Removing the Barriers to Efficient Water Leakage Management

by Ivan Nazzaretto

Executive summary

When water leakage management is addressed as a business issue, many organizations make the mistake of limiting their response to that of leak detection. However the true long-term response should involve a more comprehensive approach that includes all utility departments. This white paper offers recommendations for how water companies can leverage existing technologies to enable a more sustainable model for longer-term, efficient water leakage management.

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Introduction

Leakage is one of the most significant sustainability issues facing today's water industry. Billions of gallons of water are lost through leaking pipes every day while water shortages continue to grow across the globe.

Leaks tend to occur again and again, usually with more frequency over time. The current, short term approach for most utilities is to periodically conduct a network survey and to find the leaks. Once found, the leaks are repaired, and the resulting efficiency improvements are measured to evaluate the benefits of the repairs (this is referred to as "short cycle" leakage management).

Unfortunately, if hydraulic conditions in the network do not change or structural interventions are not put in place, the problem is likely to repeat itself in short order. This is the reason why investment in pressure management implementation and water mains and service connections replacement should be considered. Such actions will help reduce the "baseline leakage level" also referred to as the "long cycle" of leakage management (see **Figure 1**).

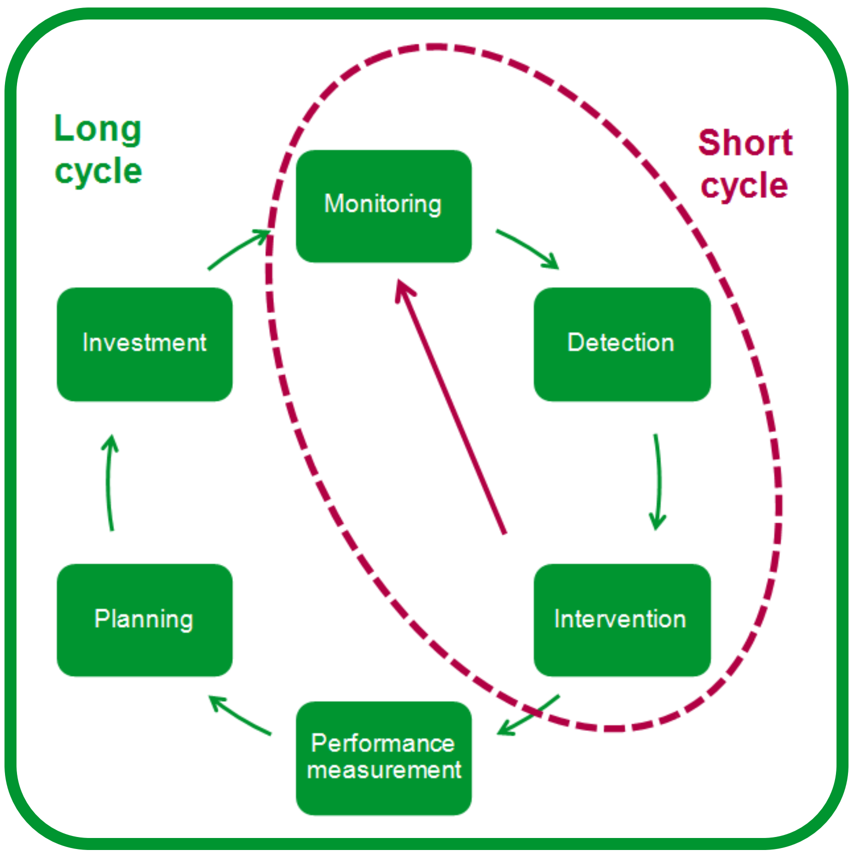


Figure 1
The two cycles of leakage management

Leakage management is such a complex challenge because the assets in question are buried pipelines most of which were installed before the modern era of digitization. The ability to assess the conditions of pipelines and spot problems is limited. In addition indifference (an out of sight / out of mind mentality) persists. Together, these two factors are the main causes of high levels of leakage.

Many "smart" solutions are already available in the market to address the leak detection problem. However, throwing technology at the problem is only a partial response with limited benefit. Technology deployment needs to be linked to the broader principle of "leak management" as opposed to the more narrow view of "leak detection". This paper offers advice on how water utilities can structure a true leak management culture within their organizations.

Leak management architecture

Successful water network management (of which leakage management is a component) relies on a proper combination of acquired business knowledge and technology. The human elements in terms of organizational leadership are just as important as the proper deployment of technologies that simplify the problem and help employees to visualize the degree of progress being made. The key elements for efficient water network management are illustrated in **Figure 2**.

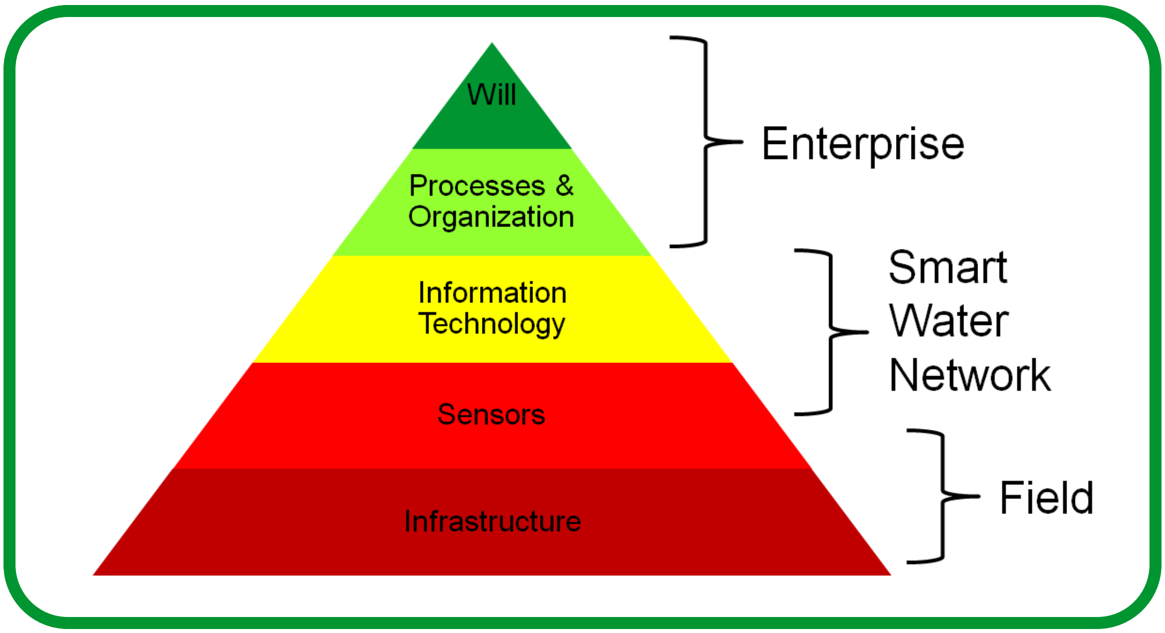


Figure 2
The pyramid of efficient water network management

The elements of the architecture in **Figure 2** are defined as follows:

- **The will** - Water utility management begins by setting up a favorable corporate environment to address the efficiency issue.
- **Processes and organization** - All utility departments need to be coordinated around the issue managing team resources and presenting performance results. This forces attention around the efficient management of the water distribution network.
- **Information technology** – This combination of hardware, software, and services enables the digitization process to take hold so that analysis is possible of the new, large volume of data that needs to be produced in order to properly monitor operations throughout the network.
- **Sensors** – These devices are installed to gather data and pass it along to the network in an intelligent manner. As a result, measurement is now much more accurate and this leads to more effective decisions. Proper measurement is foundational since it enables an organization validate whether initiatives taken are having a positive impact.
- **Infrastructure** – Proper design and maintenance are critical success factors in order to implement effective network management. However it is important to recognize that improving existing infrastructure is a long-term and costly process.

All of the architecture elements have to be present in order to achieve success. Any shortcut to this approach will not provide a sustainable solution to achieve efficiency in water network management. The Smart Water Network layer (including sensors and IT systems) is the bridge that connects the field layer to the enterprise layer.

The pyramid of efficient water network management can be applied to leakage management. **Figure 3** below identifies some of the specific leakage management technologies that should be considered when building the architecture.

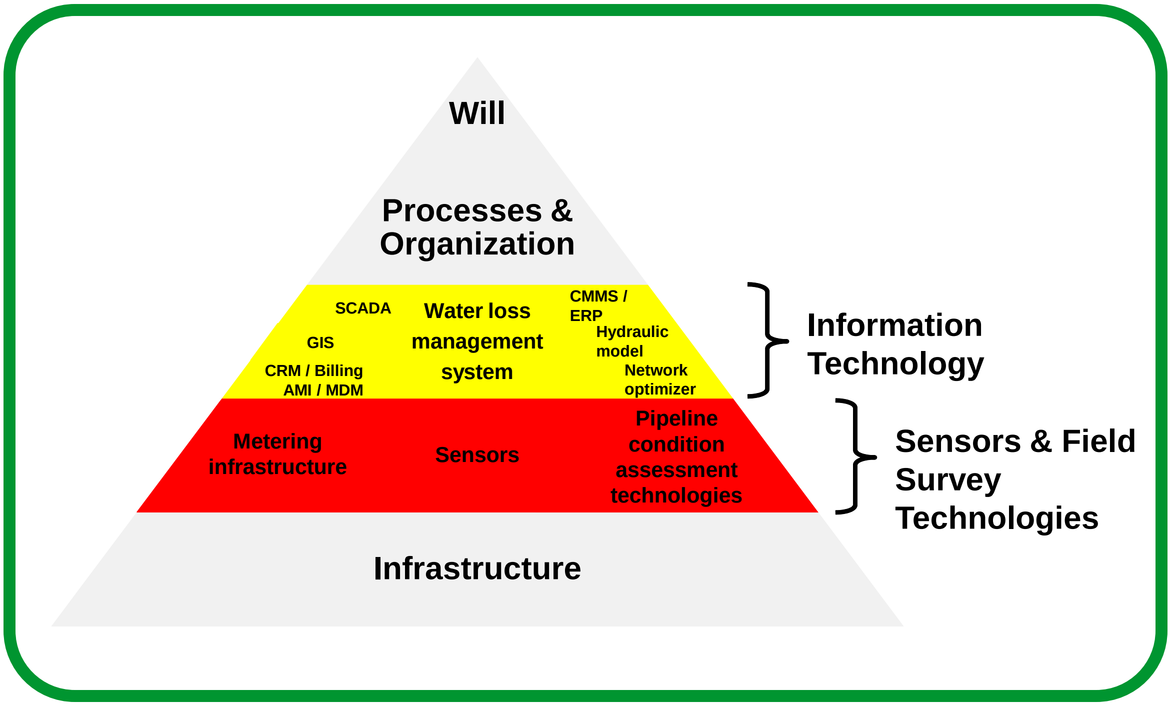


Figure 3
Core technology elements of efficient leakage management

The "sensors" layer in **Figure 3** consists of metering infrastructure, leak detection sensors, and pipeline condition assessment technologies. These three elements can be adopted either separately or in combination.

Metering infrastructure element – This represents the inventory of both current installed water meters and system input meters. **Table 1** illustrates the differing maturity levels that exist and the impact on leakage control at these various levels.

Leak detection sensors – These types of sensors imply a network of sensors that accurately identify pipe burst locations (see **Figure 4**). The accuracy is variable as it depends on the characteristics of the specific network and the sensor density. Full coverage of the distribution network using these types of devices represents a significant investment, especially where plastic pipelines are prevalent (because of the shorter required distance between sensors).

Pipeline condition assessment technologies – These technologies allow for inspection of medium and large diameter mains and provide great precision regarding pipe burst location and other pipe anomalies. However both cost and technical constraints do not make this solution viable for inspection of the full network. Surveys would be limited to a small portion of the network on a rotational basis (**Figure 5**).

Table 1
Metering infrastructure and its impact on leakage control

Metering infrastructure maturity		Low	Medium low	Medium	Medium - high	High
Measurements	System Input points (water sources, water treatment plant outlets)	All unmetered - all volumes are estimated	Partially metered - meters periodically read but not available in a central repository	Mostly metered - meters periodically read and available in a central repository	Mostly metered - some measures available in real-time in a central system	All metered - all measures available in real-time in central system
	Intermediate points (distribution zones inlets, critical network points)	All unmetered	Partially metered - meters periodically read but not available in a central repository	Mostly metered - meters periodically read and available in a central repository	Mostly metered - some measures available in real-time in a central system	All metered - all measures available in real-time in central system
	Consumption points (domestic and non domestic customer connections)	All unmetered - all volumes are estimated	Partially metered - meters read 1-2 times per year and available in a central repository	Mostly metered - large users meters read more frequently	All metered - Large users measures available in real-time in a central system	All metered with smart meters
Water balance granularity		Global	Global / Wide areas	Wide areas / Distribution zones	Distribution zones	Distribution zones or lower
Leakage control maturity		Leak detection is not done: only visible leaks are repaired	Leak detection is occasionally done if there is a specific problem in an area	Periodic leak surveys in areas on a rotation basis (e.g. once a year) are done	Leak detection is done in areas that are targeted based on theoretical optimal periodicity	Leak detection is done in areas that are targeted based on actual calculated leakage level

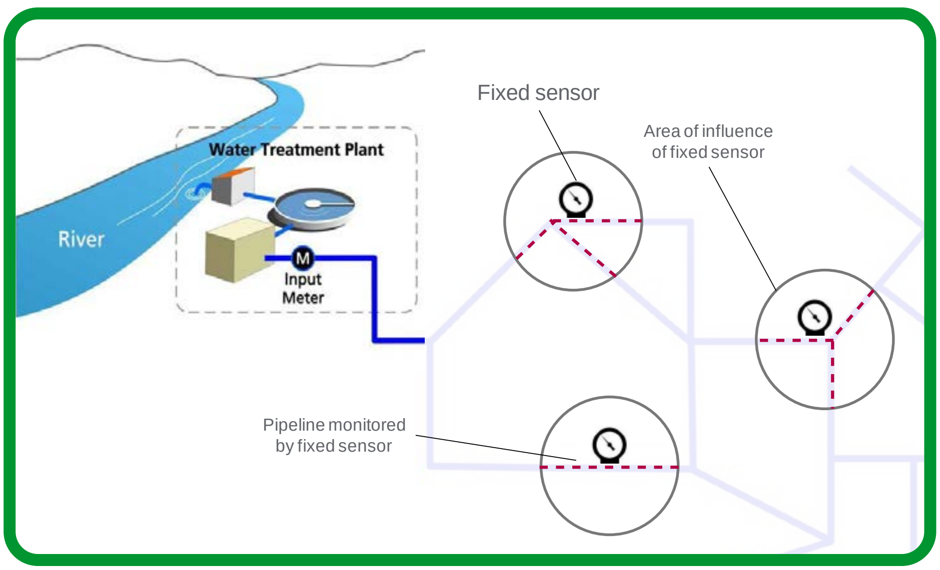
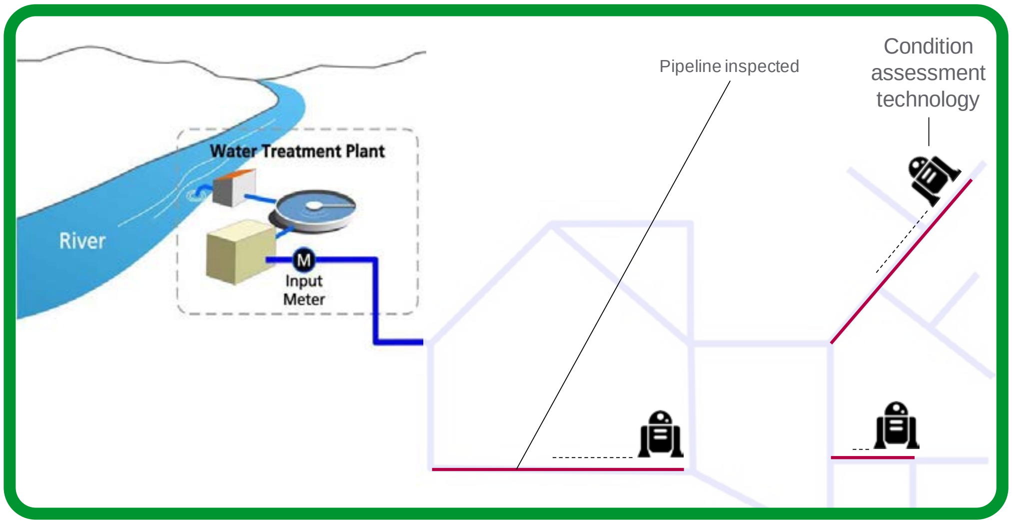


Figure 4
Water distribution system monitoring through fixed sensors network

Figure 5
Pipeline inspection with condition assessment technologies



In addition to the "Sensors" layer, **Figure 3** also illustrates the Information Technology layer. The systems identified in this layer contribute to leak management initiatives in different ways. Below is a high level description of the role these systems play:

- **Supervisory Control and Data Acquisition (SCADA) –** This serves as the main source of real time data collected from the field (mainly hydraulic parameters and network devices settings).
- **Geographic Information System (GIS)** – This system is the "master" of geo-referenced assets and infrastructure information (pipeline location and characteristics, network connectivity, etc.).
- **Customer Relationship Management (CRM) / billing system** – These systems are the main source of customer information (consumption and meter data).
- **Advanced Metering Infrastructure (AMI) / Meter Data Management (MDM) -** These systems collect and analyze water consumption measurements that are acquired from smart metering devices.
- **Computerized Maintenance Management System (CMMS) –** These manage work orders for maintenance and leak repair jobs.
- **Enterprise Resource Planning (ERP) - P**rovides financial information on network operations;
- **Hydraulic model** - Provides additional information on network behavior where actual monitoring is absent and helps identify anomalies and potential pipe bursts.
- **Network optimizer** - Based on the hydraulic model, this tool supports enhanced operations in the distribution network including real-time pressure management (dynamic pump scheduling and automatic feed-forward set-points of pressure regulating devices).

At the center of the architecture depicted in **Figure 3** is a dedicated Water Loss Management System. This layer is implemented in order to orchestrate the data flow that supports the entire organization (see **Figure 6**).

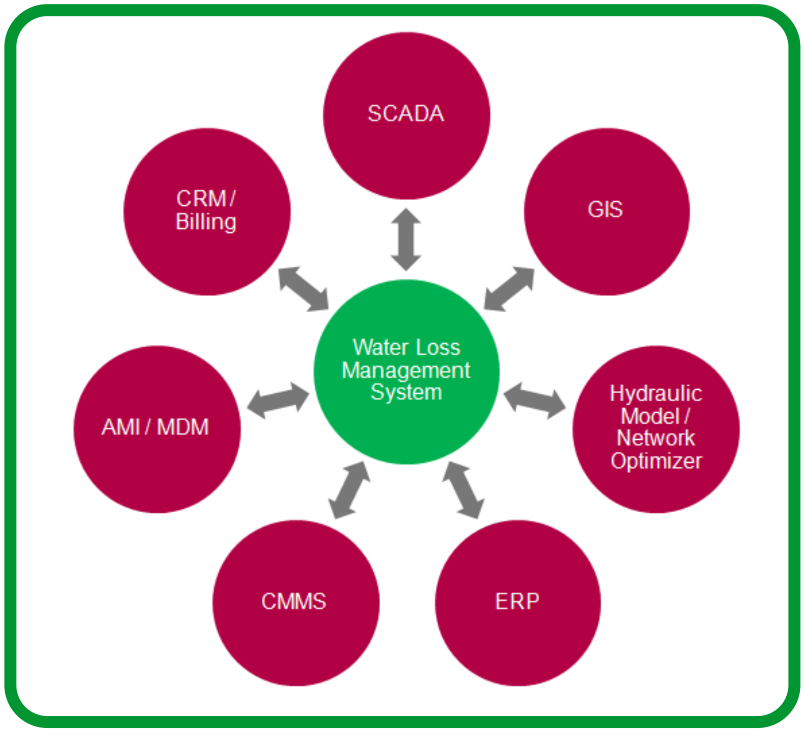


Figure 6
Integration of the various systems that make up the leakage management ecosystem

The Water Loss Management System is put into place to provide the following capabilities:

- Leakage calculation and alarming
- Active leakage control and leak repair management
- Pressure management.
- Asset management and planning
- Performance monitoring and reporting

Table 2 on the following page illustrates the challenges associated with attaining or improving each of these capabilities. In addition, potential solutions and benefits achievable with a Water Loss Management System implementation are identified.

Table 2
Water Loss Management System key capabilities

Capability	Challenges	Solutions	Benefits
Leakage calculating and alarming	Calculating leakage and water balance is a labor-intensive process. It requires access to data stored in separate systems, and involves many departments.	• Systems integration • Data validation and cleaning • State of the art calculation methods • Burst and faults alarm management • Rich contextual information (maps, charts, tables)	• Reduction of the burst and leakage awareness time • Real-time detection of network anomalies • Daily presentation of critical areas and assets
Active leakage control and leak repair management	Leak survey activities are often run in an inefficient manner. For example, crews will periodically sweep a zone without a clear understanding of the leakage level in the area. These crews are often provided with inaccurate information on the network and no precise leakage targets.	• Prioritization of zone to be surveyed based on technical and economic criteria • Planning of leak detection activities • Tracking of leak survey work progress and performance • Issuing of work orders for leak repairs • Monitoring of leak repair activities and contractors' performance	• Reduction in the cost of leak detection • Improved leak detection outcomes • Minimization of impact on customer caused by unplanned outages or network operations
Pressure management	Excessive pressure causes avoidable leak flows, new bursts and energy consumption. Even in systems equipped with pressure control devices, settings of Pressure Regulating Valves (PRV) and pumps are usually fixed over time.	• Dynamic pump scheduling based on changing water demand • Automatic feed-forward set-points of PRV to obtain just the target pressure	• Reduction in leakage level and burst occurrence • Reduction in energy consumption and CO2 emissions • Reduction in leak repair and detection cost
Asset management and planning	Even close-range leak surveys and repairs do not improve the leakage level in mains and service connections that are based on a deteriorated infrastructure.	• Identification of most critical infrastructure from a leakage/burst point of view • Prioritization of capital expenditure in the distribution network	• Simplification of planning and analysis activities
Performance monitoring and reporting	Network and organizational performances are not constantly monitored. Significant time may go by before anomalies or problems are actually detected.	• Dynamic and configurable dashboard and reports • Continuous Key Performance Indicators (KPI) calculation • Comparison of results of different units within the organization • Possibility to choose the time period and area on which calculate indicators	• Identification of critical geographic zones and business processes • Faster decision making process at operational and planning level • Easier regulatory compliance, freeing resources before dedicated to data collection and analysis

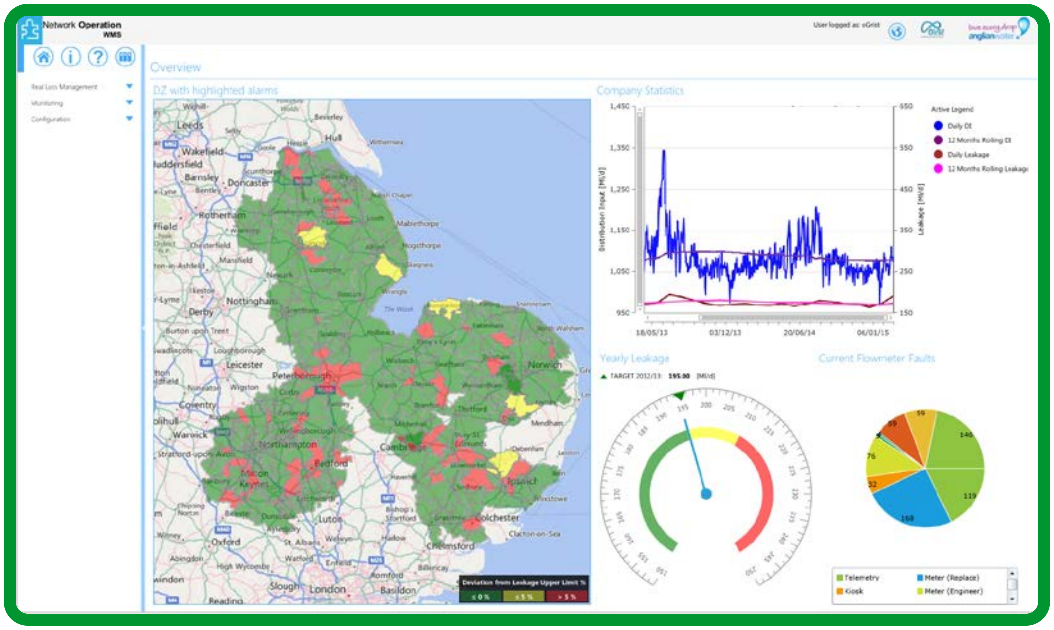


Figure 7
A screen from a water loss management system that Schneider Electric deployed in the United Kingdom: the Integrated Leakage and Pressure Management system at Anglian Water Services.

Action Plan

Organizations wishing to convert from a traditional approach to a more comprehensive leakage approach should execute the following steps:

Step 1: Conduct an assessment on non-revenue-water (NRW) management, by comparing internal practices in several areas (i.e., data availability, leak detection and repair processes, pressure management, customer metering policy, performance monitoring) to international best practices (see **Figure 8)**.

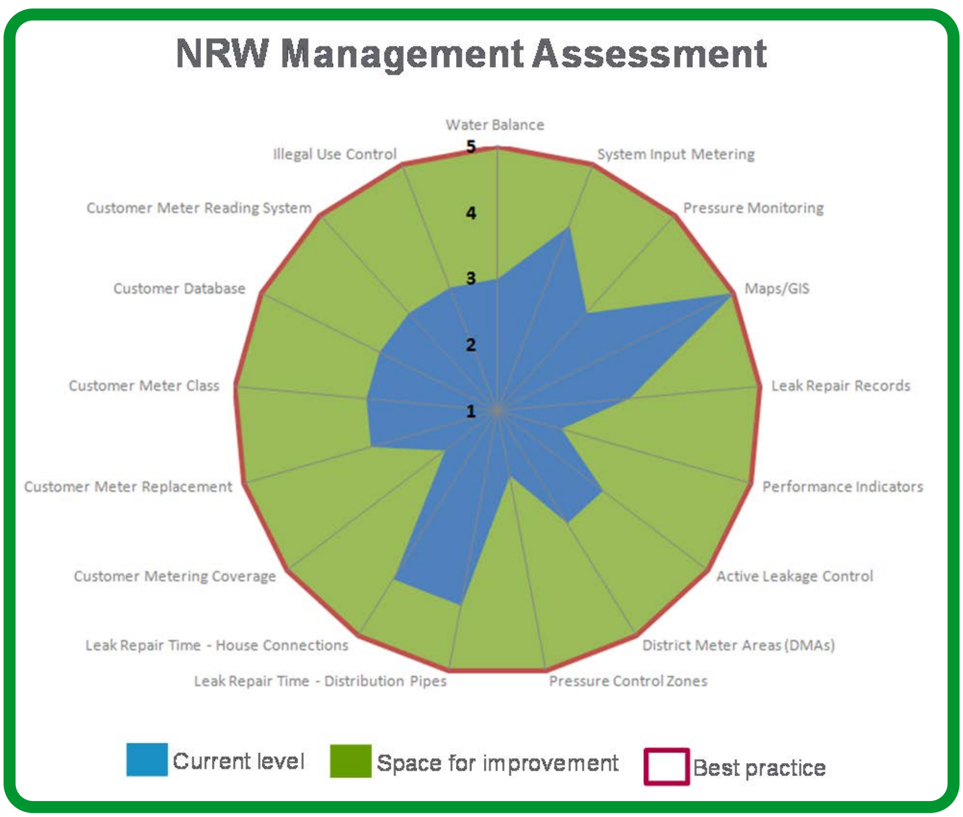
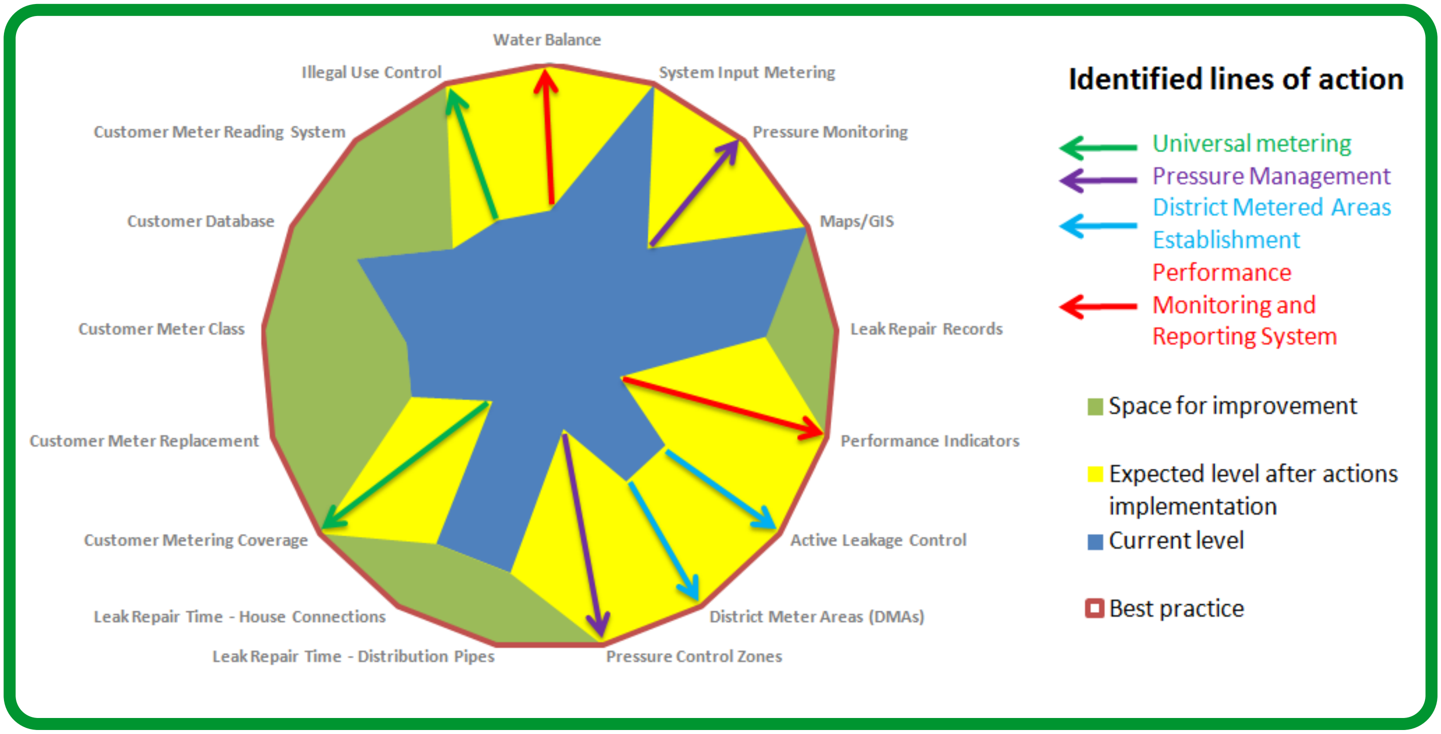


Figure 8
An example of non-revenue water (NRW) management assessment. The best practice is delineated in red. The blue areas represent current status, and the green represent the potential for improvement

Step 2: Identify actions that are generating improvements and that are applicable to specific local conditions (what works in one country may not necessarily work in another) taking into account implementation costs, benefits, completion time, and impact on the organization and customers.

Figure 9

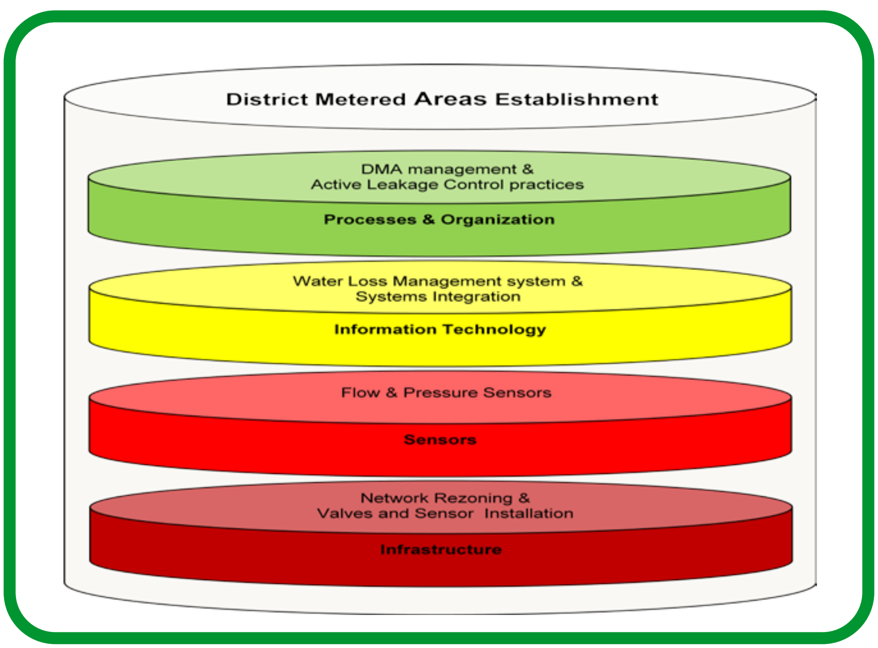
An example of lines of action identified to improve NRW management in the organization



Step 3: Improvements generally require investment in infrastructure, sensors and devices, software and changes to the operational processes and organization. An example of this is provided in **Figure 10** with reference to one of the example actions previously identified: the District Metered Areas establishment.

Figure 10

Illustration of the components/layers critical to establishing efficient District Metered Areas



Step 4: Once the plan is formalized, prioritize actions according to budget and time constraints. Begin with quick wins but without losing sight of the overall programme goals. Immediate positive results will generate trust and recognition both inside and outside of the organization (e.g., citizen advocacy groups). This can help to free up resources for longer terms investments.

Step 5: Try to manage all components of the action plan as a single project and try to "slice" the project "vertically" instead of "horizontally" (see **Figure 11**). The disadvantage of a horizontal approach is that nothing of any value gets delivered until all aspects of the project are integrated. This will hinder the project team's ability to generate the "quick wins". Consider the District Meter Area example in **Figure 10**. Instead of waiting until all the DMAs are established (the horizontal approach), begin with pro-active leak control by dividing the network into sequential zones (vertical approach "b" in **Figure 11**). Deploy new IT tools and processes in the initial DMA-divided zone and begin to record savings.

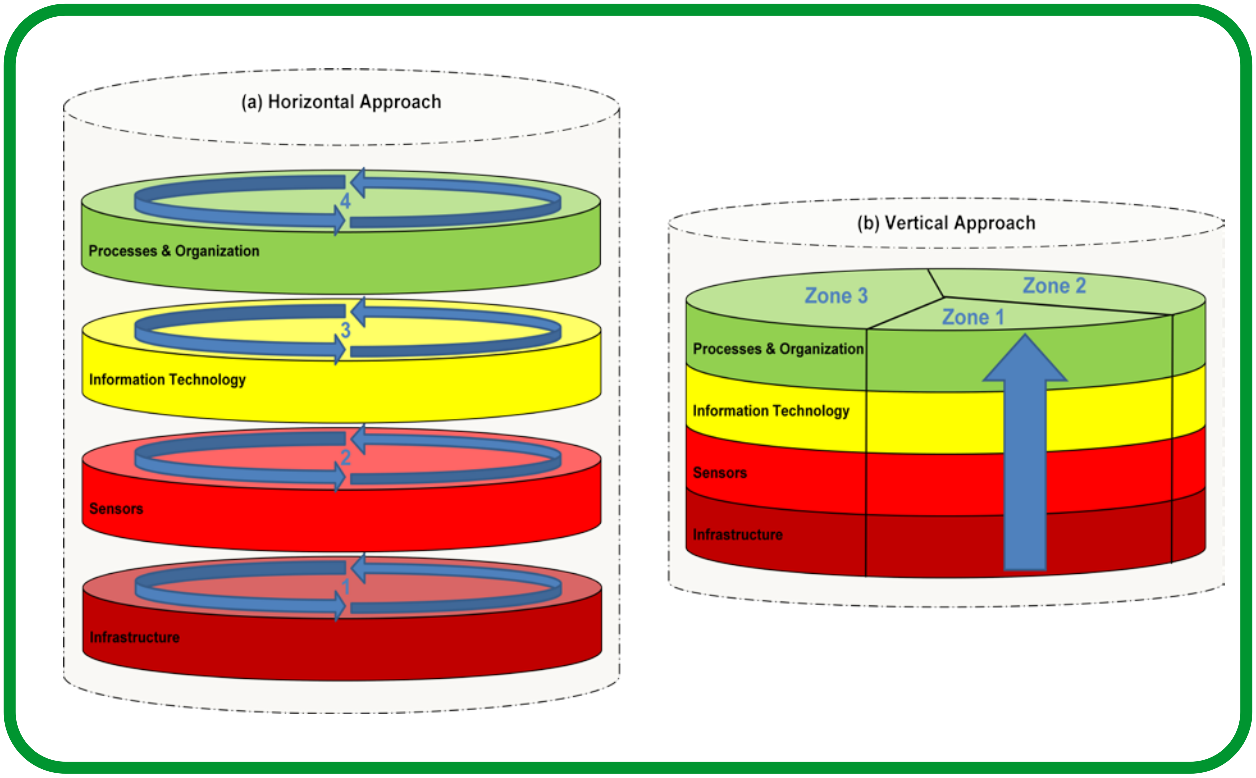


Figure 11
Vertical vs. horizontal implementation approach

Step 6: Monitor performance on an ongoing basis by measuring the efficiency that results from designated actions so that corrective measures can be applied to the plan if needed.

Conclusion

The challenge of reducing water loss is an ongoing issue. Fortunately, technological advancements in leakage detection and pipeline condition assessment are helping industry early adopters to dramatically cut water loss through enhanced non-revenue water management.

However a long-term sustainable approach to the water loss issue cannot be based on leak detection alone. The highest levels of management need to support investment in infrastructure, and also be willing to make the necessary business process adjustments.

Water loss management software is a key enabler as it serves to transform the data gathered in the field into network operational improvement actions that result in leakage reduction.

Water companies wishing to embark on a comprehensive leakage management initiative should consider a phased approach that includes the following steps:

- An assessment of current performance (where does the organization stand with respect to best practices?)
- An action plan for phasing in proper changes in infrastructure, technology and process improvement, bringing benefits to the organization in terms of leakage reduction and overall efficiency
- An early focus on yielding quick results on one pre-defined portion of the network
- Continuous performance monitoring to measure efficiency improvements and to modify actions based on results.

About the author

Ivan Nazzaretto is the product manager in the Smart Water Software division at Schneider Electric. Based in Madrid, Spain, Ivan is a civil engineer with 17 years of professional experience in the water industry, having worked in utilities and engineering consultancies in several countries before joining Schneider Electric six years ago. His main areas of expertise are: water services management with a special focus on water loss management, institutional strengthening, and product management in software for water utilities.