WATER SERVICES
ASSOCIATION OF AUSTRALIA

REDUCING LEAKAGE IN AUSTRALIA

ABOUT WSAA

The Water Services Association of Australia (WSAA) is the peak body that supports the Australian urban water industry. Our members provide water and sewerage services to over 20 million customers in Australia and New Zealand and many of Australia's largest industrial and commercial enterprises.

WSAA facilitates collaboration, knowledge sharing, networking and cooperation within the urban water industry. The collegiate approach of its members has led to industry-wide advances to national water issues.

WSAA can demonstrate success in standardising industry performance monitoring and benchmarking, as well as many research outcomes of national significance. The Executive of the Association retains strong links with policy makers and legislative bodies and their influencers, to monitor emerging issues of importance. WSAA is regularly consulted and its advice sought by decision makers when developing strategic directions for the water industry.

ACKNOWLEDGEMENTS

This Report has been produced by WSAA. WSAA would also like to acknowledge its members who have provided input to this report:

Mackay Regional Council
Sydney Water
SA Water
Unitywater
South East Water
Water Corporation

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Mackay Regional Council, SA Water, South East Water, Sydney Water and Water Corporation.

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OVERVIEW

In an era where permanent water saving rules are the norm, campaigns remind us that every drop counts, and with many areas of the country that rely on desalination and water reuse, leakage reduction has the potential to conserve our precious resource.

According to the Bureau of Meteorology, non-revenue water losses average over the country at around 10 per cent of the utilities' system input. Given this figure is among the lowest levels in the world, reducing it further may not always be cost effective. However, with a drive towards customer centricity, water utilities are more aware of improving customer experience through addressing the impacts of leakage (for example delayed travel time for commuters from maintenance for water main breaks).

Customer research undertaken by Victorian water utilities in their pricing determinations of 2017 show that getting the basics right through efficiently managing the network of pipes is important to customers. Customers also want utilities to do their best to minimise leaks and breaks and reduce water waste, especially when they are asked to save water during drought conditions.

WHERE DOES *LEAKAGE* FIT IN?

In the first instance, we need to understand the concept of non-revenue water. Non-revenue water is water that has been supplied and then lost from the network infrastructure, through either unbilled (authorised) consumption, apparent losses (unauthorised consumption - water theft - and meter inaccuracies) and real losses (leakage). This is depicted in Figure 1. There are benefits in reducing all levels of non-revenue water, with each requiring a different approach.

In simple terms, leakage is the component of water that does not make it to the customer and is "lost" somewhere in the systems. The type of leakage can be categorised into one of three categories:

- Reported bursts - visible at the surface and reported by the public or utility staff,
- Unreported bursts - not visible at the surface, and usually picked up through investigation or leak detection surveys, and
- Background leakage - small leaks that cannot be detected by, which over time may gradually worsen until they can be detected.

Various factors contribute to leakage, and while they may all contribute to some level, there will often be an overriding factor. These factors include:

- Extreme weather conditions - hot and dry weather causes the ground to contract, while cold (freezing) and wet weather causes ground swelling; these changes in weather conditions apply different forces and can cause the pipes to move, resulting in bursts, especially in reactive soils.
- Age of pipes - typically, as infrastructure ages it tends to leak more.
- Mains pressure - failure rate increases with increased mains pressure.
- Material of construction - there are a variety of materials used in water mains, from cast iron, asbestos cement to polymers. Standard requirements are changing, newer pipes have lower tolerances than older pipes and some materials are just more prone to bursting than others.
- Soil conditions - some soils are more corrosive to the pipe material, leading to degradation.

Despite the obvious loss of water and revenue, the impact of leak is far more insidious and includes:

- Increased water consumption of systems that are at capacity and/or are already stressed,
- Increased treatment costs through larger treatment system requirements (capital expenditure), chemical requirements (operational expenditure) etc,
- Increased power requirements through larger capacity treatment and pumping assets to support the higher demand, and
- Increased bills to the customer.

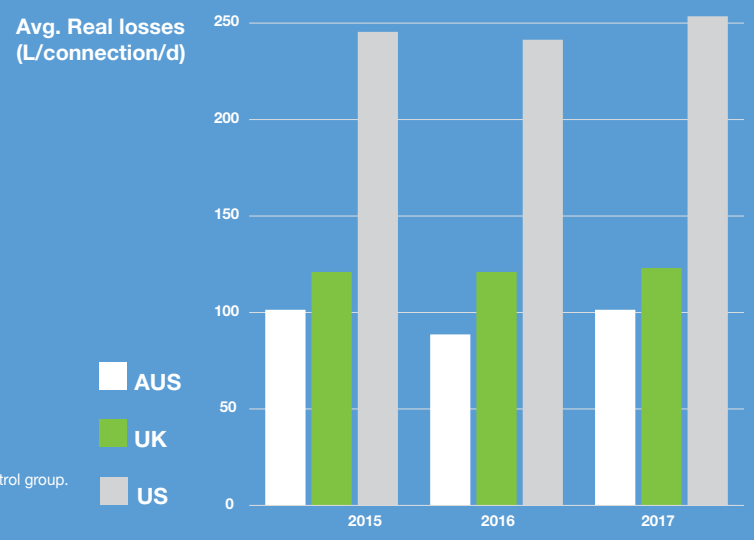
Customers want utilities to do their best to minimise leaks and breaks and reduce water waste.

SYSTEM INPUT VOLUME	AUTHORISED CONSUMPTION	BILLED AUTHORISED CONSUMPTION	BILLED METERED CONSUMPTION	REVENUE WATER
			BILLED UNMETERED CONSUMPTION	
		UNBILLED AUTHORISED CONSUMPTION	BILLED METERED CONSUMPTION	NON REVENUE WATER
			UNBILLED UNMETERED CONSUMPTION	
	WATER LOSSES	APPARENT LOSSES	UNAUTHORISED CONSUMPTION	
			CUSTOMER METER INACCURACIES	
		REAL LOSSES	LEAKAGE ON TRANSMISSION & DISTRIBUTION MAINS	
			LEAKAGE & OVERFLOWS AT RESERVOIRS	
			LEAKAGE ON SERVICE CONNECTIONS UP TO METERING POINT	

Figure 1. The IWA water balance and the components of consumption

THE STATISTICS

Every year since 2006 the Bureau of Meteorology has collated data from water utilities and councils responsible for urban water management in Australia to form the National Performance Report (NPR). The NPR benchmarks the pricing and service quality of each utility, covering indicators including water resource supply and usage, financial operations, bills and pricing, assets, water quality compliance and customer performance.



UK data from Discover Water
US data from AWWA Water Loss Control group.
All available online.

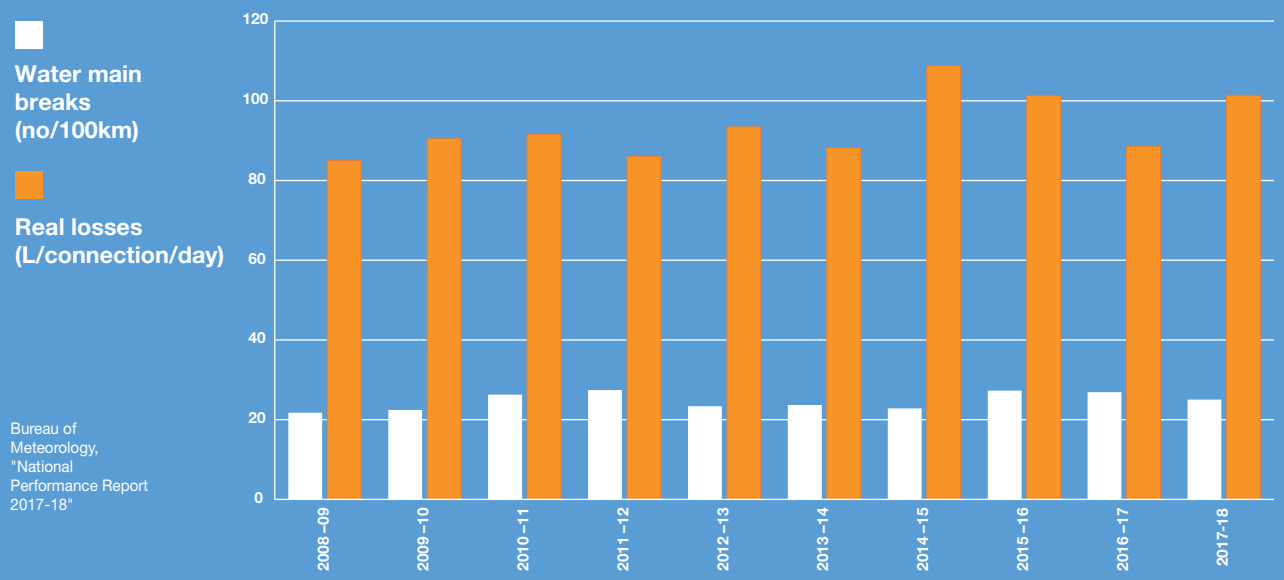
Global cost of non-revenue water is estimated at US$14 billion per year.

World Bank Paper No 8, 2006

4%
of global electricity consumptions was by the water industry in 2014.

60%
of this was for extraction and distribution.

World Energy Outlook 2016, "Water Energy Nexus"



Bureau of Meteorology, "National Performance Report 2017-18"

If all countries reduce leakage to less than 6%, the energy savings equate to 130 TWh, the entire energy needs of Poland.

World Energy Outlook 2016, "Water Energy Nexus"

6% Denmark
6% Japan
10% Australia
12% USA
24% European Union
48% India

UNDERSTANDING LEAKAGE CONTROL

The International Water Association Water Loss Taskforce has developed Four Pillars of Leakage Control. The Pillars represent best practice for reducing real losses and promote four different strategies that can be used to minimise leakage. These are shown in Figure 2 and include:

- Pressure management – the rate of leakage and new burst increases with pressure (including cyclic pressures).
- Active leakage control – requires monitoring of flows in a metered area to identify leaks and repair before they become a greater issue.
- Pipeline and assets management – includes material selection, installation, maintenance, rehabilitation and replacement, and commonly associated with renewals.
- Speed and quality of repairs – repairs should be done quickly and to a suitable standard.

The economic level or real losses, also referred to as the economic level of leakage (ELL) is the level at which it is no longer economical to make further investment to reduce leakage further. Note that this does not equate with stopping the strategies all together, as leakage requires a sustained effort.

Even though background leakage cannot be detected, for other reasons, it can be reduced through pressure management and mains renewals. Mains renewals are usually targeted, and the elimination of background leakage is an unaccounted benefit of this expenditure. As it is not practical nor cost effective to renew all mains, the unavoidable annual real losses is a result of this leakage.

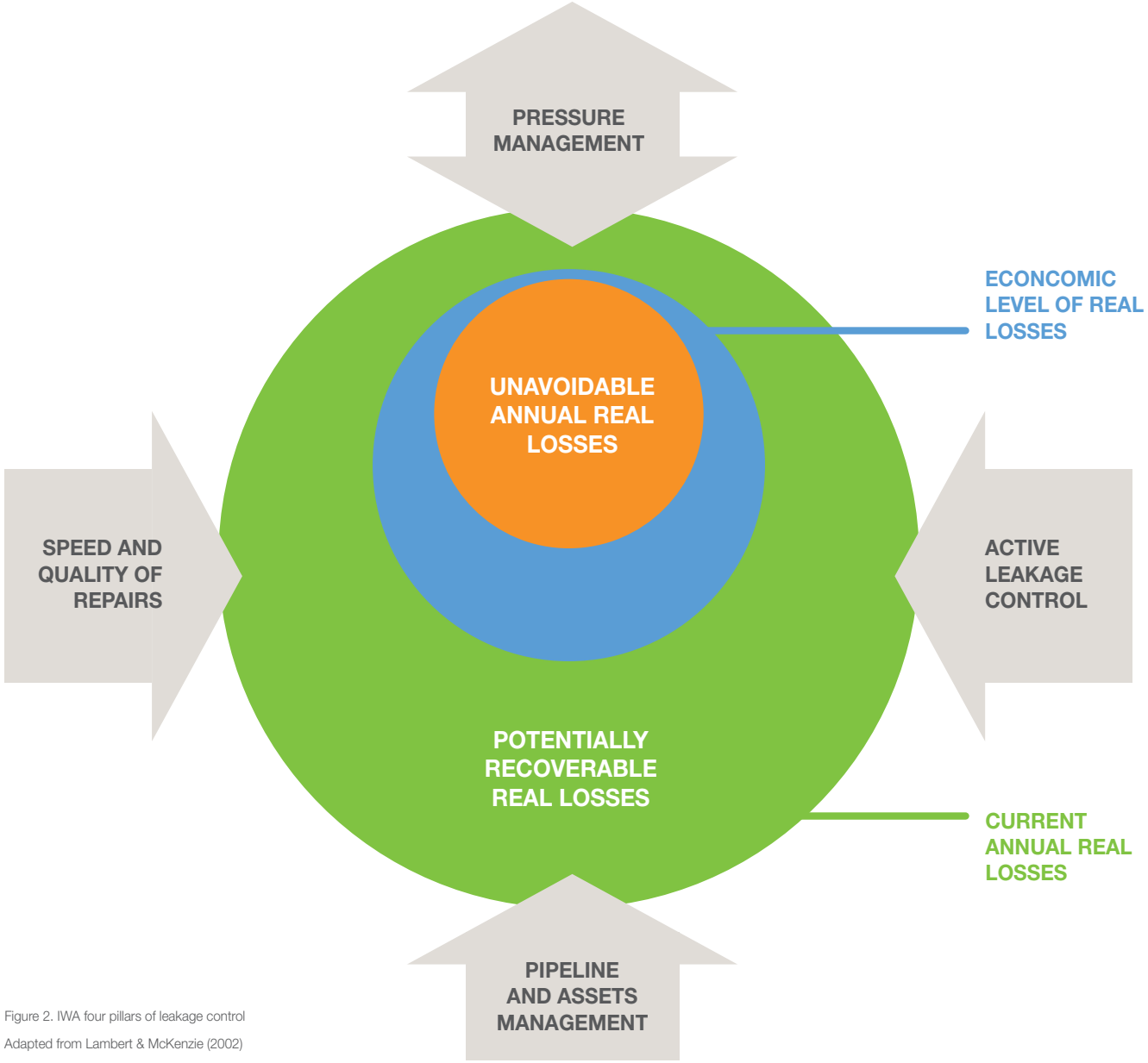


Figure 2. IWA four pillars of leakage control

Adapted from Lambert & McKenzie (2002)

CASE STUDY

WHICH APPROACH IS BEST?

UNITYWATER REVIEWS THE ECONOMIC IMPACT OF REDUCING REAL LOSSES

Unitywater delivers water and wastewater services to around 777,000 customers in the Moreton Bay, Sunshine Coast and Noosa communities.

Despite Unitywater having levels of real losses within the lowest quartile for major water utilities within Australia, they sought to understand what level of leakage was economical. High bulk water costs mean there are still some financial benefits to be realised from further reducing their current level of leakage.

INVESTIGATION

In their review they wanted to understand what was the economical level of leakage (ELL) for their system, and which lever in the Four Pillars would provide the best result. An aspirational target was set at 40 L/connection/day.

Only the following levers were considered:

- Active leakage control
- Pressure management
- Pipeline and assets management (network renewals)

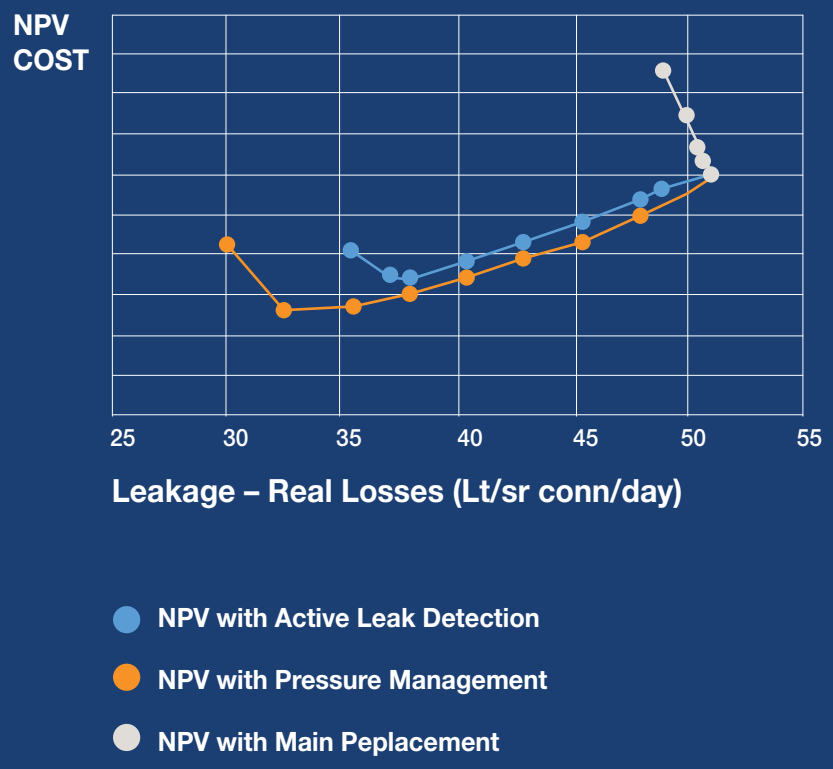
Speed and quality of repairs was excluded because this had already been resolved using TakaDu's network monitoring and analytic services. The Economical Level of Leakage Calculation enabled Unitywater to expand on the Active Leakage Detection work. In year 2018-19, Unitywater surveyed an additional 1,800km of reticulation water mains and detected approximately 55L/s leakage from the network. This is roughly equivalent to saving of $5.5M on an annualised basis.

OUTCOME

For a valid comparison, an NPV assessment over a 30-year period was undertaken. The results are shown in the figure for each option.

- Active leakage control - potential to reduce to 37.2 L/connection/day, and for every dollar spent on mitigating leakage, three dollars is saved on bulk water costs.
- Pressure management - potential to reduce to 33 l/connection/day, but deploying this can be problematic if fire flows are reduced below current regulations, especially in coastal areas with high density housing and/or commercial development.
- Pipeline and assets management (network renewals) - the NPV is not favourable to this solution on a leakage basis only, but if done for additional reasons it could be cost effective.

It was noted that the cost benefit of pressure management over leakage control shown is incremental and probably within the limits of accuracy of the assessment.



PRESSURE MANAGEMENT

Pressure management is a fundamental strategy to leakage control. It is widely accepted that pressure management has the benefit of reducing NRW and frequency of bursts and leaks. In 2011, WSAA completed a three-year study into leakage and pressure management, finding that pressure management has a three-fold benefit, not only to conservation efforts, but also reducing costs to the water utility and improving outcomes for the customer. The detail is shown in Figure 3.

The implementation of pressure management has a positive impact on the other strategies used to control leakage (e.g. active leakage control, asset management and repairs) and can be used to reduce the annual ongoing costs of the leakage program.

Unplanned bursts often result in negative media attention especially when properties are flooded and there is an impact on traffic.

Pressure reduction is most commonly is achieved through the implementation of District Metered Areas (DMAs) coupled with pressure zoning. This simplest form of pressure reduction is via an automatic pressure reducing valve (PRV), set to sustain a lower level of pressure within the DMA. As highlighted in the Unitywater case study, minimum pressures need to take into account fire flow regulations and the impact on higher density developments.

Common rules of thumb associated with pressure management are:

1.4%
reduction leak flow rates for every 1% reduction in pressure.

1%
reduction in burst frequency rates for every 1% reduction in maximum pressure.

PRESSURE MANAGEMENT: REDUCTION OF EXCESS AVERAGE AND MAXIMUM PRESSURES						
CONSERVATION BENEFITS		WATER UTILITY BENEFITS			CUSTOMER BENEFITS	
REDUCED FLOWS		REDUCED FREQUENCY OF BURSTS & LEAKS				
REDUCED CONSUMPTION	REDUCED FLOW RATES OF LEAKS & BURSTS	REDUCED REPAIR COSTS, MAINS & SERVICES	DEFERRED RENEWALS AND EXTENDED ASSET LIFE	REDUCED COST OF ACTIVE LEAKAGE CONTROL	FEWER CUSTOMER COMPLAINTS	FEWER PROBLEMS ON CUSTOMER PLUMBING & APPLIANCES

Figure 3. Summary of benefits of pressure management

CASE STUDY

DIGITAL METERING

SOUTH EAST WATER TRIALLING DIGITAL METERING TO UNDERSTAND THEIR SYSTEM

South East Water delivers water, sewerage and recycled water services to 1.7 million people across Melbourne's south east.

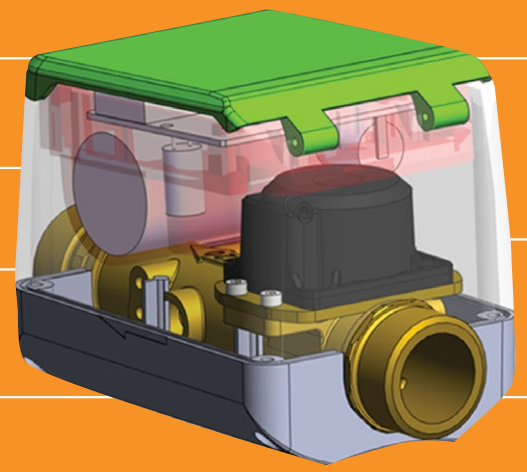
In collaboration with the other Melbourne retailers (Yarra Valley Water and City West Water), South East Water is exploring options to upgrade their fleet of digital water meters, and determine if it will provide value to customers, the community and their operations.

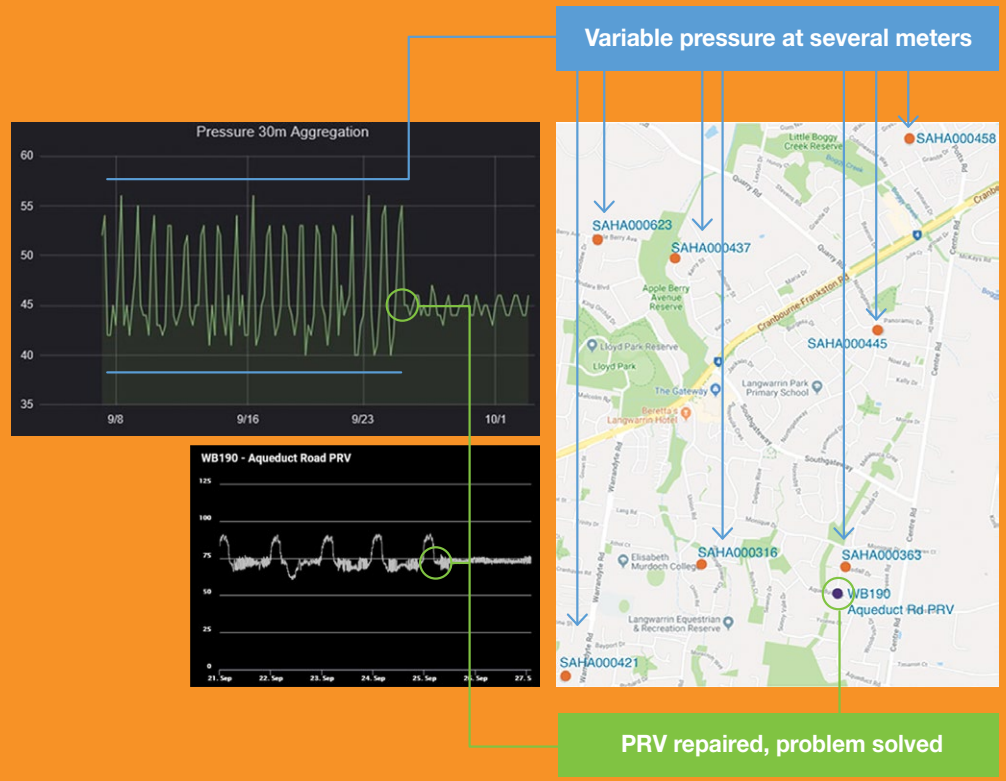
As part of their trial, new digital 'devices' have been installed on approximately 700 customer properties. Using a new Internet of Things (IoT) technology, these devices can be installed anywhere without requiring additional infrastructure. Data (including flow, pressure, temperature and alarms) is recorded every 30 minutes and transmitted daily to South East Water.

PRESSURE FLUCTUATIONS

Abnormal pressure variations were detected at several meters and at the pressure reducing valve (PRV). Upon inspection, it was found that a faulty pilot valve in the PRV was causing the pressure issues. Once the PRV was repaired the pressure returned to normal in the area.

While the digital metering has not detected a leak, in this instance higher system pressure can increase leakage rates and burst frequency. For example, a pressure increase of 10m typically increases leakage rates by 10-15 L/connections/day.





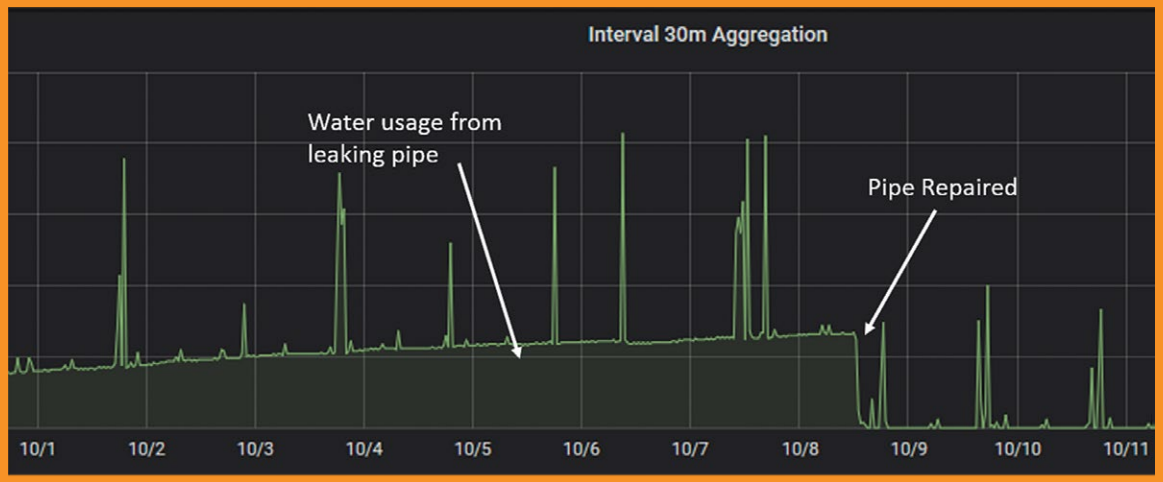
LEAKAGE DETECTION

A continuous flow alert was raised at a customer property; the rate of the leak gradually increased from 1-2 L/hr to 130 L/hr over 3 weeks, a significant change.

A plumbing audit found a leaking underground pipe between the meter and house. A plumber was engaged by the property manager to repair the leak. As this was a rental property, coordination was required between the tenant, property manager, Priority Plumbing and South East Water metering team to find the source of the problem.

Up to $1,100
saved by the customer

Up to 280KL
saved in one billing period



ACTIVE LEAKAGE CONTROL

Active leakage control is beneficial for cost-effective and efficient leakage management. When applied correctly, it can identify leaks before they become bigger problems that require reactive work, such as responding to a burst. It involves monitoring DMAs on a continuous basis, whether it is using flow rate, pressure, acoustic leak detection sensors or more recently smart meters on individual properties, and responding to changes in the zone's normal operating parameter.

Most systems use the data collected to identify and narrow down the area of a leak. It would then need to employ other methods, such as noise loggers, to pinpoint the leak and avoid high excavation costs trying to find the leak.

When these systems are coupled with a data analytics platform, as is starting to be used, it enables water utilities to respond much quicker and in a more proactive manner to leaks. This benefits the customer through minimising disruptions and, where the leak is on the customer side, it has the added benefit of reducing their bill (also see Case Study - Digital Metering).

CASE STUDY

ADELAIDE'S SMART WATER NETWORK

SA WATER USES TECHNOLOGY TO IMPROVE WATER SERVICES

SA Water provides water and sewerage services for around 1.6 million people across the state of South Australia.

In July 2017, SA Water implemented the first stage of its smart water network, integrating more than 400 sensors across the Adelaide CBD. The sensors are paired with a world-leading analytics platform, providing a detailed picture of the water network. At a cost of $4 million, it was the largest of its kind in Australia. The technology has enabled SA Water to identify and proactively fix leaks before they impact customers. i.e. work is scheduled to have minimal impact (often at night – while the city sleeps) on customers and commuters.

FURTHER TRIALS UNDERWAY

Following the success of this trial, the smart water network is expanding to Penneshaw (Kangaroo Island), including the investment in the installation of flow and pressure sensors in the main supply network, plus 300 smart meters for residential and business customers. While Penneshaw is a small community it has known NRW issues and relies on desalinated water. As this has a high treatment cost, there is significant cost saving benefits by reducing the amount of NRW in this region. A similar program will be rolled out in Port Lincoln.

This project has been recognised both nationally and internationally, winning two awards at the 2018 Australian Internet of Things Awards, a bronze prize at the International Water Association's Project Innovation Award, the title of 2018 Australian Digital Utility of the Year and Customer Service Awards from the Institute of Asset Management.

> *"In just 12 months, our smart technology has enabled us to identify and proactively fix leaks before they impact customers and commuters."*

In its first year, it has:

- **20+** water main incidents pre-empted
- Reduced reactive work by **70%**
- **50% savings** delivered by undertaking proactive versus reactive repair

CASE STUDY

THE LEAK DETECTION SPECIALIST (DOG)

WATER CORPORATION EMPLOYS NEW LEAK DETECTION METHODS

Water Corporation manages more than 34,000 kilometres of water mains across 2.6 million square kilometres of Western Australia, making it the largest water utility in the world in terms of the geographical area serviced. Given its vast geographical area, it is always looking for new and innovative ways to detect leaks and save water.

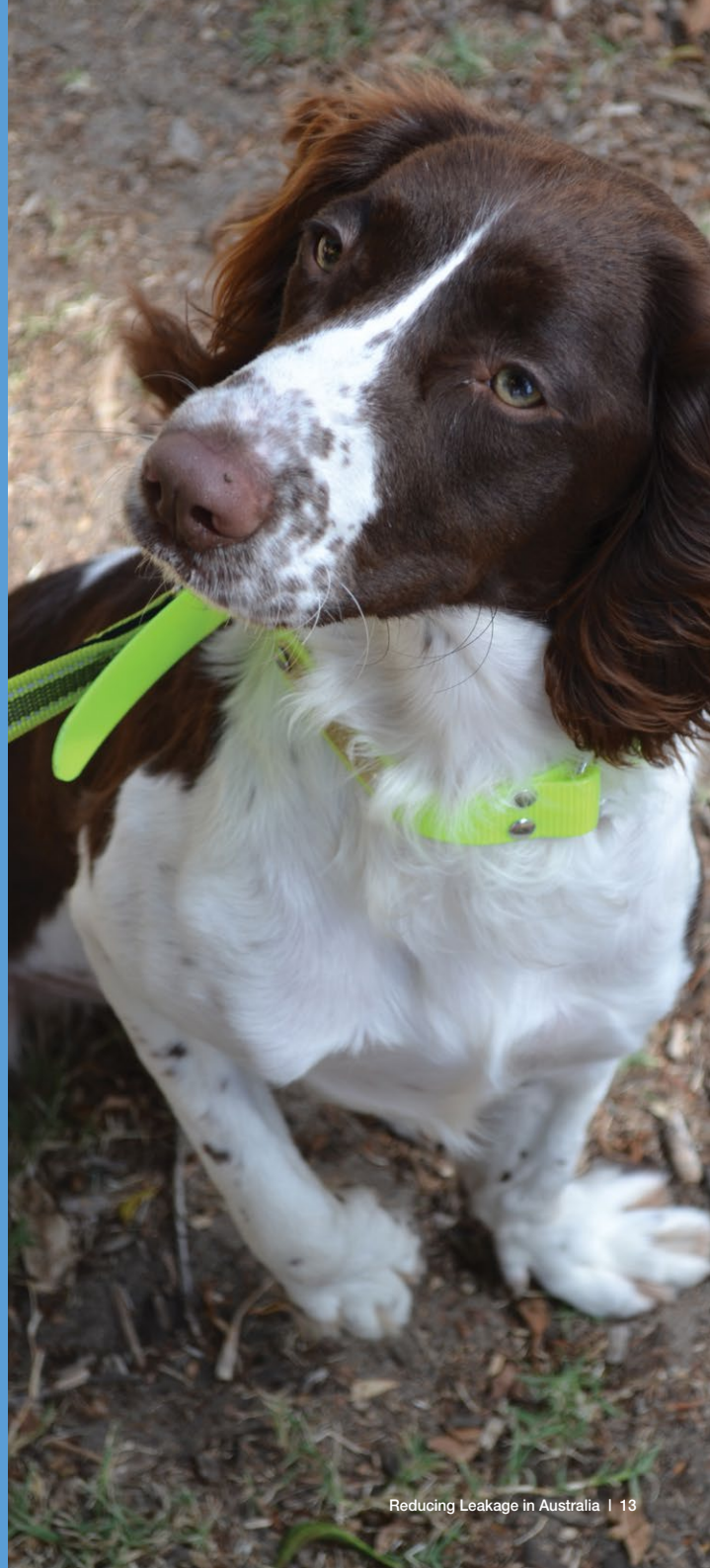
Kep, a female springer spaniel, was employed by Water Corporation in 2018 following a successful trial carried out in 2017. Kep underwent extensive training in Sydney and is now putting her skills to the test. A clear reward system to motivate her and keep her mission clear – to detect water leaks. Her number one reward is getting to catch a ball when her work is done.

RECOGNISING THE SCENT OF SCHEME WATER

Kep has been trained to recognise the scent of scheme water (chlorinated), and ignore all other scents such as rain water, pipes and fittings. She is best suited for detecting leaks in areas where traditional methods are incompatible, due to lack of fittings for acoustic methods, the pipes being too small for insertion type methods or where human access is difficult. This is typically long sections of underground water mains across farmland areas.

Kep is covering one district metered area (DMA) at a time; she is currently scheduled to work in six DMAs, with each having an average of 50 kilometres of water mains. Her first DMA, DMA1, was recently completed, and eight underground leaks were detected.

←$→ 2 times
more cost effective in long, underground pipes

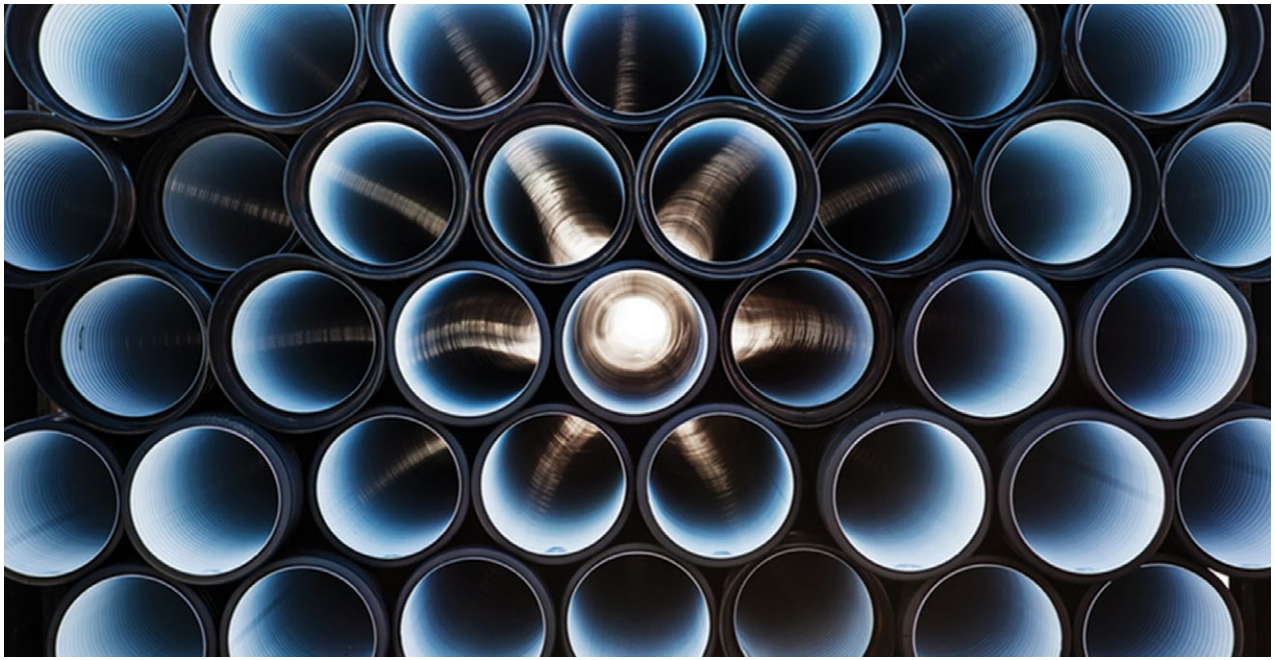


PIPELINE AND ASSET MANAGEMENT

Asset management underpins the work of a utility; it is the process is which the development, operation, maintenance, upgrade, and disposal of assets is undertaken, ensuring all costs, risks and performance attributes are considered. With recent shift towards customer-centricity, the customer has become the heart of the organisation; meeting their expectations in terms of quality, service (including time) and affordability need to be considered in the asset management program.

Asset management requires understanding how the asset is currently performing, and backing this up with good data and information systems. This closely links with the monitoring undertaken through active leakage control, and usually deals with the what next question. While renewals is not usually a cost effective method for reducing leakage, the impact of reduced leakage should be included in the assessment of the justification for capital expenditure.

We know that our infrastructure is aging, and with that comes increased leakage. It is estimated that the cost of renewals is in the order of $600 billion over the next 10 years. Utilities need to continually investigate new technologies to better manage and understand their infrastructure to ensure that these costs are not all passed on to the customer.



CASE STUDY
MYH2O

Key Message:
"Wasting water wastes a whole lot of opportunities."

100M
capital expenditure deferred

10%
reduction in peak water consumtion

Improved
customer communication

$500
reduction in forward price path per customer per year

Changed
customer behaviour

MACKAY REGIONAL COUNCIL FOCUS ON NON-CAPITAL SOLUTIONS

Water and Waste is a commercialised business unit of Mackay Regional Council. Their region extends across 7000 square kilometres, encompassing many different communities. In order to reliably supply water to these communities, water is sourced from 4 rivers and 42 bores.

The costs to deliver water and sewerage services within the region were escalating due to a booming economy and rapid population growth. It was no longer sustainable to keep doing business the way it had always been done – it was time for a change – leading to the development of a business case that focussed on non-capital solutions. In response, they developed a strategy that focused on data collection and customer engagement.

DATA COLLECTION

An intelligent water network was developed to obtain improved outcomes in operational and capital decisions; automatic meter readers (AMRs) were installed in 95% of residential properties, which allows the council to see how much water is being used in real-time. Data from the AMRs is analysed through an internal data management system MiWater.

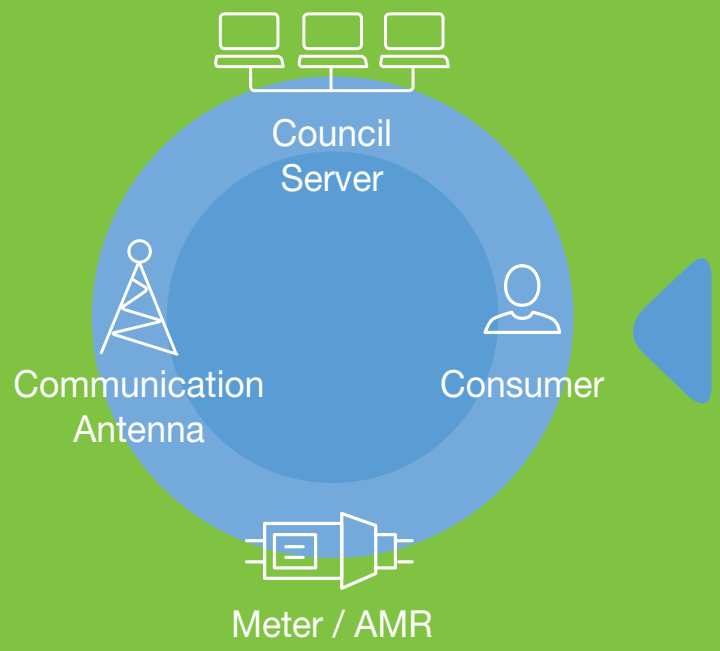
CUSTOMER ENGAGEMENT

A demand management program was implemented to minimise water consumption, primarily targeted at outdoor water usage. This program consisted of a comprehensive social marketing strategy, including customer management and education, and a consumption monitoring software coupled with a customer portal, myh2o. Within myh2o, each customer can view consumption data in detail:

- Property details
- Water meter information
- Recent usage
- How to report – either by usage or cost
- Compare usage to similar households or within suburb

MAKING CHANGES

Customers can view their daily water consumption online, and be notified of leaks and high consumption rates via email and SMS alerts within days of occurring, rather than when the bill arrives. For example, leak notifications are sent out when there is a continuous flow over a 72-hour period. myh20 has been successful in detecting small residential leaks which can save customers a significant amount on their bills. Bills are issued bi-annually and detecting even a small leak early can save the customer money, especially if detected near the start of a billing cycle.



> *"Reducing the cost of infrastructure reduces the cost of providing water services to our community."*

CASE STUDY

SMART LININGS FOR PIPE AND INFRASTRUCTURE

WSAA LEAD INTERNATIONAL PROJECT INVESTIGATING SMART LININGS

Water utilities around the world manage water and sewerage infrastructure to provide the most essential of the essential services. In Australia there over 260,000 kilometres of water and sewerage pipes – enough to go around the earth more than 6 times. Around 70 per cent of it is underground and often forgotten – until there is a pipe burst under a major road. The inconvenience it creates is a growing issue in our busy cities and towns, but replacing kilometres of pipes is a very costly exercise.

The Australian Government, through the Cooperative Research Centre, has funded $3 million to this partnership, comprising of 30 project partners (utilities, universities, manufacturers, applicators and organisations) from around the globe. The project itself is valued at a total of over $24 million which will be funded from the project partners. The project started on 1 March 2018 and will run for 3 years.

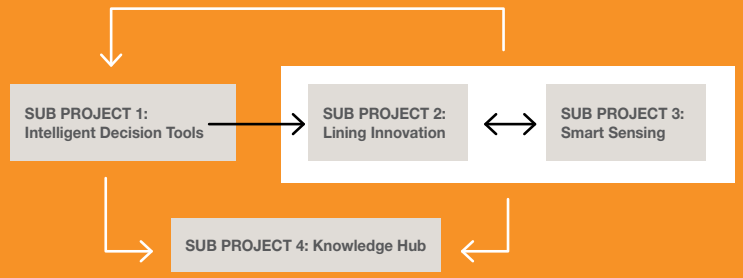
Pipe lining technology has the potential to substantially increase the service life of pipes by up to 50 years at a lower cost. Through this project new materials and technologies, including smart robotics and sensors, are being investigated. In addition to a longer life of these assets, these technologies have the potential to reduce customer bills and minimise pipe bursts, leaks and the associated inconvenience to customers. Utilities will benefit from infrastructure replacement savings (estimated $2 billion) from the reduced capital, renewal, maintenance and condition assessment costs, and cost avoidance due to asset failure.

PROJECT DELIVERY

Delivered via four interlinked sub-projects, the project will:

- Develop industry standards and guidance documents
- Perform analytical tests for validation and testing of lining
- Field-test liners
- Develop and test multi-sensor robot prototypes

Trials are now underway at several water sites across Australia and the development of an industry standard and guideline is progressing,



SPEED AND QUALITY OF REPAIRS

Leaks should be repaired as soon as possible once they are detected. The quality of the repair also plays a vital part in whether the leak is completely resolved and prevented from recurring.

While active leakage control plays a part in early detection, not all systems are monitored using the technology available. Digital monitoring and smart meters are increasingly being trialled and used for this purpose. However funding availability and the time involved in implementing the program are limiting its use at this time. To complement the technology solution, utilities are making it easier for customers to monitor their own consumption, report leaks and ensure the process is streamlined to reduce the impact on the customer.

CASE STUDY
THE CUSTOMER HUB

SYDNEY WATER TRANSFORMS INTO A CUSTOMER CENTRIC ORGANISATION

Sydney Water provides 1.4 billion litres of fresh water a day to 5 million customers across Sydney, the Blue Mountains and Illawarra.

Customer Hub is a key initiative of Sydney Water's corporate strategy, enabling its transformation to a customer centric organisation. Established to improve the customer experience for anyone either experiencing a Sydney Water service fault or affected by a service interruption, it has been a significant move away from a traditional asset centric philosophy of 'fix the asset, fix the customer problem'. It is now a process that considers and minimises customer impact, provides proactive communications and case management for customers, and seeks and acts on customer feedback in real time.

Commencing initially as a pilot covering the western population of Sydney (approximately 1 million people), it has now moved to full implementation covering the entire Sydney Water customer base (over 5 million people). Implementation cost for the entire project was less than $5 million.

The principle customer outcomes delivered by the process changes implemented through the Customer Hub include:

- minimised customer impact associated with water outages;
- pro-active notification of reactive repairs / burst water mains,
- real-time measurement of customer experience,
- real-time service recovery of any negative experiences, and
- proactive case management of individual customer circumstances.

The technology deliverables for Customer Hub comprised of:

- a geo-spatial situational awareness tool (Spatial Hub),
- new on-line channels of choice for customers,
- a SMS/email customer notification and feedback platform,
- integration with existing systems, and
- initiation of an Internet of Things (IoT) sensor pilot.

RESULTS

- Reduced impact of water outages at over 100,000 properties,
- reduced customer impact rebate costs by $800,000 in first year,
- proactive communications and case management,
- net Promotor Score currently at 57 (above 50 is considered 'excellent'), and
- 20,000 leaks reported online.

NEXT STEPS

The Customer Hub has piloted the use of sensors connected to the Internet of Things, which has helped understand network performance and identify asset performance before they become customer issues. The technology will be continually improved by the team to build on the predictive capability and focus the Customer Hub on getting ahead of incidents. This is a key part of Sydney Water's vision of being a hyper connected utility.

A FINAL WORD

Non-revenue water - including leakage - is undoubtably an issue for the water industry that is here to stay. While there will always be Unavoidable Real Losses within a network system, there are four strategies that should be employed concurrently to ensure that any losses are minimised. These include:

- Pressure management,
- Active leak control,
- Pipeline and asset management, and
- Speed and quality of repairs.

When employed simultaneously these strategies positively influence each other. Technological advances mean that utilities can better monitor network systems and proactively manage against leaks and bursts. Any decisions and investment should always consider customer expectations and requirements.

Leakage reduction should be a priority for all utilities as they seek to improve customer satisfaction.

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