Itron

Mitigating Non-Revenue Water: Strategies for Sustainable Water Supply

WHITE PAPER

CONTENTS

INTRODUCTION

Non-revenue water (NRW) poses a substantial challenge for water utilities globally, resulting in financial losses, environmental impact and social implications. This white paper investigates the causes and repercussions of NRW, assesses measurement techniques and presents an array of strategies for water utilities to minimize and manage NRW. By addressing this issue, utilities can enhance operational efficiency, preserve water resources and guarantee a sustainable water supply for communities.

Managing a water utility is a complex and vital task. It requires a combination of technical expertise, regulatory compliance, financial acumen and a strong commitment to providing safe and reliable water supply to the community. The day-to-day job of a water utility to efficiently manage these operations is crucial if they are to provide reliable service to the community they serve while ensuring long-term financial sustainability.

Taking a proactive approach to gaining insight into where water goes on a daily basis is essential for an efficient operation of a water utility. Implementing a water audit for a systematic accounting of the water that enters, and the water that exits, a distribution system helps utilities monitor and manage water resources, detect losses and optimize their operations.

The focus of this paper is to highlight the problems utilities face after running a water audit and looking at one important output of the audit, the understanding and addressing of Non-Revenue Water.

NON-REVENUE WATER

Non-revenue water is a term used to describe the portion of treated and distributed water that is lost or unaccounted for within a water distribution system before reaching the end consumers. NRW encompasses all forms of water losses that occur throughout the water supply chain, from the treatment plant to the customer's tap. These losses can be broadly categorized into real losses and apparent losses:

- **Real Losses:** These are physical losses of water from the distribution system due to leaks, bursts and other infrastructure failures.
- **Apparent Losses:** Apparent losses refer to water that is inaccurately measured or billed often resulting from metering errors, theft, unauthorized consumption or illegal connections.

Effectively managing and reducing NRW is crucial for water utilities to ensure the sustainability of water supply systems, enhance financial viability and fulfill their commitment to providing safe and reliable water services to communities.

CAUSES OF NON-REVENUE WATER

The causes of NRW can be categorized into three main topics: physical losses, commercial losses and unavoidable losses.

Real (Physical) Losses

Real losses represent physical water losses from the distribution system due to leaks, bursts and other physical failures in the infrastructure. These losses occur within the network itself and are often the result of aging or poorly maintained infrastructure.

- **Pipe Leaks and Bursts:** Aging pipelines, corrosion, the change of above ground infrastructure and the lack of maintenance can lead to leaks and pipe bursts. These failures can result in significant water loss as water escapes from the distribution system.
- **Leaking Valves and Fittings:** Faulty or poorly maintained valves and fittings can also contribute to real losses. These components are critical for controlling the flow of water within the system, and their failure can lead to water leakage.
- **Overflow from Reservoirs and Tanks:** In some cases, water reservoirs and tanks may overflow due to malfunctioning float valves or excessive pressure. This overflow represents a form of real loss.
- **Leakages in Secondary Network:** Beyond the primary distribution network, leakages can occur in the secondary network, including service lines to individual properties and smaller diameter pipes. These smaller leaks can collectively contribute to significant losses.

Apparent (Commercial) Losses

Apparent losses are associated with the inaccuracy of metering, theft and unauthorized consumption. These losses occur at the point of billing and distribution to consumers.

- **Metering Inaccuracies:** Faulty or incorrectly calibrated meters can lead to underreporting or overreporting of water consumption. This results in discrepancies between the amount of water supplied and the amount billed.
- **Meter Tampering:** Some consumers may tamper with water meters to reduce their recorded consumption, leading to underbilling and revenue loss for the utility.
- **Illegal Connections:** Unauthorized or illegal connections to the distribution system can result in water consumption that goes unaccounted for and unbilled.
- **Water Theft:** Deliberate theft of water, such as tapping into distribution lines without permission, is a direct form of apparent loss.

Unavoidable Losses

Unavoidable losses are water losses that are considered a normal part of the distribution system's operation and are challenging to prevent entirely. These losses are essential for maintaining system reliability and safety.

- **Firefighting:** Water used for firefighting purposes, including hydrant testing and firefighting activities, is an example of an unavoidable loss. Ensuring an adequate supply of water for emergencies is crucial.
- **System Flushing and Maintenance:** Flushing of the distribution system to remove sediments and ensure water quality, as well as maintenance activities like valve exercising and repairs, can lead to temporary water losses.
- **Water for System Pressurization:** A certain amount of water is required to maintain system pressure, especially in larger distribution networks. This water serves to prevent backflows and contamination but contributes to unavoidable losses.

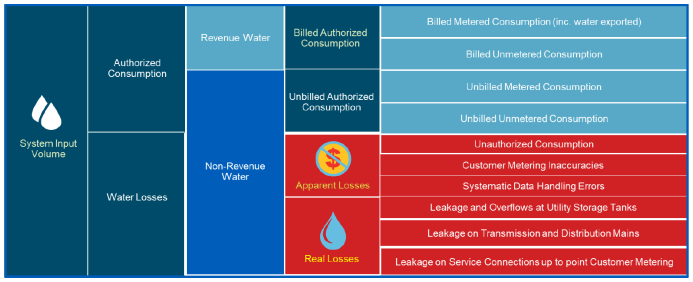


Figure 1: IWA Water Balance

WHY ADDRESS NRW?

The consequences for a utility to ignore or put off addressing their NRW, will impact not just the water utilities, but the communities, and surrounding environment.

Financial Implications

- **Revenue Loss:** Unaccounted-for water results in revenue loss for water utilities. The water that is lost or not billed represents a direct financial setback, making it challenging for utilities to cover operational costs and invest in system improvements.
- **Increased Operational Costs:** Utilities must expend additional resources to treat, pump and distribute water that is ultimately lost. This leads to higher operational costs, further straining budgets.
- **Reduced Investment Capacity:** High NRW limits a utility's capacity to invest in infrastructure upgrades and maintenance, potentially compromising the reliability and efficiency of the water distribution system.
- **Pressure on Tariffs:** To compensate for revenue losses, utilities may increase water tariffs, placing an economic burden on consumers, especially low-income households.

Environmental Impact

- **Wasteful Resource Use:** The loss of treated water represents a wasteful use of a finite and essential resource. As water scarcity becomes a global concern, conserving water is crucial for environmental sustainability.
- **Energy Consumption:** The energy used in treating and pumping water that is ultimately lost contributes to increased energy consumption and carbon emissions, impacting the carbon footprint of the water supply system.
- **Ecological Impact:** Over-extraction of water from natural sources to compensate for NRW can have adverse ecological effects, such as reduced river flows and habitat disruption.

Social and Community Consequences

- **Service Disruptions:** High NRW may result in unreliable water supply, leading to frequent service disruptions, inconveniencing consumers, and affecting their quality of life.
- **Affordability:** When utilities compensate for revenue loss by raising water tariffs, it can make water less affordable for low-income households, exacerbating issues of water equity and access.
- **Health and Hygiene:** Inadequate water supply due to NRW can compromise public health, as access to safe drinking water and sanitation services is critical for hygiene and disease prevention.

The key takeaway for a utility in addressing NRW requires utilities to understand the importance of each of these causes, the impact they have both financially, physically, environmentally and socially so that they can develop specific strategies for each of these causes.

STRATEGIES TO MITIGATE NON-REVENUE WATER

Mitigating NRW is a critical objective for water utilities seeking to improve operational efficiency and reduce losses in their distribution systems. These strategies encompass various approaches and actions that utilities can undertake to minimize NRW effectively.

Accurately assessing and managing NRW is essential. Running a water audit is the first step in understanding the performance and inefficiencies associated with the distribution system. A water audit is a systematic evaluation of water use and losses withing a water supply or distribution system. Conducting a water audit can provide valuable insights into how water is managed and can help identify areas for improvement in terms of water conversation, operational efficiency and cost savings.

In order to run the water audit, a defined area that the audit will cover should be defined. Then data from various sources such as water treatment plant/pump stations to individual consumers will require collection and synchronizing and normalizing for any time variations between collection periods.

A continuous water audit (water balance) essential for utilities to identify problem areas, allocate resources efficiently, and implement targeted strategies to reduce NRW, thus mitigating the financial, environmental and social consequences associated with water losses.

Mitigation efforts may include pipeline rehabilitation, regular maintenance and monitoring, technology adoption for leak detection, meter accuracy improvements and regulatory measures to prevent theft and unauthorized connections. By understanding and addressing these causes, utilities can minimize NRW and improve the efficiency and sustainability of their water distribution systems.

Infrastructure Improvement

- **Pipeline Rehabilitation and Replacement:** Identify and replace aging or deteriorating pipes to reduce physical losses caused by leaks and bursts.
- **Valve and Pump Optimization:** Ensure that valves and pumps are well-maintained and operate optimally to minimize water losses.
- **DMAs:** DMAs involve dividing the distribution system into smaller, manageable zones, each equipped with flow meters and isolation valves. This allows utilities to monitor and isolate sections of the network, making it easier to detect leaks and manage NRW more effectively

Technology Adoption

- **Advanced Metering Infrastructure (AMI):** Implement modern metering systems that provide accurate real-time data on water consumption, enabling utilities to detect anomalies promptly.
- **Remote Monitoring and Control Systems:** Use technology to remotely monitor and control water distribution systems, allowing for quick responses to leaks and abnormal consumption patterns.
- **Flow Meters:** Flow meters are used to measure the flow of water in various parts of the distribution system. They provide real-time data on water consumption and can help detect abnormal consumption patterns that may indicate leaks or theft.
- **Data Analytics:** Advanced data analytics techniques can analyze flow data, consumption patterns and pressure levels to identify areas with potential leaks or high NRW. Predictive analytics can assist in proactive NRW management.
- **Pressure Management:** Optimizing pressure within the distribution system can help reduce the likelihood of leaks and bursts. Pressure management systems can adjust pressure levels based on demand, minimizing stress on pipes.
- **Leak Detection Technologies:** Various technologies, such as acoustic sensors, can detect the sound of water escaping from pipes, aiding in the identification of leaks. Additionally, satellite-based technologies and drones can provide comprehensive leak detection and monitoring.

Metering Metrology

Meters are measurement devices installed at each connection for counting the consumed water.

- **Water Meter Types:** Water meters come in various types with different measurement technologies. These include multi-jet, single-jet, volumetric, nutating disc, Woltman, ultrasonic, fluidic oscillation and electromagnetic meters. Each type has its own advantages and limitations, and the selection of the appropriate meter type depends on factors such as the flow rate, water quality, and budget.
- **Sizes and Installation Conditions:** Water meters also vary in size to accommodate different flow rates. It's essential to choose the right meter size to ensure accurate measurement. Additionally, proper installation conditions apply to specific meters, such as ensuring a straight/horizontal pipe run before and after the meter, are crucial to prevent turbulence and inaccuracies for some technologies.
- **Meteorological Performance:** Water meter accuracy is critical for revenue collection and NRW reduction. Meters should be chosen based on their accuracy and ratio specifications. Regular maintenance and calibration are necessary to ensure that meters continue to perform within acceptable limits.

Metering Metrology (continued)

- **Aging Curves:** Over time, water meters may experience wear and tear, leading to decreased accuracy. Understanding the aging curves of meters can help in predicting when meters need to be replaced or recalibrated to maintain accuracy.
- **Reading and Handling Mistakes:** Human errors in reading water meters can contribute to NRW. Mistakes can occur when manual meter readings are incorrectly recorded or misreads that require estimation. Moving towards automated meter readings in addition to proper training and quality control measures will help reduce reading data errors.

Proper meter selection, installation, maintenance, automated meter readings and monitoring of reading processes are essential steps in reducing NRW and optimizing water supply systems.

Human Resources and Training

- **Leak Detection Teams:** Assemble dedicated teams trained in leak detection techniques and equipped with the tools needed to identify and repair leaks efficiently.
- **Data Analysts and Engineers:** Employ professionals to analyze data, assess system performance, and develop strategies for NRW reduction.

Regulatory Measures

- **Pricing Policies:** Implement pricing structures that encourage water conservation and discourage wasteful consumption.
- **Legal Actions Against Water Theft:** Enforce legal measures against water theft and unauthorized connections to deter such activities.

SETTING AND ACHIEVING NRW REDUCTION TARGETS

Efforts to mitigate NRW are most effective when guided by clear targets and a well-defined strategy. Setting and achieving NRW reduction targets is a crucial step in the process, and it involves several key components:

Setting Realistic Goals

- **Specific and Measurable:** NRW reduction targets should be specific and measurable, allowing utilities to track progress accurately. For example, reducing NRW by a certain percentage or volume over a defined timeframe.
- **Achievable:** Targets should be realistic and attainable based on the utility's capacity, available resources, and the condition of the distribution system.
- **Time-Bound:** Setting a timeframe or deadline for achieving the targets provides a sense of urgency and accountability.

Monitoring and Evaluation

- **Regular Assessment:** Utilities must continuously monitor and evaluate their NRW reduction efforts. This involves collecting data on water losses, conducting regular audits and employing measurement techniques to assess progress.
- **Performance Metrics:** Develop key performance indicators (KPIs) that measure the effectiveness of NRW reduction measures. These metrics might include leakage rates, meter accuracy and revenue collection rates.

BENEFITS OF ADDRESSING NRW

Mitigating NRW yields numerous benefits for water utilities and communities. These benefits encompass financial, operational, environmental, and social aspects, making NRW reduction a critical objective for water management. Here are the key benefits of addressing NRW:

1. Cost Savings:

Financial Efficiency: Reducing NRW leads to increased revenue, as utilities accurately bill for water supplied. This additional revenue can offset operational costs and reduce the need for rate increases.

2. Increased Revenue:

Accurate Billing: Mitigating commercial losses ensures that utilities receive payment for the water they provide, increasing their revenue stream.

3. Improved Service Reliability:

Consistent Water Supply: Lower NRW means fewer service disruptions, resulting in a more reliable water supply for consumers. This improves overall customer satisfaction and trust in the utility.

4. Resource Conservation:

Preservation of Water Resources: Addressing NRW contributes to the conservation of precious water resources, particularly crucial in regions facing water scarcity or drought conditions.

5. Infrastructure Resilience:

Reduced Physical Losses: NRW reduction measures, such as pipeline rehabilitation, enhance the durability and resilience of the distribution system, reducing the risk of infrastructure failures.

6. Customer Satisfaction:

Improved Service Quality: Lower NRW means improved service quality, reduced water wastage, and more equitable access to water services, leading to higher customer satisfaction.

7. Environmental Benefits:

Water Resource Protection: Reduced water losses translate to less water extraction from natural sources, preserving aquatic ecosystems and minimizing ecological impact.

Energy Savings: Lowering NRW reduces the energy required for water treatment and distribution, leading to reduced greenhouse gas emissions.

BENEFITS OF ADDRESSING NRW *(continued)*

8. Operational Efficiency:

Optimized Resource Allocation: Utilities can allocate resources more efficiently, directing savings from NRW reduction toward infrastructure improvements, technology upgrades or additional service enhancements.

9. Sustainability and Long-Term Viability:

Financial Sustainability: The increased revenue and cost savings resulting from NRW reduction support the financial sustainability of the utility, ensuring its long-term viability.

10. Compliance with Regulatory Requirements:

Regulatory Compliance: Addressing NRW helps utilities comply with water quality and conservation regulations, reducing the risk of penalties or sanctions.

11. Community Well-Being:

Access to Safe Water: Reduced NRW ensures that more people have access to safe and reliable drinking water, improving public health and well-being.

12. Equitable Water Distribution:

Equity: NRW reduction measures can help ensure that water services are distributed more equitably, benefiting all segments of the community.

13. Climate Resilience:

Reduced Vulnerability: By minimizing water losses and optimizing distribution systems, utilities become more resilient to climate-related challenges, such as droughts and extreme weather events.

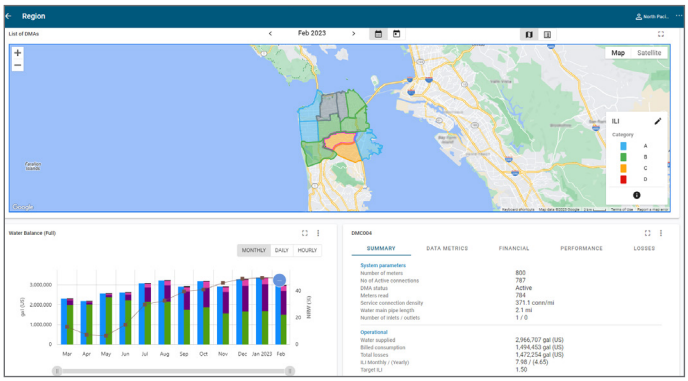
In summary, addressing NRW is a multifaceted endeavor that brings about financial stability, operational efficiency, environmental responsibility and social benefits. Water utilities that prioritize NRW reduction not only contribute to the sustainability of water resources but also enhance the quality of life for their communities while ensuring the long-term viability of their operations.

ITRON'S NRW OFFERING: TEMETRA ANALYSIS

Temetra Analysis is a comprehensive solution designed to address non-revenue water losses within water distribution systems. This solution aims to deliver measurable results by improving operational efficiency, reducing operating costs, enhancing reliability and increasing resiliency. Here's a breakdown of the key components and functionalities of Temetra Analysis:

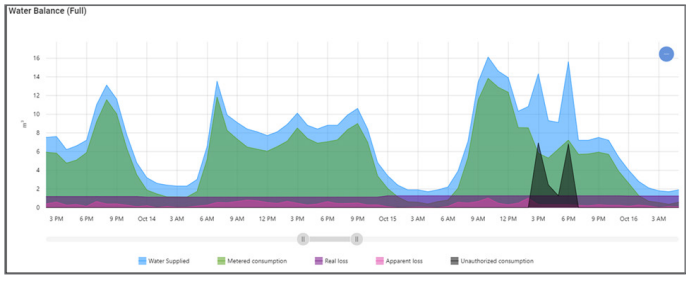
Operational Visibility

- **Automated Water Balance:** Temetra Analysis automates water balance calculations for all connected District Metered Areas (DMAs) using various sources of utility data.

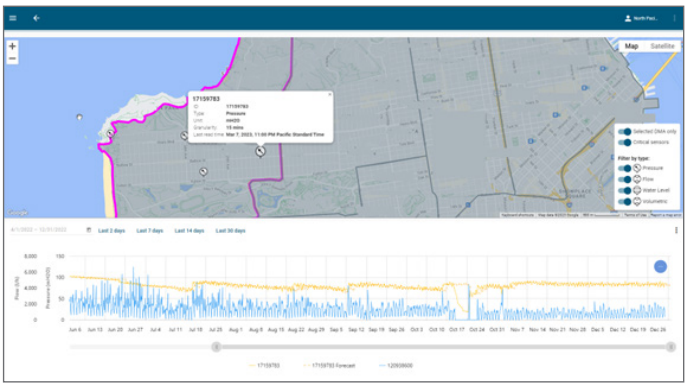


Operational Visibility provides intuitive views, dashboards and reporting, enabling water utilities to monitor the health and performance of their entire water distribution network.

- **Water Loss KPI Monitoring:** Besides loss percentages, the solution provides additional Key Performance Indicators (KPIs) following International Water Association (IWA) standards to prioritize work and distinguish between DMAs more meaningfully.
- **Hydraulic Simulation and Visualization:** Visualizing the hydraulic characteristics of each DMA helps in monitoring and locating losses efficiently.
- **Transmission Mains Monitoring:** The platform provides a comprehensive view of the entire network, including mains, water tanks and storage sectors, to monitor inflow, outflow and losses.



View your Water Balance with hourly consumption



Display flow and pressure data across various Sectors.

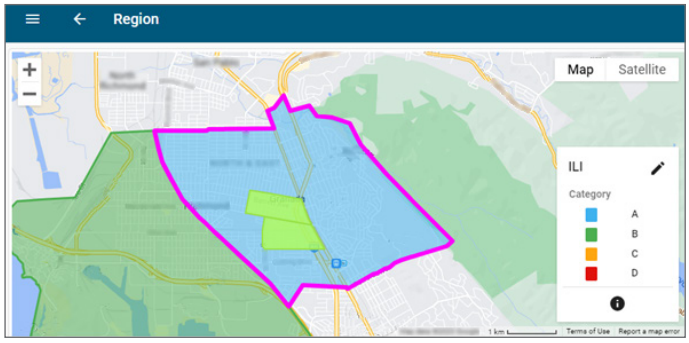
Water Revenue Assurance

- **Consumer Data Accuracy:** This component focuses on maintaining accurate consumer records within the Customer Information System (CIS) to ensure an understanding of revenue flow.
- **Data Cleaning:** It includes detecting and correcting inaccuracies in the database, such as duplicate IDs, missing IDs, data errors, etc., before analyzing consumption data.
- **Consumption Analysis:** After data cleaning, consumption profiles are applied to meter data to detect losses, anomalies and consumption patterns, including reverse meter flow, meter size issues, unusual usage, etc.

ITRON'S NRW OFFERING: TEMETRA ANALYSIS

Water Leak Management

» **Leak Detection Using Hydraulic Models:** Temetra Analysis employs hydraulic models for spatial analysis of flow, consumption and pressure to pre-localize potential high-leakage areas.



Water Leak Management flags when DMAs have unexpected real losses, and then uses available pressure or acoustic sensing data to identify the likely areas for leaks.

» **Targeted Leak Pinpointing:** The solution allows utilities to target specific areas for leak pinpointing regularly, instead of waiting for leaks to surface or conducting labor-intensive surveys.

Temetra Analysis offers a holistic approach to address the challenges associated with non-revenue water losses. By integrating utility data into a unified platform and leveraging advanced algorithms and forecasting tools, utilities can gain quantifiable results, improve KPIs and make informed decisions to enhance the efficiency and reliability of their water distribution systems. It provides insights for utilities to prioritize their short/long-term investment strategies to reduce NRW by identifying causes of NRW within their distribution network.

CONCLUSION

In conclusion, setting and achieving NRW reduction targets is a critical undertaking for water utilities seeking to enhance operational efficiency, financial stability and environmental sustainability. By establishing clear, realistic goals, continuously monitoring progress, learning from successful examples and recognizing the benefits of addressing NRW, utilities can embark on a path towards a more sustainable water supply system.

Recap of Key Findings

» NRW reduction is essential for financial stability, operational efficiency and environmental responsibility.

» Setting clear and realistic NRW reduction targets is crucial for success.

» Regular monitoring and evaluation of progress are essential.

» Learning from successful NRW reduction initiatives is valuable for utilities.

» NRW reduction yields multiple benefits, including cost savings, increased revenue, improved service reliability, resource conservation, infrastructure resilience and customer satisfaction.

The Path to Sustainable Water Supply

Achieving NRW reduction targets is a key step on the path to ensuring a sustainable and reliable water supply for communities.

Call to Action for Water Utilities

Water utilities are encouraged to take proactive measures to address NRW, realizing its importance in achieving financial viability, environmental stewardship and community well-being. Prioritizing NRW reduction is not only responsible but also a strategic investment in the future of water supply systems.

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