the sphere in which you operate, helping you to transform yourself in the way other successful and respected leaders did:

1. Position - People follow you because they are forced
2. Permission - people follow you because they want to
3. Production - people follow you for what you did for the organization
4. Developing people - people you follow you for what you have done for them personally
5. Apogee - People follow you for what you are and what you represent

Max Landsberg says that leadership seems to resume from a single formula:

Leadership = vision x motivation x drive. So, the leader focuses initially on building a team and then on building motivation and enthusiasm.

In the last 30 years there have been three organizational trends:

- In the '80s there was management; the manager was the one who had to ensure that the company's growth was constant
- In the '90s it was passed to individual leadership, because working for an organization that was constantly changing lead to a constant need for leaders
- In 2000's, the leadership team appeared; now emphasis is placed on teamwork, on the responsibility of all its members, as the leader can not do it all by himself.

Therefore, we ought to show leadership in all aspects of our lives, not only in the workplace, in society, but also in our personal lives. No matter your social status, where you are in your life at this point, we all have a moral duty to behave as leaders because of a very simple reason: either you choose to be a leader or you choose to be a victim, but you can not be in both situations simultaneously. And nobody loves victims, maybe just other victims.

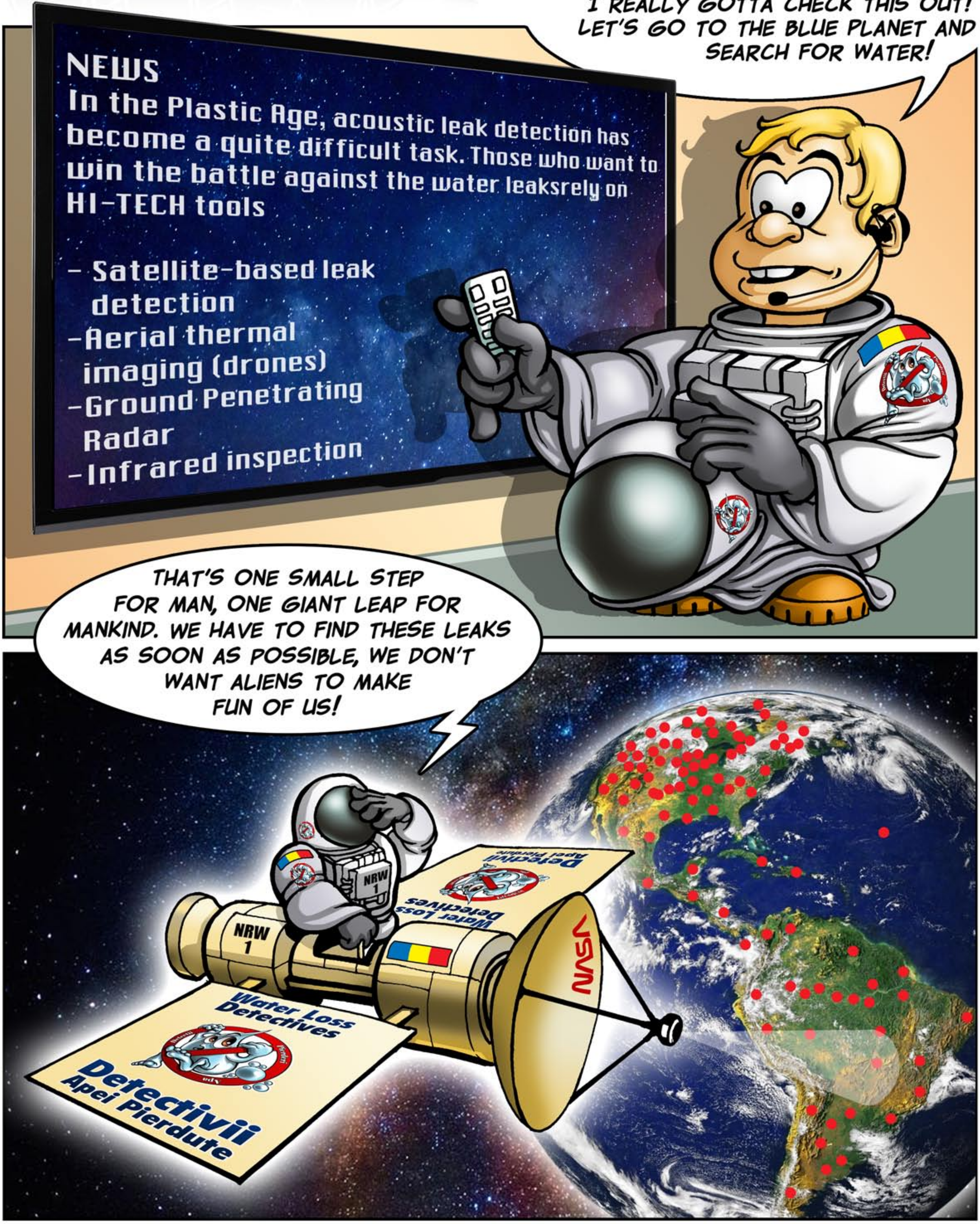
The need to lead is often imposed from outside, regardless of whether we want it or not. Most of us are leaders of a team: company director, heads of families, leaders of a group of friends, the leader of a sports team or any other form etc.

The conclusion is that we ought to be at least our own leader.

A.L.EX.

Acoustic Leackage EXpert

EPISODE 5 OUTER SPACE LEAK DETECTION



Ronnie McKenzie

„I personally believe that Drone technology can be very potent as a means of identifying leaks from large pipelines..."

Ronnie is a Civil Engineer specialising in Water Demand Management, Hydrology, and Water Resource Planning and has more than 30 years of experience in these fields. Since 1994, Ronnie has worked to introduce the Burst and Background Estimate (BABE) procedures to South Africa where he currently resides. He developed and introduced new leakage management software which is freely available through the South African Water Research Commission and is used in many parts of Southern Africa and numerous other countries. He has a particular interest in pressure management and was responsible for the introduction of Advanced Pressure Control to South Africa in the late 1990's which resulted in the development of several very large and successful pressure management installations in Cape Town (Khayelitsha) and Johannesburg (Sebokeng). He has organised and/or presented more than 50 workshops/courses on water loss management in over 20 countries throughout the world and has written and presented more than 100 technical papers on various aspects of water loss management and water resource management.

He has a BSc in Civil Engineering and PhD in Water Resources Planning from the University of Strathclyde in Glasgow, and has been MD of WRP Pty Ltd for over 18 years, which he established with two colleagues in 1998. He is a member of many organisations and a fellow of the International Water Association and the South African Institute of Civil Engineering. He received the inaugural Ministerial Award for services to South Africa in the field of Water Demand Management and when he is not trying to reduce leakage somewhere he is often collecting minerals or meteorites.

Current organization of the WLSG

The new elected Chair; Ronnie Mckenzie and Secretary; Jurica Kovac took over their duties a couple of months ago after the recent conference in Bangalore. Both Ronnie and Juri have been active members of the WLSG for many years and are looking forward to building on the achievements of the previous management teams for a period of 2 years, until 2018.

Questions:

1. What are the main challenges to successful leakage management facing water companies today?

Ageing infrastructure and low levels of essential maintenance are problems in most parts of the world , especially in developing countries where water losses are on the increase in many areas. A lack of proper planning where water restrictions can be introduced early on in a drought event is leading to situations where it becomes necessary to introduce intermittent supply is creating a „vicious cycle" which invariably leads to higher leakage, damage to the infrastructure and potential health hazzards. The key challange to water companies is to introduce low level water restrictions early on in a drought event in order to avoid the need to move to intermittent supply. With proper planning and drought management it is often possible to get through a drought without moving to intermittent supply.

2. How can water companies ‚design in' resilience and sustainable water management?

Many countries around the world do manage their water resources in a pragmatic and methodical manner to minimise the detrimental effects of a severe drought. Droughts cannot be avoided as they are natural events which will occur. Climate Change is an additional risk which in itself does not cause droughts but it can add to the severity of natural drought events. The impact of population growth and land use change are the dominant factors which will make future droughts more severe than previous events. Between the "man-made" impacts and the more subtle impacts of Climate Change, water companies must expect future droughts to be more severe than anything they have experienced previously and must have plans in place to deal with the potential water shortages.

3. Are water companies investing enough in ‚smart' networks and innovative technologies?

There is a lot of talk about smart metering , smart networks, the Internet of Things etc etc which are all important and offer some help in managing water supplies and reducing water losses. There is a stark contrast between developed and developing economies with the greatest problems and risks to health in the developing areas. In such areas, appropriate technology is needed which may not always be the most recent or advanced equipment or software available. In countries where visible leaks can run for years without being repaired, there is little benefit to be gained from smart metering or smart networks for example. Getting the basics sorted out should always be the first priority after which the hi-tech solutions can be considered.

4. With data coming in from multiple sensor points in the network, do companies have sufficient data analytics in place?

This is clearly a loaded question to promote the analysis of data which may well be an option in some areas. From experience in most developing countries the problems faced by the water managers are very basic and they need to get the networks working properly on 24/7 pressurised supply before embarking on more sophisticated solutions.

5. How can companies use the latest technologies and systems to understand and use the data?

– see above response – in our view, the approach should be toward appropriate technology which may not always involve the latest technology. If the basics are not in place, the latest technology will often be innappropriate.

6. What are the latest developments in analysing the significance of background losses and trunk main leakage?

– There are many new systems and software packages on the market to assist water suppliers to address background losses and mains leakage. Each has its own benefits and constraints and there is no single solution that can address the problems experienced by different water suppliers. Most water suppliers that we deal with struggle to understand the basics and even some of the world's largest water suppliers appear to favour the introduction of intermittent supply as the first measure in reducing water use during periods of shortage. With such short-sighted managers, there seems little point trying to recommend smart systems or the latest technology in leak location.

7. When should large commercial customer meters be replaced to maximise income and reduce under-registration?

– The meter companies will offer different advice on this issue. In our experience the useful life of a meter depends on the quality of the water, the design of the meter installation and the flow through the meter. On a well designed bulk meter, we would expect the meter to last between 5 and 15 years but it may only last 1 year or much longer depending on local conditions. Areas experiencing intermittent supply will often experience high levels of meter failure due to the refilling spikes as well as air through the meter which can damage mechanical meters. In our view, all water suppliers should ensure that the water meters to their to 100 or top 500 (or more depending on size of utility) largest customers are checked regularly since they are often responsible for most of the revenue of the water company. Replacing or calibrating the meter every year may be appropriate in some cases and in other cases, every 5years or longer mey be appropriate. There is no simple answer to this question. Some water companies use check meters and when the two readings drift by more than a specified amount, they will replace boh meters with recently calibrated or new meter heads. Magnetic flow meters can offer greater accuracy, but they have their own problems and are often not utilised in developing countries for various reasons.

8. Is satellite imaging the upcoming non-intrusive leak detection technology? How does it work and what are the results so far?

This question is best answered by someone from the water companies as our experience in about 30 countries, most of which are developing, suggests that they are not ready for the more sophisticated forms of leak location etc since they don't address the visible and reported leaks efficiently. In our view, the water companies must implement measures to address reported and visible leaks as a matter of priority after which they can start looking for the unreported/invisible leaks. In our experience, we believe that monitoring of Minimum Night Flows is one of the best management tools to identify and monitor leakage levels either through permanenet live monitoring in cases where sectorisation is in place or through step-testing in areas where sectorisation is not in place. I personally believe that Drone technology can be very potent as a means of identifying leaks from large pipelines in areas where surface water is not an issue. In other words in such areas a leak will be picked up from a drone using infra-red technology – the cost is now 5% of what it was 20 years ago.

At the end, I invite you to join IWA and our Water Loss Specialist Group.

Our group has new web space at IWA Connect web site (https://iwaconnect.org/#/group/water-loss/dashboard). Here you can check for regular updates; news, events and new free educational materials.

We are looking forward to continuing the past growth and success of the Group in order to help to reduce water losses globally.

best practices and case studies on water loss

Case Studies on Water Loss - Losses Detection Using G.P.R.

Postavaru Alexandru

HEAD OFFCIE NRW at C.J. APASERV.S.A. NEAMT

On 31st October 2013 County Company APASERV S.A. NEAMT purchased two geo-radar systems to identify fraudulent consumers connected to the drinking water distribution network.

We all know what a geo-radar namely G .R .P. (Ground Penetrating Radar) is a signal-based technology via electromagnetic radio wave.

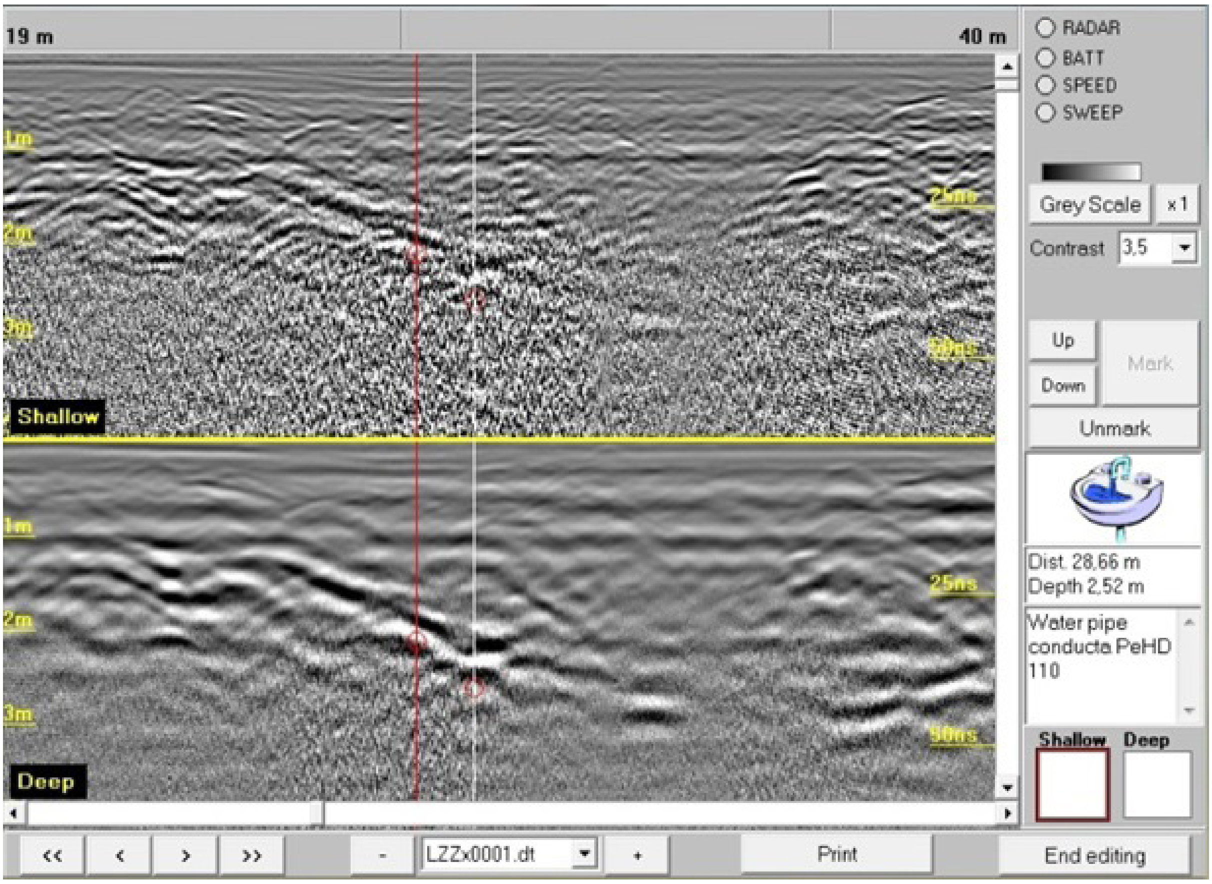
G.P.R. allows the harmless investigation of the pedological soil structure and underground installations.

Besides the usual possibilities a geo-radar provides – such as pinpointing sealed manhole covers, gas networks, power networks and buried water connections identification - the geo-radar also allowed us to identify water loss in ideal situations.

The system the NRW office uses consists of a data recording unit and two antennas, for low and high frequency, representing a transmitter and a receiver.

Thus, high conductivity regions (> 10-7 S / m) cause disturbances that can be easily identified in geo-radar scanned graphs, therefore when using the geo – radar to scan the soil one should pay attention to what the device displays in the case of clay soil, any type of saltwater infiltration and generally any soil consisting of very fine grained particles or high water concentration which may be misleading.

GPR could, in principle, identify leaks in buried water pipes either by detecting underground voids created by the leaking water as it erodes the material around the pipe,



or by detecting anomalous change in the properties of the material around pipes due to water saturation. Unlike acoustic methods, application of ground penetrating radar for leak detection is independent of the pipe type (e.g., metal or plastic). Therefore, GPR could have a higher potential of avoiding difficulties encountered with commonly used acoustic leak detection methods as it applies to plastic pipes.

Below there are some cases that we encountered in the field, where damaged water distribution networks were identified using the geo-radar.

The first case the NRW Office were involved was Borca village. The main problem of this village was the water level in the main 3000 m^3 tank which fell very quickly. Several days of trying to determine the water losses on a 4 km - long polyethylene network failed to reveal any damage.

The problem was discovered in the main tank area when geo-radar scans were performed.

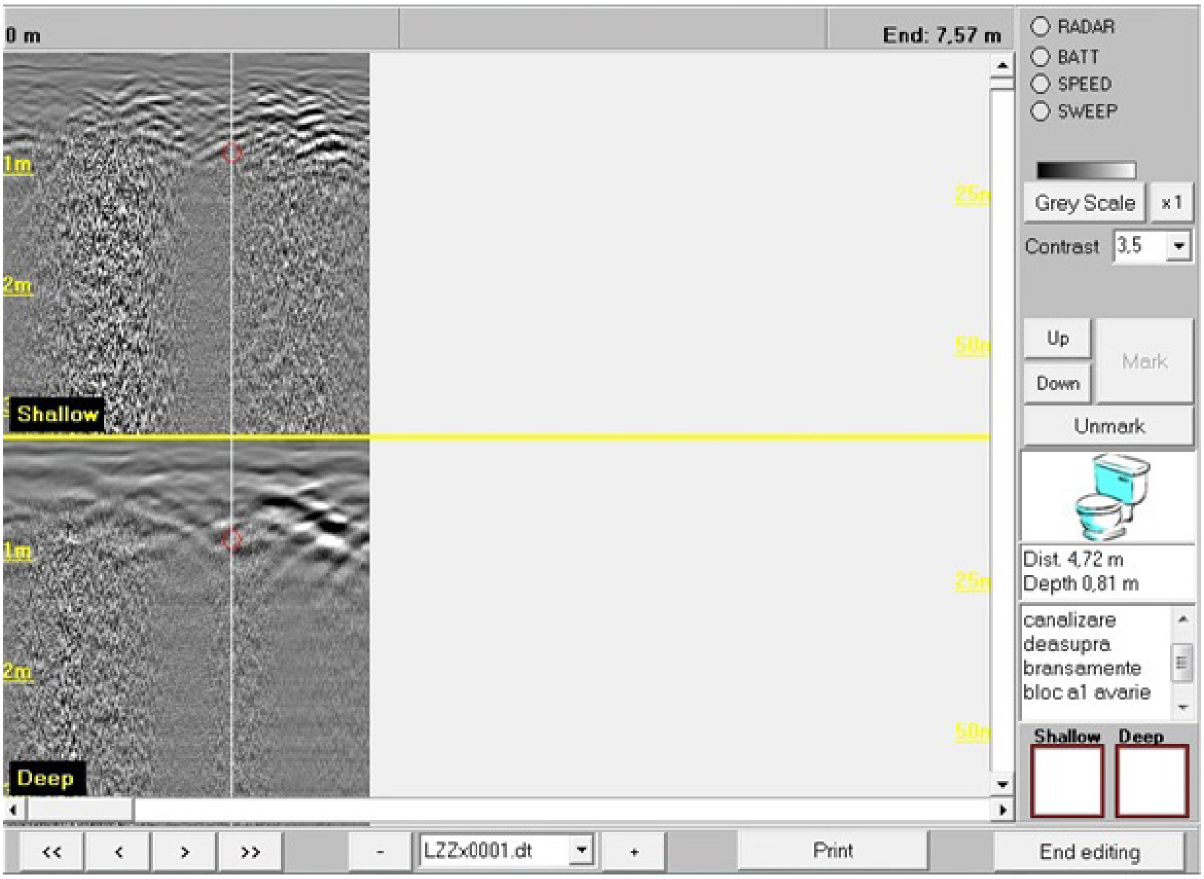
Thus the full water volume from the water abstraction plant was lost along the main pipeline and did not reach the distribution network.

As it can be seen from the pictures, around the DN 110 HDPE pipe there was a gap where water missed the pipe and went back to the underground water it originally came from.

In this situation where underground water level was quite high thus increasing the earth conductivity and consequently making it impossible not only to identify the pipeline but also to determine pipeline damage, we relied on the fact that the water losses was very high, which made the soil conductivity much higher than normal around the damage, so it could be easily identified by geo-radar.

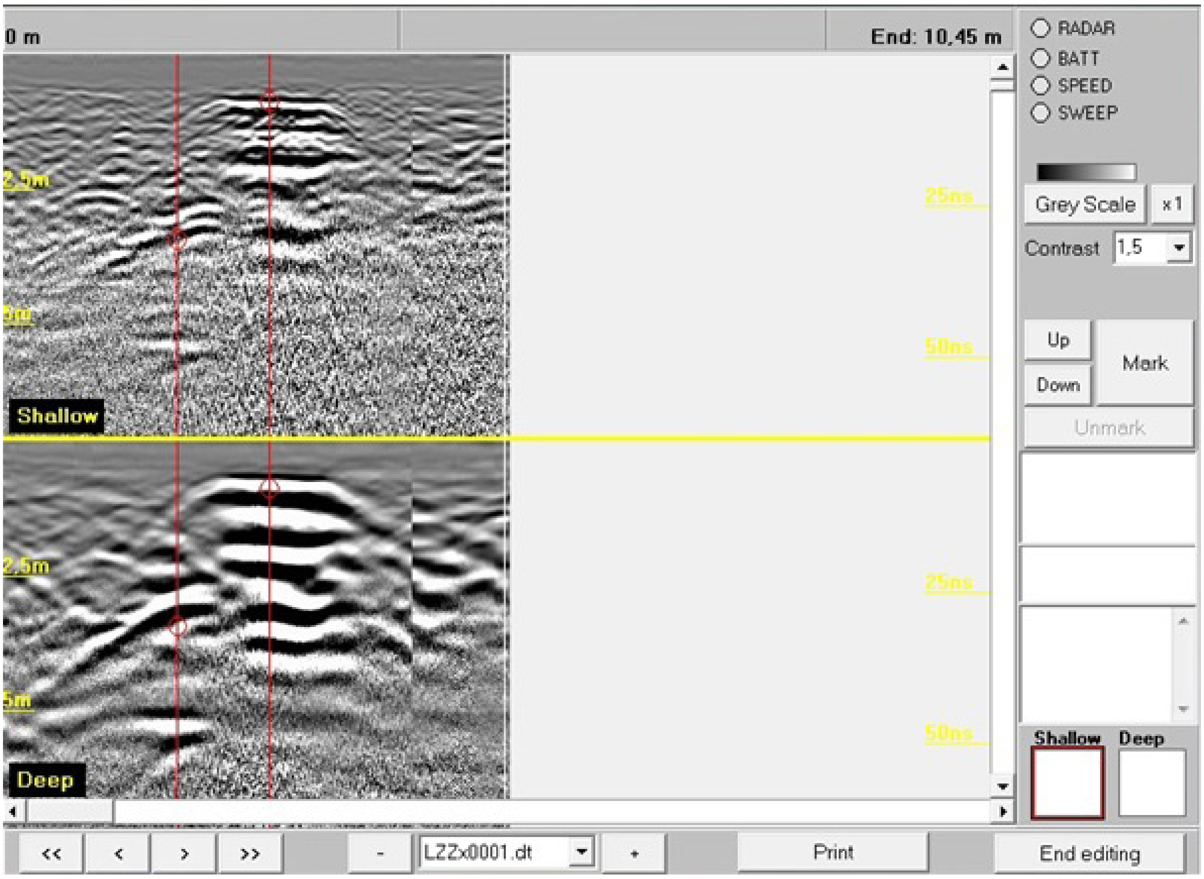
Another case the NRW office participated was in Piatra Neamt to a block of flats on Traian Street where lack of access to the pipe prevented us from mounting another device to detect losses on pipe, and since we did not have the electronic ear device at that time, we used only the geo-radar to identify the damage and the pipeline.

As seen in the pictures, the damage was successfully identified.

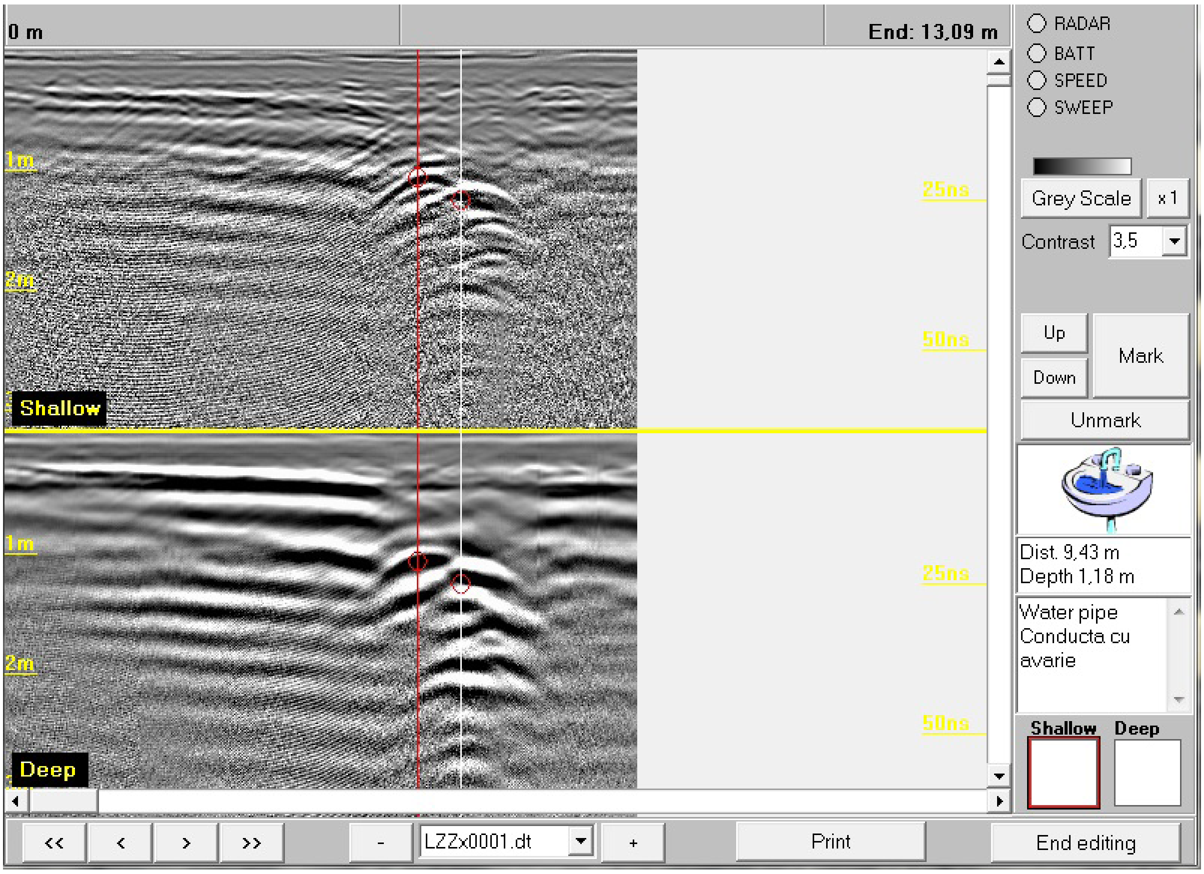


In this situation the chart scan displays two parables, which I later on found to be the block water connection crossing over the sewerage network and the high conductivity around the parables clearly indicated the connection damage.

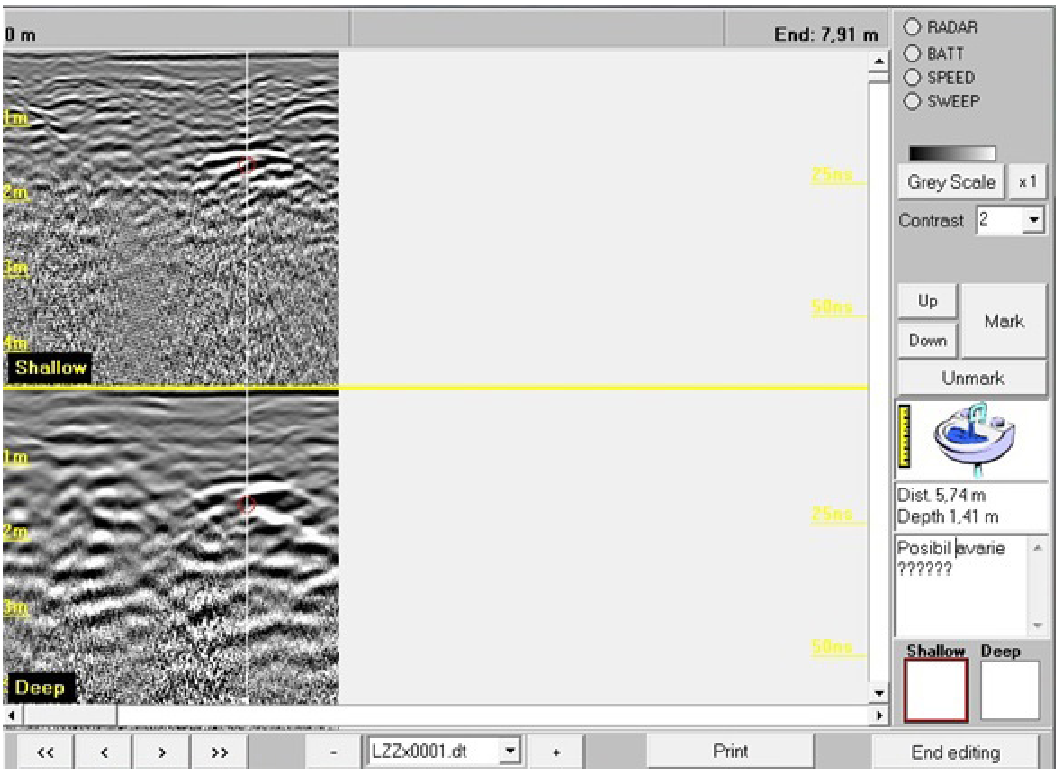
Another case was addressed in Radauti, Suceava County where, in a home garden, we discovered a water manhole with a pipe coming out. In the chart the disruption caused by the existing damage is obvious.

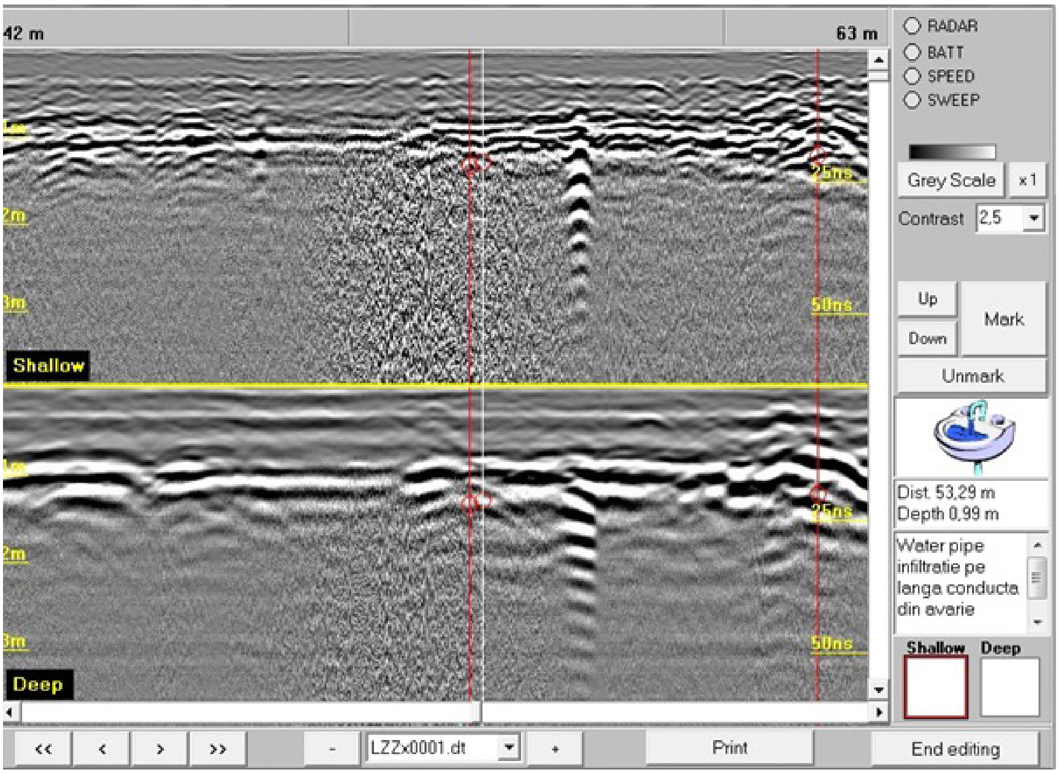


Another case we dealt with was in Piatra Neamt on Sportului Street where - as clearly seen in the graphic - the disturbance around the parable had been caused by infiltration in the damaged water pipe.



Hereinafter there are some scans of drinking water pipelines, where we can also identify the water infiltration caused by the damage on the existing pipelines.





In conclusion the purpose of this short presentation was to highlight the possibility of using other loss detection methods, as the geo-radar must not be seen as a replacement of all existing detection equipment, either related to loss identification or utilities identification.

The presentation comprises several cases that we actually encountered on site and successfully identified using the Geo-radar.

These cases were also confirmed by the usage of other devices existing on the Mobile Laboratory for Loss Detection and by conducting surveys at those specific points.

It is recommended to use it in parallel with other equipment, as the NRW office uses it with low conductivity soils and when other devices could not help us identify the problem.

GPR could also be used as a supplement to these methods to increase accuracy in high risk areas such as high traffic streets and large structures.

Non-Revenue Water Management is Smart Business for the City of Asheville

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The City of Asheville formally launched its Non-Revenue Water (NRW) program in 2012, instituting practices to identify, analyze and ultimately reduce NRW across the system.

Cavanaugh provided initial support to the City in getting the program up and running and has assisted the City in moving the NRW program into advanced practices including leakage component analysis, economic analysis of losses for target setting, zonal metering analyses for leak detection prioritization, and large meter testing support.

Cavanaugh is an industry leader in the fields of non-revenue water and bioenergy. For more information contact will.jernigan@cavanaughsolutions.com.

Not Another Drought Story

Nestled near the Great Smoky Mountains National Park in western North Carolina, the City of Asheville has much to boast about – including quality of life, a vibrant arts culture, and more microbreweries per capita than any U.S. city (that's roughly 100 local beers). In fact the Asheville area recently became home to the second brewing sites for Sierra Nevada and New Belgium. Part of the draw for these breweries (apart from the population's demand for beer) has been the area's water – which comes in plentiful supply and of the highest quality. Which makes for an interesting case study when it comes to managing water loss (water extracted from the rivers or aquifers but lost largely due to aging infrastructure). Those headlines are usually dominated by the cities in the western arid states.

Enter the City of Asheville, who has put themselves on the national water loss management map despite having no constraints on available supply and no mandating regulation forcing them to address it. It was in fact a recognition that efficiency gains in water loss reduce costs, improve revenues, and serve to mitigate risk for future water supplies. Water loss control also means better management of the water system and better serves the long-term interest of the rate payer. In the end this recognition led the City of Asheville to formally launch its Non-Revenue Water (NRW) program in 2012, focusing heavily on identification and reduction of water losses.

A Starting Point

An audit of the water system in the early 2000s found the City produced around 80 megalitres of treated water each day but lost nearly 27 megalitres per day, or approximately 30%. While the City of Asheville has abandoned the use of "% of supply" to track water loss performance due to its unreliability, this initial assessment served to catch the attention of the managers and elected officials. Over the subsequent years, the City invested in large scale capital projects to replace millions of dollars of its distribution pipe network, and a wholesale replacement of its roughly 55,000 customer meters. This set the stage for its formal NRW program launch in 2012, following attendance to the AWWA Distribution System Symposium in St. Louis by key staff. Upon return from this conference event, system managers established a framework of teams each focused on a different aspect of NRW. Standing up any NRW Program requires a team effort from various roles, committed to regular inter-departmental communication of accurate data – including, but not limited to supply, billing, consumption, metering, costs and other operational data.

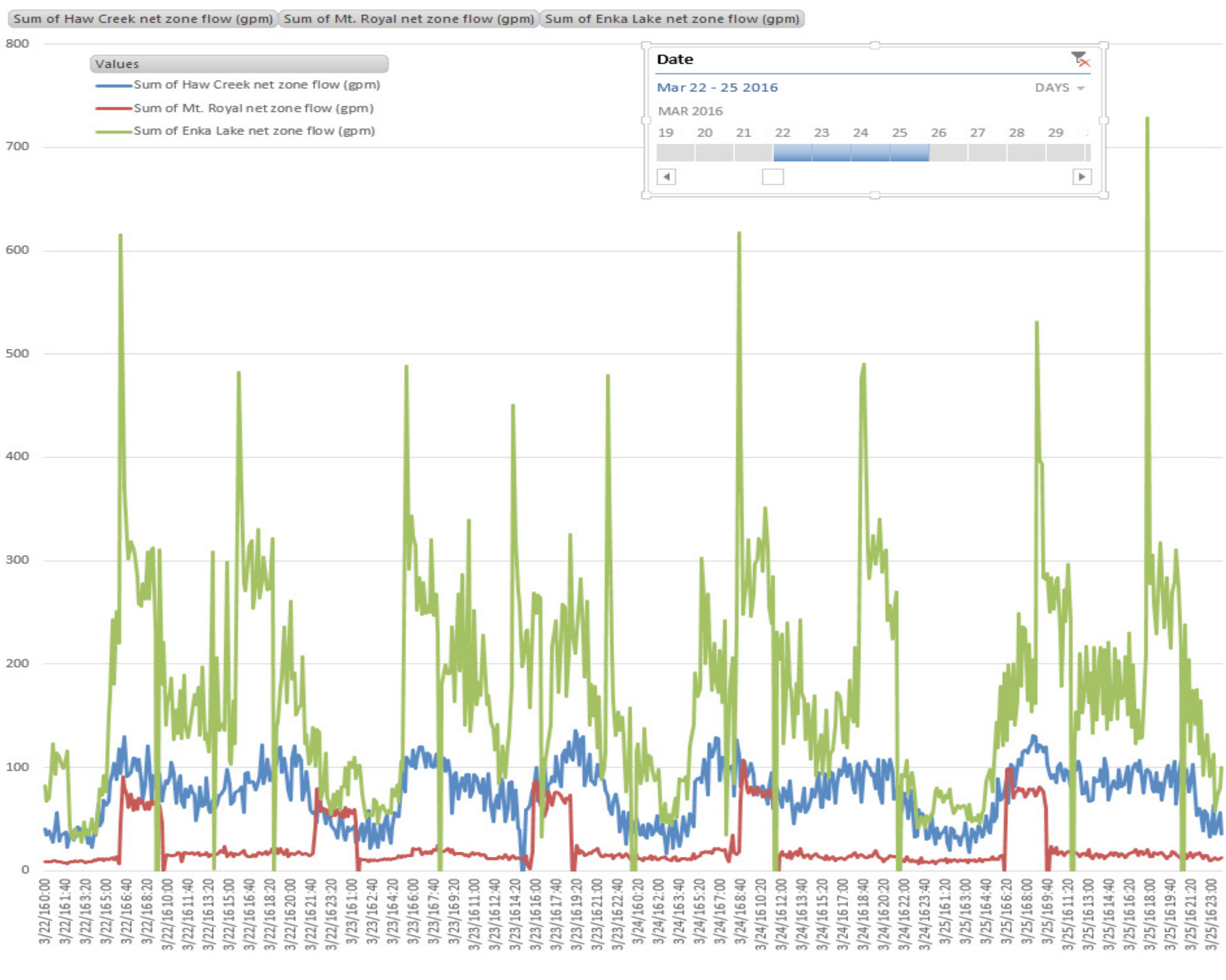
Not a Solo Sport

The City of Asheville recognized the need for a concerted NRW team. The NRW team was developed with the following groups and focuses:

- **Audit Input Team:** Responsible for tracking and collecting the various points, but has procedures in place in order to validate the information as it is compiled.
- **Valve & Leak Team:** Dedicated team that focuses on proactive leak detection and repair, and control valve maintenance.
- **Unbilled Customer Team:** Responsible for analyzing potential illicit use on unmetered fire service lines and other unmetered connections.
- **Customer Service Team:** Responsible for account coding cleanup, billing software migration cleanup, and revenue recovery calculations.
- **Metering Team:** Oversight of Automated Meter Reading (AMR) conversion, planning and execution of the large and small meter testing programs
- **Pressure Team:** Maintains pressure database, confirms pressure boundaries, provides input for Pressure Optimization and District Metered Areas (DMAs).

All water systems have water loss – only the extent and composition varies. Each of the teams established work plans with prioritization based upon the water loss components in the baseline (2012) American Water Works Association (AWWA) water audit. The metrics utilized by the City of Asheville are water loss component volumes, their associated values, and the overall audit validity as

Tying NRW to the Capital Program



a measure of reliability. This approach for separating and ranking water loss components by their volumes and values have enabled the City to identify where resources should be directed, and more importantly – where they should not be directed. Once work plans were in place, a routine framework was established for communicating progress updates, as well as meeting to evaluate program effective and chart course for next steps. The City has seen first-hand that dedicated teams, regular communication and accountability are core necessities for it NRW program.

While auditing, establishing focus teams and putting the NRW program into place fall comfortably into the City's operations, there have and continue to be considerable capital infrastructure projects that take place each year. Recognizing that NRW is, at its core, driven by the infrastructure, the City sought to ensure a healthy tie between the two efforts. A few exemplary projects are highlighted here.

Leakage and pressure management are very significant components of the City's NRW program. With more than 1,500 feet in elevation change, over 50 pressure zones and some pressures as high as 400 psi, pressure and DMA projects rise to the top of the capital projects list. Using existing zone configurations, in 2015 the City installed 23 master meters to existing pressure zones to launch its DMA efforts.

The zone input flows are tracked in conjunction with tank drops in order to monitor nighttime flows to identify which zones are exhibiting actionable leakage levels. The DMAs have been online for several months and have already allowed the Valve and Leak Team to considerably streamline its efforts.

Another capital project, known as the Fairview Project, involved storage and piping modifications that were made in one particular high pressure zone. The project identified a need for redundant storage as well as pressure reduction, anticipated pressure reduction of over 100 psi with increase in fire flow for nearby schools, and improved water quality by getting rid of dead end lines. While the project was not originally conceived for the purposes of improving water loss, with the substantial pressure reduction that zone has observed lower overall leakage rates and a reduction in the frequency of main and service line breaks.

Another capital project launched under the NRW banner is known as Pressure Optimization, starting with a pilot study are in two zones: Haw Creek and Spivey. The aim of the pilot, conducted in 2015, was to identify the business case for pressure modifications – considering the cost basis in the zone for leakage, main and service break frequency, pumping energy consumption, and the extension of useful life on the pipe assets. In the Spivey zone, a business case for *no action* was determined. However, in the Haw Creek zone, a payback of *2 months* was determined for implementation of pressure optimization, as the whole zone was over pressurized on the order of 50 psi – incidentally not an uncommon occurrence in hilly terrain where some homes built atop the hill sit in excess of 200 feet above the meter box. Even with the additional customer coordination on a handful of homes requiring supplemental boosting, the business case was compelling. The zone also experienced transient pressure surges on a routine basis, which was contributing to main and service line break frequency.

Bridging the Divide

The City's formation of focused teams within the organization, in and of itself represents an exercise of communication and inter-departmental dynamics. It's a fact of life – it takes lots of kinds of people to make a water system run. Engineers, operators, technicians, accountants, customer service, and managers – just to name a few. This exemplary communication extended outside of the City staff as well, as the City's water system is also home to **20** fire departments throughout the City and County. The Audit Team set out and met with each of these departments to establish a communication, and develop a better understanding of their water uses. This also allowed the City to migrate to a uniform policy for metering and billing of non-suppression type fired department uses.

The Good Kind of Nose Dive

The City's NRW program results are compelling. These results did not occur in a single year, but rather are an aggregate result of putting the right attention on the right parts of the problem with consistency. Since its formal launch in 2012, Asheville's NRW program has seen steady reductions in water losses – nearly 9 megalitres per day of reduction. The City has observed growth in demand during this same time (breweries notwithstanding), and as a result has enjoyed to accommodation of system growth without increasing volumes extracted from the source. In this same period, the City has also steadily improved its audit reliability – as measured by the AWWA Data Validity Score – through the continued implementation of best management practices including source meter testing, customer meter testing, and billing system data analytics. The NRW program has demonstrated an improvement to employee engagement in the mission and overall operational cohesion between departments, fed by more efficient communication and improved business processes.

The efforts and results from Asheville's NRW program have earned it accolades including being featured in the latest version of the AWWA Free Water Audit Software and M36 Manual for Water Audits & Loss Control, as well as invitations to present on the national stage at conferences dealing with water loss management subject matter. Looking ahead, the City's next frontier includes achieving and maintaining its economic water loss targets, and further expansion of DMAs and Pressure Optimization across the distribution pipe network.

Dynamics of Water Losses

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Keywords:
Non-Revenue Water,
Action planning,
Water Balance

Abstract

Action planning to control for Non Revenue Water (NRW) in a water system consists of defining the conditions for transition from an initial Water Balance to a targeted Water Balance.

The authors have conducted in-depth analysis of the transitory stage of the passage from the initial water balance to the final one and have developed related simulation models. For this purpose, they have introduced and defined new concepts such as: Time Factor and Visibility Threshold, Coefficient of Return of Anomalies and Migratory Attribute of Losses.

In many cases, designers and practitioners fail to consider these factors and it seriously jeopardizes the results of their actions and plans to manage NRW. Great improvements have been recently achieved in terms of forecasting action planning on real losses; the authors show that similar improvement can be achieved with respect to apparent losses.

The consideration of these newly defined concepts is necessary to simulate the result of complex NRW reduction programmes including many components and to ensure comprehensive follow-up of these programmes.

Based on these new concepts the authors are laying the foundation for a new branch of the water loss topic that could be called “the dynamics of losses”.

Introduction

The concept of water balance of a water supply system is currently well known and commonly used to assess both real and apparent losses (Alegre et al 2000). However, this balance only gives a picture of the situation in terms of Revenue and Non Revenue Water (NRW) during a specific period of time, generally one year. Action planning to reduce and control for NRW is about how the water balance will gradually change when an action plan is carried out, and finally reach a new equilibrium represented by a new-targeted water balance.

Progression from the initial water balance to the targeted one requires considerable analysis and simulations. Experience shows that many plans have failed due to inadequate assessment of the initial situation and to a poor or wrong estimate of the impact of the forecasted actions. This paper reiterates the main causes for failure of an action plan that were originally detailed by Vermersch and Carteado (2006) and Vermersch and Rizzo (2007) together with new criteria required to avoid these failures.-It provides some additional guidance on how these concepts and indicators can be usefully used in the frame of action planning modelling. A case study is also presented.

Dynamics of Water Loss: New Concepts

Main causes of failure in action planning

In any water supply system there is a *natural entropic tendency to disorder and misinformation:* if nothing is done, there will be an accelerated propagation of leaks and occurrences of defective water meters as-well as the accumulation of out-of-date information in the database.

Therefore, the value of the network efficiency at any moment is the combined result of the natural deterioration of the installations and the procedures that have been put in place since their creation by the technical and customer services sections to fight this deterioration.

To counter this natural tendency it is necessary to understand what the causes of this deterioration process are and to carry out appropriate actions to minimise the negative effect of these causes. This may either be: (i) appropriate procedures to keep the loss ratio at its current value; or (ii) an appropriate action programme to meet specific efficiency targets. This is called the action plan and it includes many components such as the targets, list of the actions to carry out to meet the target, human and material resources, budget, time schedule, etc.

There are many reasons why an action plan may fail, for example if there are no improvements in the water loss indicators, if the improvements are less than scheduled, if the improvements do not meet the time schedule, if capital cost is much higher than scheduled, if the results are not sustainable, etc.

Ways to avoid these failures have already been mentioned. The following are some of the main causes for failure: the time schedule is not controlled; the possible returns of the anomalies are not quantified; and potential interactions between the various kinds of losses are underestimated. These considerations have lead the authors to propose some new concepts and indicators that are defined and commented in this paper.

Time Factor (TF) and Visibility Threshold (VT)

The Time Factor for one specific action is the period of time that it takes from the implementation of the action until the moment it impacts the water loss indicator. The Visibility Threshold is the moment when the impact of the action becomes noticeable (inflection on the water loss graph).

How many detected and repaired anomalies will there be before there is a visible impact on the value of losses and relevant performance indicators? Often the utility management lacks the patience and abandons the project even before the threshold is reached. This is unfortunate as it is only after the detection threshold has been reached, that there will be an accelerated improvement due to a “snowball effect” that will eventually ensure the success of the project.

Some examples related to various types of losses are given as follows:

(i) It is common that reducing real losses leads to reducing water input into the surveyed areas. This is true, but considering an example of a large distribution network repairing some small leaks may be insufficient in impacting the volume of water input. The visibility threshold on the water input will only be met when the volumes saved are sufficiently large to impact the volume supplied. This is the main purpose of district metered areas (DMA); the smaller the DMA, the easier the leak detection and the measurement of the repair impact. The visibility threshold is met sooner in a DMA than in the whole utility service area. The same approach may be applied to the various categories of apparent losses such as undermetered and unauthorised consumption.

(ii) If the water utility decided to renew the consumers’ meters because the error (under metering, thus underbilling) is increasing by 0.5 % annually, i.e. more than 5% in a 10-year period. This action should lead to some calculable increase in the water sales. What is the visibility threshold and how long does it take to reach it? It is a precision matter. In addition, it may be difficult to appreciate the visibility threshold when the meters are read once a year or when there are important seasonal and yearly variations in the consumer’s consumption.

With respects to the water leakage the impact can be appreciated by the review and assessment of the minimum night flow. With respect to apparent losses it may be more difficult due to the frequency of meter reading.

The visibility threshold for each action will also depend on the *rate of return of the anomalies*. In the case of a complex action plan involving various actions the visibility threshold of the plan will also depend on *possible interactions between the various components of the plan.*

The Coefficient of Return of Anomalies (CRA)

The name is self-explanatory and applies to both real and apparent losses. When one hundred anomalies are corrected in the time frame of the action plan, what number of similar new anomalies will occur due to the natural deterioration process? The CRA is an indicator that can be calculated as a percentage. The following examples are considered:

(i) After detected and repaired many leaks in the distribution network, new leaks will appear during the next months. Implementing annual active leak detection in the same areas, the CRA may be 1 (100%), less than 1 or more than 1. When it is 1 or more than 1, the visibility threshold on the water input figures may never be reached. The policy then requires reviewing: pressure control or pipe renewal might be more effective. In the case of real losses the present concept of CRA covers the existing concepts of Natural Rate of Rise (NRR) and Infrastructure Condition Factor (ICF) (Fantozzi and Lambert 2005, Lambert and Lalonde 2005)

(ii) In the case of the meter replacement campaign, the utility may decided to replace 5% of the meters every year because the errors are increasing by 0,5% every year. Remember that meters that have not been replaced that year (i.e. 95%) are continuing to lose 0,5% a year. It is easy to calculate the CRA for under metering and the minimum number of meters required to reduce the total loss due to under metering.

(iii) The detection and regularisation of unauthorised connections can be matched by the occurrence of a similar number of new unauthorised connections. When the Utility disconnects 100 customers for fraud or non payment, how many disconnected customers will reconnect their connection illegally? The CRA needs to be assessed to know what is the global impact of the actions and, obviously, to take appropriate corrective actions at the management level.

These examples show that there are obvious relationships between the Coefficient of Return of Anomalies (CRA), the Visibility Threshold (VT): the highest the CRA, the longer the TF and more remote the VT.

The Migratory Attribute of Losses (MAL)

Generally speaking, any action may have side-effects and these effects need to be forecast and taken into account in the design of the action plan.

When a volume of water is saved through a leak detection campaign part leads to a reduction of the water input however, another portion may be lost through other leaks or apparent losses.

This concept applies for instance to the automatic transformation of real losses into apparent losses under certain circumstances. If the leak repair creates pressure increase and new leaks or if the water saved from the leak repair campaign is used to supply some inadequately served and metered areas, the visibility threshold on production will be higher, or may never be met. Some consumers will transform a part of the water saved into apparent losses through unmetered additional consumption. This is called the migratory nature of the loss.

This concept is of paramount importance because if some MAL phenomenon occurs, it completely distorts the former TH, VT and CRA analyses and the final target may never be reached.

Formula

This paper does not present any general formula to calculate indicators like TF and CRA. In fact the formula is different for every type of loss. Many formulas are already proposed for real losses (Lambert et al, 1999) and it is rather easy to establish these formulas for meter ageing for instance (Arregui et al, 2006). Each case requires tailoring to local conditions, and there is no other way other than field and laboratory analysis of samples and pilot areas to assess the value of these indicators. In the case of the MAL, which is a concept and not an indicator, the impact completely depends on the characteristic of the project and the possible impact needs to be estimated through specific detailed surveys.

A Holistic Approach

The previous examples show that TF, VT, CRA and MAL may be assessed for each type of action. But these indicators also need to be considered holistically because there are many interrelations between the various components of a complex programme to control NRW (Rizzo, 2006 and Rizzo & Vermersch, 2007)

A complex action programme is a programme that simultaneously involves various types of action addressing real and apparent losses such as leak detection campaign, pipe renewal, large-scale and selective meter replacement programme, fraud and unauthorised connection detection campaign, pressure control.

Some managers prefer not to address all the problems at the same time, but just to address the priorities! Apparently, there is good sense in this approach but it also leads to frequent failures. The definition of priority actions needs to take into account the MAL concept, which automatically leads to multi-component action programmes.

On the one hand the analytic approach is complex and its effectiveness underestimated by some utilities. Superficial preliminary analyses often lead to the failure. On the other hand contractual relationships are ruled by the time factor and the actual evolution of the NRW indicator.

Therefore, the practitioner, who is responsible for the success or failure of the programme, needs to have an efficient tool to monitor the performance indicators against the plan and to take appropriate decisions when changes or inflexions are necessary during the implementation stage so that the target is eventually reached.

Dynamics of Water Losses: Modelling Dynamics of Water Losses

Principles

Most programmes to control for NRW are complex because they comprise many actions in various fields of activity such as water production, water distribution, water metering and customer management. In such cases, it is very difficult for the Management of the Utility – and for the manager in charge of the NRW project – to have a clear overall view of the effectiveness of each individual action. Which department does not act properly? Which component of the programme does not produce the forecast results? What are the interactions between the various components of the programme? Which action jeopardizes the impact of others? How to correct or to modulate the programme in order to meet the final targets?

To answer these questions, it is recommended to build a model, which is given in the following text. The objective of the model is to simulate the dynamic evolution of the losses when going from the current level of loss to the targeted one.

At the outset, the model needs to be built on the basis of a very detailed audit of the operation of the water utility that includes the following:

- the main causes for water losses have been identified and quantified

- the water balance has been established
- cost-benefit analyses have been carried out

In addition - last but not least - CRA and risk of MAL must be carefully analysed and quantified. This point requires emphasizing as many plans have failed due to the lack of integration of these various concepts.

The pertinence of the model and the actions to reduce NRW depends largely on the correct diagnosis of the NRW situation of the Utility and the values used for the different ratios. Therefore, it is important for these two elements to receive the greatest attention and preferably the support from specialists.

The main objective of the model is to compare - as often as possible – the actual value of the loss (i.e. the one which results from the direct measurement of water input and consumption volumes) and the calculated value of the loss (i.e. the one which results from the algorithms and hypothesis of the model).

Construction of the model

Next figure describes the structure of the model.

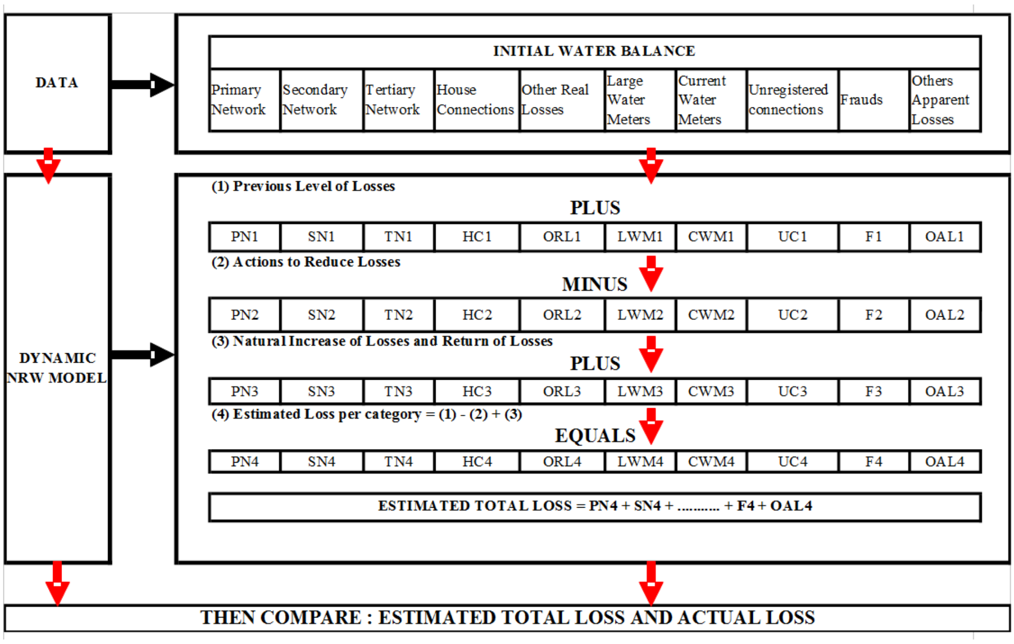

Figure 1: Dynamic NRW Model used to monitor a complex action plan

The model includes various modules. Each module refers to a component of the action plan. For instance: leak detection and repair on primary distribution network (PN), leak detection and repair on secondary network (SN), leak detection and repair on house connections (HC), large-scale meter replacement campaign (CWM), large meter resizing campaign (LWM), unauthorised connection detection campaign (UC), fraud detection campaign (F) , specific actions, etc.

For each module, the calculation of the impact in terms of loss reduction results from one positive and one negative factor such as:

- positive impact: what is due to the action itself: leak repair, meter replacement, etc.
- negative impact: natural deterioration and coefficient of return of anomaly (CRA)

The results obtained from the different modules are added together with the previous losses to produce the “Estimated Total NRW”. The results of the model can also be presented by module (Primary Network, Meter Replacement Policy etc.) or in totality.

TF (Time Factor) and VT (Visibility Threshold) will then appear as outputs of the model.

Operation of the model

For each action the model takes into account the past operational data and, using ratios calculates the future evolution for that specific element. These ratios must be defined according to the operating conditions of each utility.

At the beginning when the model is developed and the data is not available the provision of the NRW volume derived from ratios defining the gains that may be obtained for each action (number of bursts per km of network inspected; average volume lost from a burst repaired; increased billing per new meter installed, etc.) Equally, the losses that reappear are defined by ratios (number bursts to reappear per km; volume lost from a new burst; deterioration of volume billed per old meter, etc…). These basic data should come from the operation report or from preliminary investigations carried out during the audit stage.

Application of the model requires that it is updated monthly or quarterly using the new operational data (number of meters replaced, number of bursts repaired, etc.) from the NRW reduction programme, which improves the accuracy of the predicted NRW value.

Calibration of the model

As with any other model such as distribution network model or aquifer model, the NRW dynamic model requires calibration. This can be done at the audit level but also during the implementation of the programme through the continuous comparison between actual losses and calculated losses.

The main items to be considered to calibrate the model are aspects such as the predicted impact of each action and the values of the coefficients of return of anomaly (CRA) as well as whether both categories have supposedly been defined during the review and assessment stage of the project.

The analysis of the evolution of the NRW value from the Model and the comparison with the actual value allows not only the calibration of the model but also highlights possible anomalies that require correction.

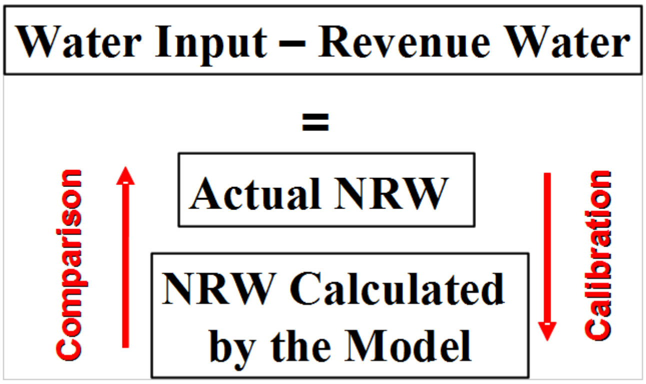

Figure 2: Flowchart calibration of the Dynamic Model

Some practical considerations regarding calibration, as previously discussed, relate to the initial data entered into the model that come from the audit stage, and the establishment of the water balance. But very often there are many constraints due to administrative and financial backgrounds aspects for instance as follows,

The water audit and the implementation of the action plan are generally assigned to different persons.

The budget allocated to the audit is inadequate to carry out very detailed field surveys.

The client does not wish to spend a lot of money for additional studies and insists upon immediate results!

These issues may jeopardize the project. To mitigate these negative tendencies requires implementation of pilot studies at the commencement of the programme, as part of the project itself. This approach will then be the basis for a gradual calibration of the model. .

Case Study

The following graphs refer to the case of Casablanca city in Morocco. A presentation of this case has been done by Lydec, the water and power utility, at the Marrakech IWA Conference in 2004 (Djerrari & Vermersch, 2004).

The action plan included many components with the following examples: systematic leak detection campaign with acoustic correlators on the distribution network; leak detection on mains by using the Sahara method; large-scale meter replacement programme based on selective analysis; various actions to reduce illegal connections and other types of apparent losses.

Figure 3 shows the evolution of the water loss (including both real and apparent losses) which were measured quarterly due to the billing frequency and the evolution of the simulated water loss calculated by the model. At the current stage illustrated, the Model is well calibrated and the modelled values meet the actual values.

Figure 4 relates to a former provisional modelling. It shows that there was a discrepancy between the measured loss and the modelled loss from the 3rd quarter of 2002. Related analyses demonstrated that this discrepancy was due to the use of an incorrect ageing formula of the meters (CRA component for meters). The correct formula was then established, based on laboratory tests and the model was corrected

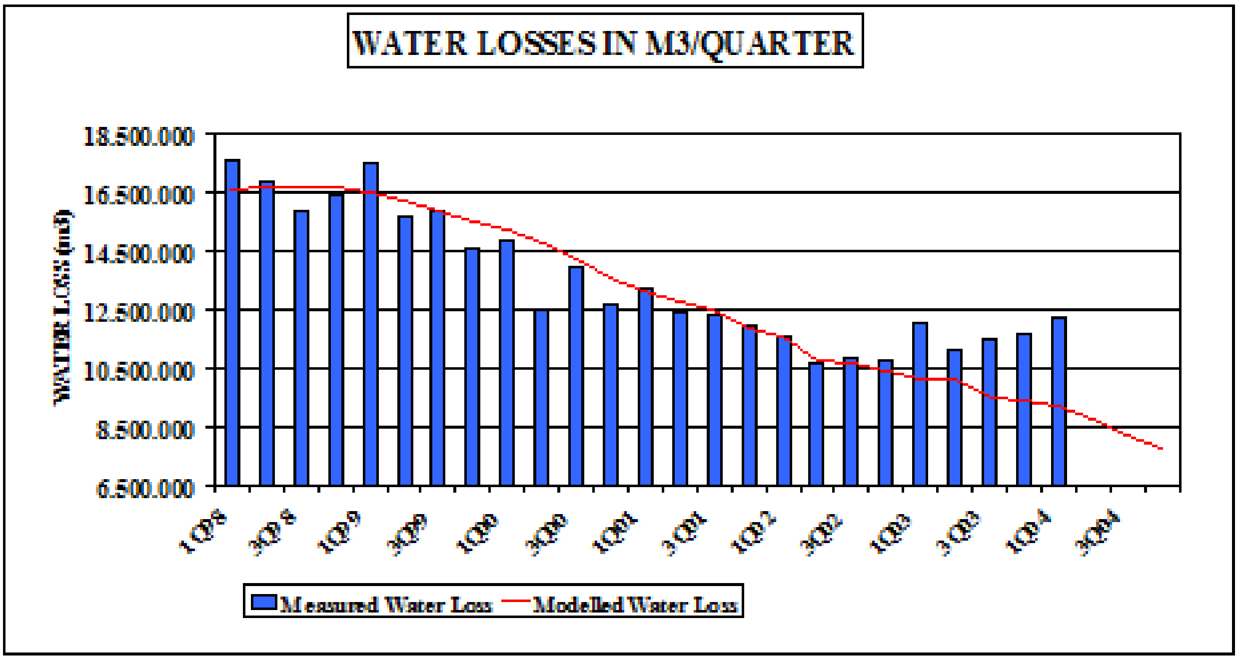

Figure 3: Evolution of actual and modeled water loss in Casablanca from 1998 to 2004: model with correct calibration. Source: Lydec (ref.3)

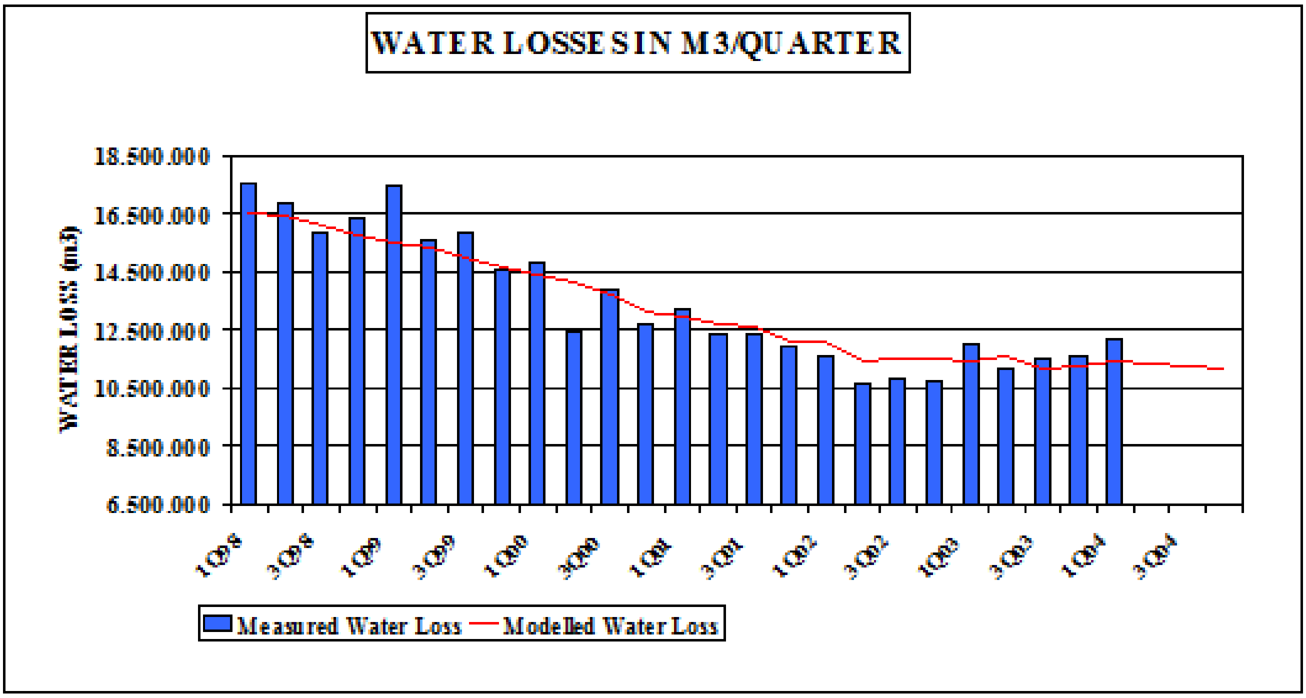

Figure 4: Evolution of actual and modeled water loss in Casablanca from 1998 to 2004: model with wrong calibration. Source Lydec (ref.3)

as shown in Figure 2. A new strategy was implemented from 2004 to 2008 in order to emphasise the loss reduction process again. This example illustrates the gradual calibration of the model. It also shows how the model can assist in detecting discrepancies within a complex action plan.

Conclusion

The NRW Action Planning Model predicts the volume of Non Revenue Water that will be produced by the system taking into account the actions by the operator to reduce the losses and the natural growth of real and apparent losses over time. The model follows and quantifies the reduction of losses obtained through the different actions thereby providing the utility with a clearer vision of the impact of each action. This model is obtained by integrating the new concepts introduced within the "dynamics of water losses": threshold of visibility, rate of return of anomalies and migratory attribute of the losses.

The NRW Model is a tool to visualise the current losses and to predict the evolution of NRW in the short term during the programme implementation. A financial module can also be incorporated into the model with the return on investment of each action. The model may also be considered as a training tool to aid managers to better understand the different parameters and issues behind the optimal reduction of NRW for the lowest possible cost.

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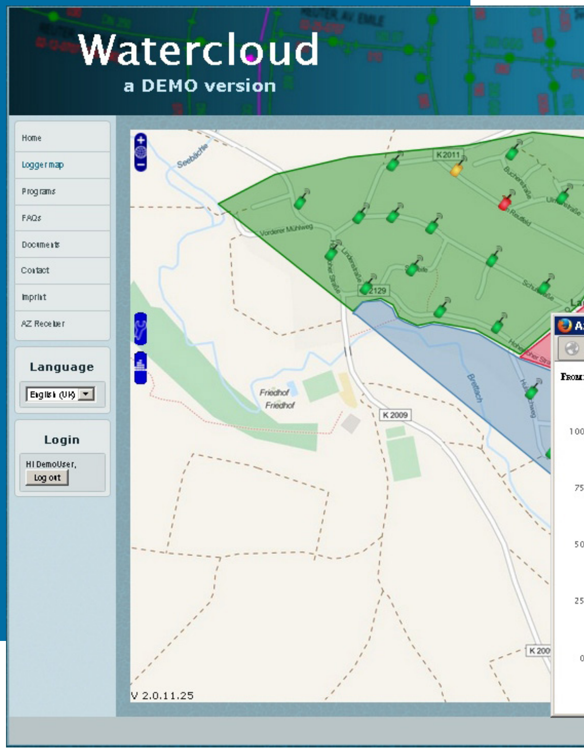
From Hunted to Hunter: How One Water Company Achieved a Tenfold Decrease in Water Leakage From 36% To 3.7%



About Service Des Eaux De La Ville De Luxembourg

Service des eaux de la Ville de Luxembourg is the public authority with responsibility for the provision of water to Luxembourg City. It supplies 105,000 residents over an area of 51Km². Although Luxembourg City is not particularly large, it poses a number of challenges for the water provider. The city layout is complex, as it straddles hills and drops into two gorges. The water infrastructure must cope with elevation changes of over 100 meters. Additionally, there are large changes in population with the number of people present in the city more than doubling during the day.

Much of the water is supplied from local springs which can provide up to 60% of requirements. The remainder must be purchased in from a third party, which is more expensive. This makes the cost of lost water through leakages very apparent. For this reason, VDL has a history of investing in technology to reduce leakages. However, this investment is carefully scrutinised and decisions are made using a data led approach. Results have been impressive with successive rounds of investment yielding a tenfold reduction in water lost through leakage from 36.6% to 3.7%.

Introduction Of Noise Loggers

VDL's first use of noise logging as method of leak detection was in 1996. The previous years had been difficult with leaks on the network increasing to over one a day. Of those 40% were emergency call outs for visible leaks. As Roger Schlechter, who oversees leak detection at VDL commented, "We felt like we were being hunted. Everybody knew the number for the water service". The introduction of flow monitoring and correlation technologies had not achieved the desired results. Collating and analysing the leakage data, Roger noticed that flow monitoring appeared to be making things worse. Pressure changes from opening and closing the system combined with the potential to introduce air were putting stress on the infrastructure. A new approach was clearly needed.

For the next round of investment Roger believed it was important to work alongside a partner who would get to know and understand their problems and work on solutions with them. A relationship was developed with FAST GmbH to introduce Acoustic Zone Monitoring, a noise logging technology.

Noise loggers were directly installed onto pipes, valves or fittings where they recorded noise levels during low-water-usage times. The loggers were programmed to transmit this data during set times during the day. A measurement van with a receiver unit was used to collect and analyze the data as it was driven past during transmission times. By comparing over time minimum noise levels during periods of low usage, (typically taken at night), it is possible to determine the likelihood of a leak. For simplicity, this is given as one of three values: leakage, no leakage, possible leakage. Crews can then be deployed to a specific site to investigate as appropriate.

After an initial 18 noise loggers were deployed two immediate advantages became apparent. Firstly, passive monitoring ensured the infrastructure was not being put under any additional stress and so new leaks were not being introduced. Secondly, the data collected gave a more accurate indication of the leak location. Consequently, repairs were quicker and the manpower required to conduct the leak surveys was less.

With the success of these loggers clearly evident, VDL increased their numbers to 120. These were used on a “lift and shift” basis and moved around the different zones. The loggers were split into three groups of 40 loggers which were left for three days at a time. The recorded measurements were saved which enabled comparisons over time. With the introduction of these additional loggers the time taken to find and repair a leak reduced from a month to a week. The number of leaks was also steadily decreasing. In 1994 prior to the introduction of the loggers 398 leaks had been recorded, in 2006 this had fallen to 84.

Further investment followed with an additional 310 loggers permanently deployed on known weak areas of the infrastructure. The benefit of noise logging for leak detection was clear and an obvious next step was to deploy the technology across the entire infrastructure. This would ensure leaks would be found across the whole network and a program of planned repairs could be put in place. In addition to the cost savings from reduced water leakage, it would allow planned repairs with advance warnings of road closures and supply disruption. However, the challenge was to achieve this without requiring additional manpower for data collection.

Watercloud: Enabling The Wider Deployment Of Noise Loggers

Watercloud uses peer to peer transceiver stations and GSM master stations to automatically send monitoring data to a cloud database which can be accessed at any location by the client. The number of noise loggers which can be used on the network is no longer constrained by the manpower required to collect the data.

Each transceiver station can receive data from up to 10 loggers. The master stations can then collect the data from up to 50 transceivers or loggers and upload it by GSM into the central database. This data is overlaid onto a graphical depiction of the network giving a simple overview of the network status at any time. The data for each logger is displayed in a clear traffic light format: red indicates a leak; yellow indicates concern and green requires no action.

Currently, VDL have deployed 1400 loggers. The goal is to cover the complete infrastructure using 2000 loggers, 750 transceiver stations and 40 GSM master stations. Finally, as Roger puts it, “We are no longer the hunted but the hunter. Working with FAST GmbH we have developed a solution that puts us in control of our leak detection process. With the reduction in non-revenue water we see the system paying for itself.” Instead of reacting to calls or emergencies, the crew can check the network status either in the control room or out in the field. It is possible to plan and prioritise responses. With less time being used to collect data, the crew can focus their time on repairs. Additionally, with the correlation capabilities of the loggers, survey sites are smaller and the time to repair is shortened.

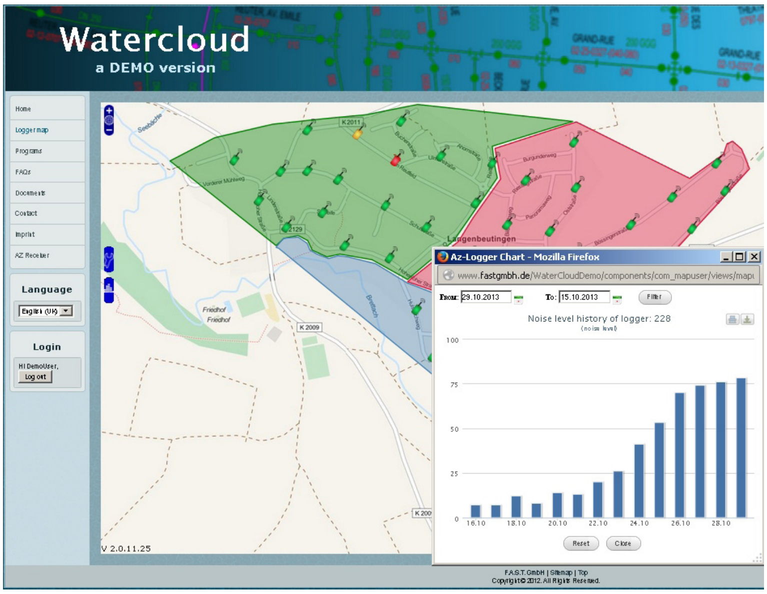
Benefits

	2010	2011	2012	2013
Total water consumption m^3	7,422,626	7,264,333	7,246,556	7,081,452
Customer consumption m^3	6,933,860	6,959,388	7,055,447	6,821,503
Non-revenue water m^3	488,766	304,945	191,109	259,949
Non-revenue water %	6.6	4.2	2.6	3.7

Table 1: Revenue and non-revenue water 2010 to 2013

Reduction In Non-Revenue Water

Prior to the introduction of noise loggers non-revenue water was 36% of total water consumption. Since the investment in Acoustic Zone monitoring the trend has been towards a steady reduction in non-revenue water



and was 3.7% in 2013. Continued savings have been made in recent years with a reduction in volume from 488,766m³ in 2010 to 259,949m³ in 2013. As leaks are being found and repaired quicker the volume of non-revenue water has been falling faster the number of leaks. For VDL this has represented considerable savings as less water needs to be purchased from 3rd parties.

	1994	1998	2004	2009	2013
No. of loggers installed	0	18	130	440	1,115
Total no. of leaks	398	192	114	74	52
Leak type %					
Emergency	41	33	30	12	19
Customer call	56	48	27	51	29
Planned repair	3	18	43	36	52

Table 2: Number and type of leaks since the introduction of noise loggers

Number of leaks reduced

The introduction and increased installed base of noise loggers has resulted in a reduction of leaks from 398 to 52. With the number of the repairs reduced and the locations more accurately indicated less staff is required for repair crews.

Fewer emergency calls

Prior to the introduction of noise loggers on 97% of all repairs were in response to emergency or customer call outs. In 2013 just over half of all repairs were planned allowing VDL greater control over the work. This resulted in less disruption for the residents of Luxembourg as the impact of inconvenient road closures or supply restrictions could be minimised.

Improved leak location information

As the noise loggers are capable of correlation it is possible to localise leaks. Smaller survey areas improve the time it takes to pinpoint and repair the leak.

Reduced staff requirements

With fewer leaks and better information on their location it has been possible to reduce the number of repair staff from 15 to 4.

About the technology

AZ BIDI Loggers

Bi-directional pro-gramming	Allows user to set own parameters for: Duration of measurement window Timing of measurement window Frequency of measurements Data transfer window Data transfer frequency Amplification factor for noise signal Transmission power Date and time
Data collection	Statistical minimum for previous measurement window Statistical level for previous 14 measurement windows Frequency spectrum Logger no. Logger position
Correlation	User can conduct correlation using two noise loggers
Transmitting power	10mW
Frequency	433Mhz
Amplification	200,000 fold
Port	Bi-directional radio
Protective classification	IP 68
Temperature Range	-15°C to +55°C

Transceiver station

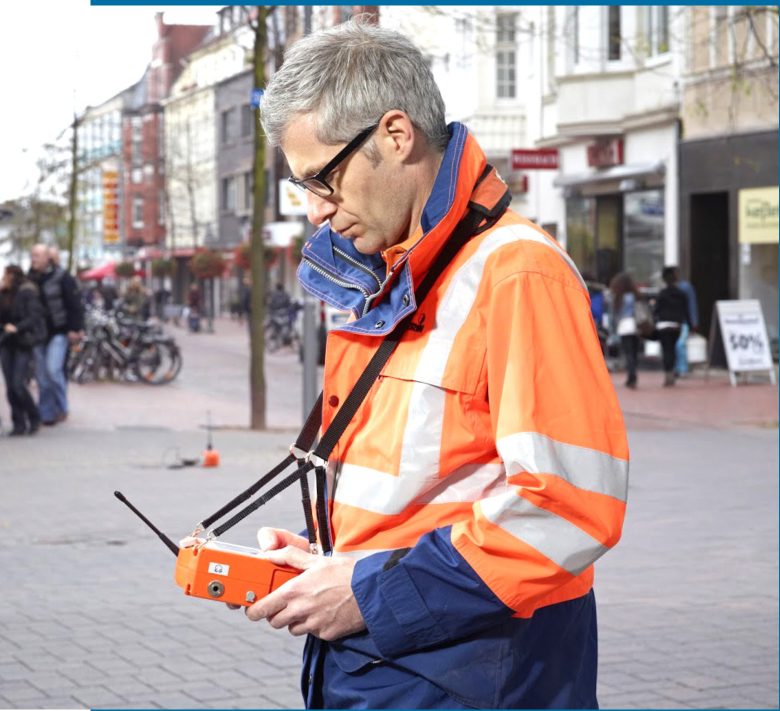
Transmitting power	10mW
Frequency	433MHz
Radio distance,(Repeater to Repeater – above surface)	Max. 2500m dependent on local conditions
Port	Bi-directional radio
Protective classification	IP 67
Temperature Range	-15°C to +55°C

GSM master stations

Transmitting power	10mW
Frequency	433MHz
Transmitting Data	UMTS (SIM-Card, mobile network)
Port	Bi-directional radio
Protective classification	IP 67
Temperature Range	-15°C to +55°C

If you want to know more about the noise loggers and its advantages, please visit F.A.S.T. GmbH at Wasserberlin at Hall 3.2b Stand 408. A demo version of the watercloud is also available at

http://www.water-cloud.de



Combining Location Techniques for Water Leak Detection

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The importance of drinking water as a vital commodity has been growing steadily for years, and both water suppliers and their customers are increasingly aware of the need to conserve this not inexhaustible resource. Just as consumers should continually ask themselves how they can do more to reduce water usage on a day-to-day basis, water supply companies too are constantly seeking out possible ways of saving water. Their focus is primarily on the water distribution network, which for various reasons is highly susceptible to leaks: by the time a leak is repaired, vast amounts of water may have been lost. For that reason water companies are keen to minimise the number of leaks and to ensure that once a leak is detected, it is repaired without delay.

In its simplest form, the process of repairing leaks has changed little over the decades: Passersby or householders affected by flooding report a visible water leak to the water company; the water company pinpoints the damage and then repairs it (reactive process). Unfortunately, however, a leaking water pipe does not always result in visible evidence or a surface water leak. In addition, the still widely held assumption that leaks always come to the surface – it is often simply a matter of time – is actually true (with some exceptions), since depending on the soil type and the structure of the distribution network, much of the escaping water may well appear at the surface at some point. However, this disregards the fact that the length of time for which the leak has been in existence has a major impact on the total amount of water lost. When water appears at the surface, the length of time for which it has been leaking is not necessarily obvious. Reactive, visual methods can therefore only ever form one strand of the strategy for leak detection in the water pipe network, and they are never suitable as the sole method of permanently reducing water losses.

A fundamentally different approach from the simple response to visible pipe fractures is now much more widespread. Most water suppliers have systemised the search for water losses and are using proactive methods for the early detection of losses in the pipe network. In Germany, DVGW (Technical and Scientific Association for Gas and Water) Code of Practice W 392 underpins all measures aimed at reducing water losses. Chapter 6 recommends introducing a strategy for monitoring, reducing and keeping down water losses and defines three key steps: measuring leak tightness, determining water losses by measuring flow, and using leak detection methods.

Leak tightness measurement and the quantitative determination of water losses can be combined into a single step. The information obtained can be sufficient to identify even minor leaks and small leakage volumes. In order for losses to be detected as accurately and reliably as possible, it is essential to divide the pipe network into monitoring zones. These zones must be able to be isolated completely from the rest of the network by means of slide gates and be supplied by a defined infeed of a measurable volume. These pipe network zones could conceivably be fitted with a permanent meter. The process of determining all inflows and outflows in the zone is defined by Code of Practice W 392 as continuous flow measurement.

The measured values should be transmitted and evaluated promptly. Sections of the pipe network measuring from around 4 to 30 km in length are suitable as stationary zones. Measurements should be carried out overnight for a period of 1 to 2 hours. The overnight minimum consumption determined over the measurement period always includes a certain residual consumption volume, which must be used as a reference value in defined stationary zones. Overnight minimum consumption values do not change significantly provided that the operating conditions of the network section remain the same. So in normal conditions roughly the same minimum values are measured every night. If a leak occurs in the measuring area, the overnight values will rise appreciably and will remain high. Since continuous flow measurement allows the actual leakage amount to be measured directly, changes can be responded to immediately. The necessary actions to contain the problem, such as closing slide gates to reduce the size of the measuring area, can be taken without delay. This type of continuous flow measurement is a costly exercise for the installation and the operation. It also requires a detailed knowledge of the pipe network hydraulics in order for suitable measuring points to be selected. A thorough and verified pipe network survey is usually essential.

Instantaneous flow measurement represents an alternative to continuous flow measurement with fixed measuring points. Here the network is inspected at regular intervals, depending on the water losses. The pipe network zones should generally be rather smaller than those used for continuous measurements. Sections of between 1 and 10 km are recommended, so that the influence on the measurements of the anticipated residual consumption volume and any continuous customers such as industrial firms is not too great. The designated section of the pipe network is shut off from the rest of the network for the inspection. The isolated network zone is supplied by means of a bridging hose via two hydrants, one inside and one outside the measuring area. A portable metering device (see Figure 1) connected to this bridging hose transmits pressure and flow measurements to a PC. The minimum flow can be calculated from these measurements. The residual consumption volume has to be estimated as accurately as possible. If only a few consumers are connected to the pipe network zone being measured or if the diversity factor of water withdrawal is very low, in practice a zero-consumption measurement is frequently also recorded, where no water flows into the area in question.

If the result of the leak tightness inspection in a section of the pipe network suggests the presence of leaks, further steps are necessary to narrow down the detected leak and ultimately to pinpoint it as accurately as possible. One proven option for prelocating the leak site in a given pipe network section is the temporary use of noise loggers. They are installed in a hydrant in the network section for one or two nights, and the quietest moments during the measurement time are recorded. If the logger is close to a leak, the volume at even the quietest moment during the night will be significantly greater than zero. By systematically moving the logger within the area in question, the hydrants at which loud noise can be measured can be identified quickly and reliably. Just 20 or so loggers are sufficient to narrow down the possible leak sites within the area to a few hundred metres after a few nights.

If, however, the leakage amount in the inspection area is very high and there is an imminent risk of the leaking water causing damage to buildings or roads or other structures due to subterranean erosion, faster methods of prelocating the site of the damage are required. This is where portable electroacoustic methods come into their own.

Here a leak detector systematically surveys the network with a test rod. He or she opens all manhole covers and assesses the noise at all fittings, including slide gates, valve saddle clamps and hydrants (see Figure 2). If audible leak noise can be heard at the fittings, these sites are marked. This concludes the prelocation process. As the effectiveness of all electroacoustic methods is very much dependent on ambient noise and on the experience of the operator, these inspections often take place at night. This is the quietest time, and traffic noise and water consumption are low. The biggest advantage of this prelocation technique is that it is suitable for all network structures. The noise that is heard is influenced by the nature of the pipe, its material and diameter, so it is highly individual. One leak rarely sounds exactly the same as another. But in every case a leak has a distinctive noise that cannot be mistaken for normal flow noises in the water pipe network.

To enable a site to be excavated, however, the exact location of the leak has to be pinpointed, and that cannot be done simply by inspecting the fittings. One technique that has been used successfully for many years is the correlation method. This pinpointing method involves installing microphones at two measurement locations (fittings in the pipe network). The microphone signals are transmitted wirelessly to a receiver, where they are analysed mathematically (see Figure 3). The correlator then shows the position of the leak as the distance from one of the two measuring points. Correlation methods do not require an experienced operator, and the accuracy

of the measurement is determined by objective factors: the length of pipe between the two fittings used as measuring points and the material and diameter of the correlation section.

In plastic pipes in particular, pinpointing a leak is often very difficult as the noise does not travel as far as it does in metal pipes. So it is often hard to correlate a leak in non-metallic pipe networks, especially if the distance between adjacent fittings is very long. In such a case the leak noise may not even reach the contact points. Successful correlation is still possible, however, using a different type of microphone: the hydrophone. This is installed directly in the water column. As noise propagation in water is much more effective than structure-borne noise in a pipe, successful correlation using hydrophones is possible even over long measuring sections. In practice, the accuracy of leak detection depends on the quality of the available pipe data. Following a successful correlation it has proved beneficial to confirm the result and the location of the leak site using an electroacoustic method.

This is done by connecting a receiver to a ground microphone, which should be suitable for the surface at the site in question. The inspection is then carried out directly over the pipe at the correlated position. The noise transmitted through the ground to the surface is analysed by the leak detector. A noise is generally loudest directly over the leak. If ambient noise such as rain, wind or traffic noise at the leak site makes it harder to pinpoint the leak or if the leak noise is not clearly audible, filter settings on the receiver can help to isolate the noise.

Once all the pinpointing steps have been completed and the result has been confirmed by acoustic methods, the position of the leak is marked on the ground surface and a report is produced. Work to repair the damage can then begin.

All of the aforementioned methods for prelocating and pinpointing a water leak – use of noise loggers, prelocation with a test rod, pinpointing with a correlator and electroacoustic confirmation of the leak with a ground microphone – depend upon a noise being generated by the water escaping from the site of the damage.

However, the leakage amount determined during inspection of the pipe network section may not necessarily come from a leak that is large enough to create an audible noise. Instead it may be made up of several small leaks, which on their own do not generate a measurable or audible noise.

along the pipe in the form of bubbles close to the top of the pipe, unless severe turbulence in the pipe causes the gas and water to mix. There are, however, a number of disadvantages associated with the presence of bubbles of an undefined size in the pipe. One is that sensitive fittings in the network, such as automatic bleeders in a transport pipe, continuously release the gas, causing a leak to be indicated at the ground surface. Another is that bubbles are released with the water when the consumer turns on a tap. This can cause damage to domestic appliances in some cases. However, the biggest disadvantage of the incomplete dissolution of the gas in water and the resulting bubbles close to the top of the pipe is undoubtedly the fact that leaks at the bottom of the pipe are not detected because the leaking water contains no hydrogen.

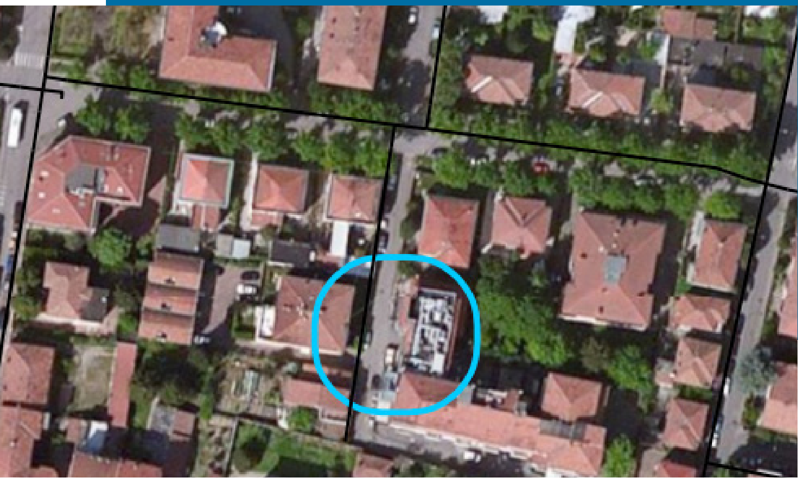
The leak detection techniques mentioned so far can also encounter difficulties for other reasons. The absence of contact points (slide gates, hydrants, etc.), or too great a distance between them, makes it more difficult to use acoustic methods. A case that is typically encountered in practice is the inspection of long transport pipes. Instantaneous flow measurement is an effective way of checking for leaks in this type of section, but using acoustic methods to prelocate and pinpoint the damage is often unsuccessful. An alternative approach is the gas inspection method.

Here a volatile, odourless, tasteless and non-combustible gas is introduced into the pipe to be inspected. Hydrogen mixtures with nitrogen have proved effective for this purpose. Helium is also used, though only very rarely in the drinking water supply sector. Unlike helium, hydrogen in nitrogen has the advantage that hydrogen is readily detected at the ground surface even in trace amounts of a few ppm. These mixtures are known as tracer gas or forming gas. They are technical gases which are easily available and mostly contain 5% hydrogen in nitrogen. Mixtures containing 10% hydrogen are also used, though less commonly.

There are various ways of using tracer gas to pinpoint leaks in water pipes. Firstly the gas can be added to the pipe during operation. As both hydrogen and nitrogen have very restricted solubility in water, the gas flows

So in practice the pipes in question have to be taken out of service and drained. The gas can then expand to fill the entire volume of the pipe. This ensures that the gas can escape from all possible leaks over the full extent of the pipe in the ground. The hydrogen, which is very light, then diffuses quickly to the surface, where it can be detected with a highly sensitive gas leak detector (see Figure 4).

DVGW Code of Practice W 392 recommends that the frequency of leak tightness inspections should be based on the level of water losses in the pipe network. It recommends annual inspections for high losses, three-yearly inspections for moderate losses and at least six-yearly inspections for low water losses. The key elements of any strategy are the division of the pipe network into monitoring zones for inspection, the quantitative determination of the leakage amount in the pipe network, and the choice and combination of techniques to allow a leak to be located with sufficient accuracy for confident excavation. The exact combination of the methods used depends as much on local conditions as on the available measuring technology. No one method or technique used in isolation will deliver success, however. The only sure way of achieving a long-term reduction of water losses in pipe networks is by combining location techniques for water leak detection.



Leaks Can Be Detected from Space

Today, two main methods are in use for managing non-revenue water around the world: acoustic leak detection surveying & smart water management systems.

Most water managers use these methods because they are the best solutions available: tried and tested, result-driven technologies. However, these approaches are also notoriously time consuming and expensive. Identifying leaks after a prohibitively high investment in infrastructure and equipment normally will not be covered by the number of leaks that are identified. Vast quantities of non-revenue water is wasted each year, which has prompted some technology providers to suggest that water leakage in urban environments has become an epidemic.

Meet Utilis. An innovative water management company which has developed a revolutionary new way of detecting non-revenue water (NRW) leaks by analyzing spectral images from satellites. This innovative technology has been adapted from the search for water on other planets, underscoring its high reliability and outstanding capability for applications on earth. Utilis offers a fresh approach which provides a non-invasive method to the problem of urban water leakage. When compared with any other current NRW solutions available, satellite based leak detection will identify water leaks in less time. Therefore, Utilis is the most efficient way to detect leaks in urban water networks.

The process includes four stages:

Spectral satellite image acquisition

Radiometric corrections

Algorithmic analysis

Web-based app and intuitive User Interface (UI) delivery

The result of our process is much lower operational costs for reducing non-revenue water. Furthermore, it allows for water managers to spend their budgets more efficiently as they will be able being able to look at an urban grid in its entirety, from up in space. Most importantly, Utilis does not require any prior investment or adaptation of existing distribution systems. As such, it is an extremely cost effective solution. Utilis provides an opportunity to move beyond the outdated approach of plugging emergent leaks by offering a proactive solution to the reduction and management of NRW.

The Utilis approach to finding leaks is similar to a doctor basing diagnosis on imagery techniques, rather than just addressing a patient's symptoms. Current leak detection antiquated methods rely on the "symptoms" of leaks, such as noise, a pressure drop or flow increase. The Utilis solution performs periodic scans of the network so any leak is detected as soon as it appears, thus reducing the "awareness time" of leaks to the period between scans, effectively reducing physical NRW and helping prevent bursts.

Key features:

1. Utilis provides an efficient and accurate survey of a very large area, the perimeter of which can cover an entire water network in a single scan. Instead of taking years to survey an entire system, Utilis provides periodic updates on the whole system over time.
2. A considerable number of leaks are identified for on – ground assessment. With Utilis' findings, local acoustic teams identify and verify anywhere from 5-15 leaks a day. The results over time are consistent and lead to significant reductions of non-revenue water.
3. The minimal detectable leak size is 0.5 liter per minute.
4. Integration with GIS data: the system output is cross-referenced with data covering the location such as water mains in the distribution system.
5. No installation costs: Utilis remote sensing does NOT require installation or changes to existing infrastructure. Input is received from sensors and is combined with data that is either publicly available, or managed by local authorities. Regardless, the technology is operated remotely.

6. Intuitive output: unlike other remote sensing technologies which require external consultation, the Utilis service is accessible and ready for use by untrained personnel.
7. Evaluate technology by its effectiveness in reducing non-revenue water, economically and logistically.
8. Utilis offers periodically reports on a monthly / quarterly basis which enables utilities and municipals to track their leaks in the system.

The Utilis solution is novel, patented and unique. It enables a utility company, a municipality, a local authority or even a state or a region to monitor an entire water distribution system in an accurate manner, without and changes or installations in existing infrastructure.

Utilis has won an Innovation Award from Piers Clark, Chairman of Isle Utilities, during Innovative Technologies Competition at Singapore International Water Week 2016.

Brief Case Study:

HERA (Holding Energia Risorse Ambiente, Energy Resource Environment Holdings) is a multi-utility company based in Bologna, Italy.

HERA Group is one of the largest Italian operators in integrated water service management. With a total network of over 53 thousand km and approximately 1,400 production plants (such as wells), treatment plants and purification plants, 3.6 million citizens receive catchment, treatment, distribution, sewage and purification services.

Before engaging in a service contract with Utilis, HERA Group conducted a trial in the city of Ferrara. Utilis acquired and processed satellite images, then subsequently delivered the findings. HERA Group's leak detection teams verified the findings on ground.

The following results obtained:

Leakeges (liter/minute)	Leak found	Not found	Not investigated	Total	%
Red (>30 l/m)	6		1	7	100%
Orange (>5 l/m)	10	4		14	71%
Light blue (>1 l/m)	7	9	1	17	44%
Blue (>0. l/m)	7	15	2	24	32%
Total	30	28	4	62	52%

"Innovation is one of the main values for HERA Group, that it is constantly looking to become more efficient and to deliver the best service possible to our customers. With this goal in mind we run a pilot with Utilis in the city of Ferrara, the results were good and we've decided to engage in a multi annual service contract with Utilis for leak detection using satellite based technology."

Emido Castelli
Head of Water Networks, HERA Group

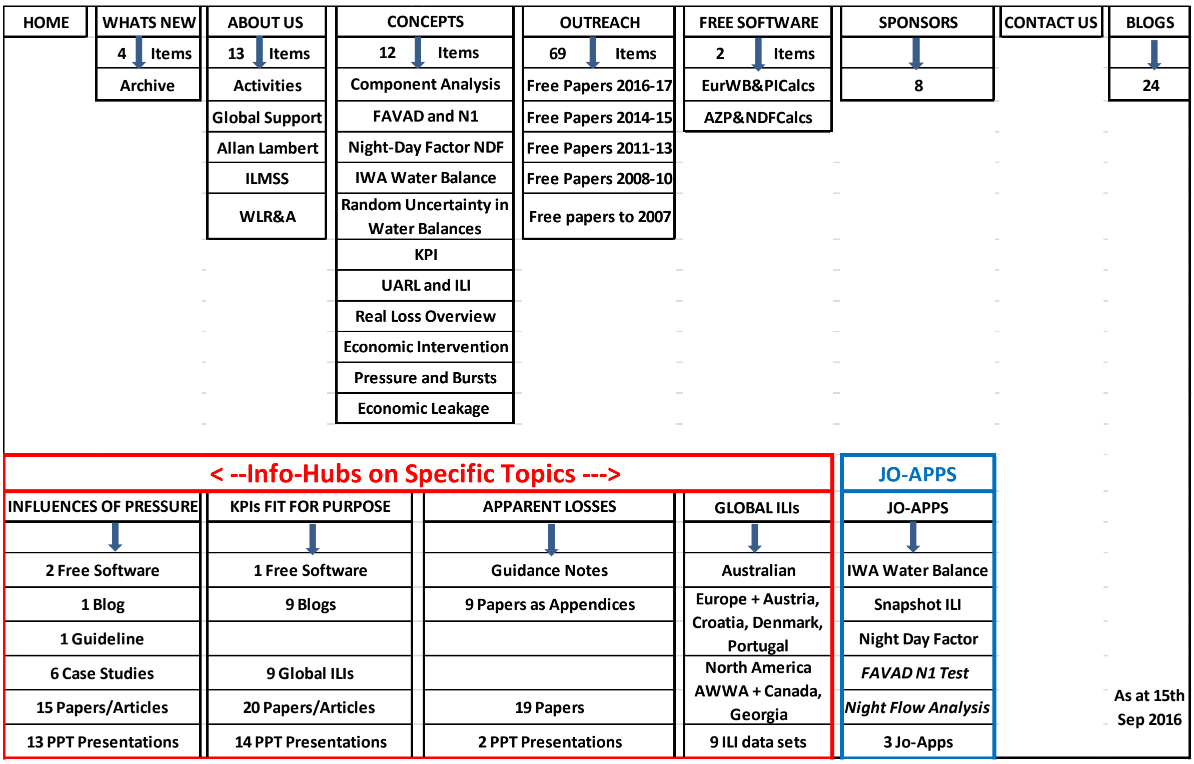
The Leakssuite Website: a Free to all Resource on NRW Concepts, Assessment and Management

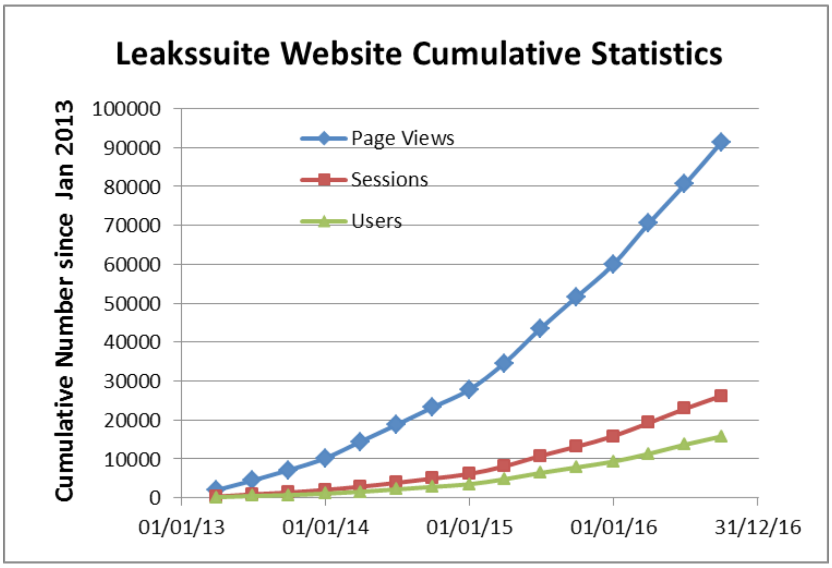
Allan Lambert

By early 2013, Allan Lambert and some of his international Water Loss management colleagues had become concerned that increasingly restrictive copyright requirements for published material on NRW management were limiting web-based opportunities for the rapid spread of new information. Many practitioners unable to attend Conferences or afford copies of published papers and books cannot access such information, even if they are aware of their existence.

To meet this need, in April 2015 Allan and Barry Griffiths (webmaster) converted ILMSS's LEAKSSuite website to a non-commercial web-based resource for **easily accessible free-to-all information** on effective practical proven concepts for assessment and management of NRW components in public water distribution systems. The page rank and authority of the site are dependent upon substantial verified industry leading content and references. The navigation chart below, from the http://www.leakssuite.com/welcome/ Home webpage, shows the main sections and sub-sections of the website.

An average of 4 new items per month, on diverse topics, are added to the Whats New webpage http://www.leakssuite.com/whats-new/ . Users who wish to receive auto-notification of these updates & additions can join LEAKSSuite's social media feeds on LinkedIn





and Twitter, from either the Home Page or Whats New Webpage. The About Us webpage http://www.leakssuite.com/about-us/ is self –explanatory.

The Concepts Section http://www.leakssuite.com/concepts/ is very popular, with some 14,000 page views to date. It summarises key concepts in the IWA methodology with multiple web links to additional material. However, the Outreach Section http://www.leakssuite.com/outreach/ is the most popular overall, with some 16,700 page views to date. It currently contains 69 papers, presentations and articles, dating from 1994 onwards

The Free Software Section http://www.leakssuite.com/free-software/ now contains just 2 programs, AZP&NDFCalcs, and EurWB&PICalcs in English, Croatian and Greek versions. Both are regularly requested through links on the webpage,and individually licensed. Commercial software is no longer available through the website.

The Sponsors webpage http://www.leakssuite.com/sponsors/ lists current sponsors from South Africa, Belgium, Italy, Croatia, Greece, USA, Mexico and Brazil. Their generosity and philanthropy enables the LEAKSSuite website and philosophy to continue and develop.

The Blog webpage http://www.leakssuite.com/blog/ currently contains 24 blogs on diverse topics, notably KPIs (and problems with %s by volume), Pressure Management, and International Conferences/ Publications and Reports. Statistics for the website are also published quarterly as blogs. Since January 2013, over 17,000 new users from 176 countries have accessed the website, with a 40%:60% ratio of New to Returning visitors.

Substantial Info-Hubs have also been created for http://www.leakssuite.com/influences-of-pressure/ and http://www.leakssuite.com/kpis-fit-for-purpose/ . The Apparent Losses Info-hub http://www.leakssuite.com/apparent-losses/ is a more recent addition, and now includes Guidance Notes at http://www.leakssuite.com/guidance-notes-app-loss/ with 9 separate Appendices, and 20 papers and presentations in http://www.leakssuite.com/apparent-losses/outreach-app-loss/

The http://www.leakssuite.com/global-ilis/ Info Hub has an ever-increasing international set of validated ILIs, for technical comparisons of leakage management performance in Australia, New Zealand; Austria, Croatia, Denmark , Portugal and Europe; North America, Canada and Georgia.

http://www.leakssuite.com/jo-apps/ provides links to 3 free Apps for mobile platform access for calculations of IWA Water Balance and KPIs, Snapshot ILI and Night-Day Factor.

The content and philosophy of the LEAKSSuite website was recognised in 2016 when a poll of Water and WasteWater International readers, sponsored by Evoqua Water Technologies, voted Allan Lambert 8th out of 25 'best of the best' global thought leaders in international water/wastewater industries http://www.leakssuite.com/wwis-top-25-leaders/ . As Allan says, 'we must be fulfilling a previously unsatisfied need, as is 'Water Loss Detectives; which we are happy to support'.

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