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SUSTAINABLE CITIES PROJECT

Preparation of Non-Revenue Water Management Guidelines
to Combat Climate Change for Water Utility Departments
(WUDs) in Trkiye

Service Contract No: IB A1.C7

Final Non-Revenue Water Management Guideline

September 2022

Consultant: SAFEGE-İO EVRE JV





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LIST OF ABBREVIATIONS

AL	Apparent Losses
CARL	Current Annual Real (Physical) Losses
CAAL	Current Annual Apparent Losses
DGWM	Directorate of Water Management
DMA	District Metering Area
DSİ	General Directorate of State Hydraulic Works (Devlet Su İşleri Genel Müdürlüğü)
DWTP	Drinking Water Treatment Plant
EARL	Economic Annual Real Losses
ELAL	Economic Level of Apparent Losses
EU	European Union
GIS	Geographic Information System
IBRD	International Bank for Reconstruction and Development
ICF	Infrastructure Condition Factor
ILBANK	İller Bankası A.Ş.
ILI	Infrastructure Leakage Index
IUWM	Integrated Urban Water Management
IWA	International Water Association
MERNIS	Central Population Administration System (Merkezi Nüfus Idare Sistemi)
MIS	Management Information System
MM	Metropolitan Municipality
MoEUCC	Ministry of Environment, Urbanization and Climate Change
MoAF	Ministry of Agriculture and Forest
NRW	Non-Revenue Water
PMA	Pressure Management Area
QA	Quality Assurance
SCP	Sustainable Cities Program
UARL	Unavoidable Annual Real (Physical) Losses



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UAVT	National Address Database (Ulusal Adres Veri Tabanı)
UBL	Unavoidable Background Leakage
WB	World Bank
WDS	Water Distribution System
WSA/WUD	Water and Sewerage Administrations /Water Utility Department
WFD	Water Framework Directive



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EXECUTIVE SUMMARY

SAFEGE / İO ÇEVRE Joint Venture is awarded to contract of “Preparation of Non-Revenue Water Management Guidelines to Combat Climate Change for Water Utility Departments (WUDs) in Turkey” project. This project is implemented within the scope of the Sustainable Cities Program (SCP) – Component A with the technical and financial support of the World Bank (WB) through a European Union Pre-Accession Fund.

In current situation, tons of cubic meters of treated water are lost, and water utilities continue to lose a substantial amount of revenues. To meet growing demand, new resources are developed, more water are pumped into the leaking networks. The vicious cycle will continue without sustainable comprehensive solution.

The positive impacts of NRW reduction are greater access to scarce resources and increased financial revenue to a cash strapped water sector leading to a more efficient and sustainable sector and improved service to the customer. Illegal connections mean that honest customers pay for the water which is stolen which is unfair.

High levels of NRW are causing a loss of scarce resources and financial income in the already cash-strapped water sector. NRW has a significant impact on the financial sustainability of Water and Sewerage Administrations (WSAs) and Water Utility Departments (WUDs) through its impact on revenue loss and increased operating costs. Therefore, it is now widely accepted that the NRW is an important indicator of the operational and financial performance of a public institution. Successful utilities actively address NRW by controlling physical losses in other words leakages from the distribution network, ensuring customer meter accuracy and making all efforts to keep the number of illegal connections in other words water theft, within limits. Taking these measures can boost revenue by increasing the amount of water that can be billed while reducing wastage of the product. This increases profitability and improves the return on investment. Together with sustainability in other words with increasing profits, the water service utility will have an ability to improve its productivity.

Underestimating NRW’s complexity – and the potential benefits of reducing NRW – often leads to the failure of reduction programs. Effective NRW management will lead to increased revenues and profitability for the utility if done properly. The ‘Vicious Circle’ of NRW is one of the key reasons for poor company performance and results in both physical and commercial losses. Physical losses divert precious water from reaching customers and increase operating costs. They also result in larger investments than necessary to augment network capacity. Commercial losses, caused by customer meter inaccuracies, poor data handling, and illegal connections, reduce income and thereby financial resource generation. The challenge for water utility managers is to turn the Vicious Circle into the ‘Virtuous Circle’. In effect, reducing NRW releases new sources of both water and finances. Reducing excessive physical losses results in a greater amount of water available for consumption and postpones the need for investing in new sources. It also lowers operating costs. Similarly, reducing commercial losses generates more revenues.



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One of the cornerstones of the NRW Management strategy is to understand the relative significance of each of the components, ensuring that each is measured or estimated as accurately as possible, so that priorities can be set via a series of action plans.

Financial constraints, limited institutional and technical capacity, and political, cultural and social limitations may be encountered during implementation. All of these factors have an impact on the extent of managing losses and demand and affect the speed with which changes are made. But the goal should always be to make some improvement in current operational practice. This can be achieved step by step by increasing staff motivation, through knowledge transfer or new skills.

The first step in developing a strategy is to ask some questions about the network characteristics and the operating practices, and then use the available tools and mechanisms to suggest appropriate solutions, which are used to formulate the strategy. Typical questions are¹;

- How much water is being lost?
- Where is it being lost from?
- Why is it being lost?
- What strategies can be introduced to reduce losses and improve performance?
- How can we maintain the strategy and sustain the achievements gained?

In this Guideline, the structure of overall NRW Strategy and particular strategies to be developed by WSA/WUDs are given and these strategies are summarized below.

- Overall NRW Management Goal is a sustainable, water and energy efficient water management system with optimum NRW level.
- In this context, each NRW management component is designed as an area of action to serve the NRW management overall strategy.
- Action areas have been developed in a structure that will allow the development of strategic actions specific to WSA/WUDs. Each action area includes diagnostic (where we are), goal setting (where we want to reach) and strategy (how we will achieve it).
- Goals for each key area of actions will be set in order to streamline and focus on the action development process.
- Actions proposed in “Understanding Current Status” sections for each action area are basically self-water auditing for WSA/WUDs, in other words diagnostic of current status. Standard Water Balance Form given in Annex 1 of the Regulation² will be

¹ NRW – International Best Practice for Assessment, Monitoring and Control, UK

² The Regulation on Control of Water Losses in Water Supply and Distribution Systems was published in the Official Gazette dated 8 May 2014 and numbered 28994. Amendments were made with the Official Gazette dated 31 August 2019 and numbered 30874.



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completed as accurate as possible to understand the problem along with the use of specific Performance Indicators (PIs).

- As a result of “Understanding Current Status” in other words diagnostic (where we are), the actual status of NRW components will be identified. The questions of “how much water is being lost?” and “where is it being lost from?” are determined by using the streamline given in each action area.
- The current status will show the problematic areas of WSA/WUD. Based on the causes of losing water volumes, an NRW reduction strategy can be formulated by WSA/WUD with priorities.
- A diagnostic approach that follows the practical application of viable and achievable solutions is recommended for WSA/WUDs to develop a tailored non-revenue water management strategy.
- The data gathered after “Understanding Current Status” for each component of NRW will be used to calculate PIs proposed in “PI Definitions and Calculation” section. The international limits proposed in the “PI Evaluation for Goal Setting” sections will be used for determination of targets for WSA/WUDs for the NRW management strategy.
- Specific measures/actions are proposed in the action areas in order to tackle each of the NRW causes.

It can be seen in all applications that small savings in the NRW have a great positive impact on service delivery. Results of good practice and case studies conducted worldwide submitted provided in the Guideline annex also support this impact. In order to determine the steps recommended in the guideline and the measures to be implemented, a pilot field study was carried out in the Kepsut District center to diagnose the current situation within the scope of Task 1. As a result, it was determined that there was a 10% decrease in monthly energy consumption with the studies carried out for only one month period, and this revealed that the studies carried out also have a high potential in terms of energy efficiency and are of great importance.

It is particularly important to understand that NRW management is not a one-off activity hence, it requires the long-term commitment and involvement of all water utility departments. Successful NRW reduction is not about solving an isolated technical problem, but is instead tied to overall asset management, operations, customer support, financial allocations, and other factors. It is not only the management’s responsibility, but the responsibility of everyone in the utility. Many utility managers do not have access to information on the entire network, which would enable them to fully understand the nature of NRW and its impact on utility operations, its financial health, and customer satisfaction.



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1 NON-REVENUE WATER AND WATER BALANCE

1.1 Non-Revenue Water and Components

The International Water Association's (IWA) definition of **Non-Revenue Water** is the difference between the cubic meters of water distributed into the water supply system and the cubic meters invoiced with the customer. In other words, the difference between the amount of water a utility puts into the distribution system and the amount of water billed to consumers is known as 'Non-Revenue Water'.

Non-Revenue Water is mainly composed of two components:

- Water losses,
- Unbilled authorized consumption.

The first component of NRW is water losses in water supply and distribution systems. High level of water losses in water supply and distribution systems have been one of the major challenges facing WSAs (Water and Sewerage Administrations)/WUDs (Water Utilities Departments) across the developing world. Total water losses include:

- Physical (Real) Losses comprise leakage from all parts of the system and overflows at service tanks. Therefore, it indicates the water loss before the consumer meters, due to leaks and overflows. 'Real Losses' are referred as 'Physical Losses' or 'Leakages' in our country's regulatory system and therefore, the term 'Physical Losses (Leakages)' will be used primarily to describe 'Real Losses' in the Guideline.
- Apparent (Commercial-Administrative) Losses are defined as water losses caused by meter and reading errors, data handling errors, and theft of water in various forms. 'Apparent Losses' are referred as 'Administrative Losses' in our country's regulatory system and therefore, the term 'Administrative Losses' will be used primarily to describe 'Apparent-Commercial Losses' in the Guideline.

The second component of NRW is unbilled authorized consumption as stated previously. Unbilled authorized consumption consists of either metered or unmetered authorized consumption not billed due to the policy of the water utility. Such consumption includes firefighting and training, flushing of mains and sewers, cleaning of suppliers' storage tanks, filling of water tankers, water taken from hydrants, Street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc.

It is particularly important to understand that NRW management is not a one-off activity hence, it requires the long-term commitment and involvement of all water utility departments. Successful NRW reduction is not about solving an isolated technical problem, but is instead tied to overall asset management, operations, customer support, financial allocations, and other factors. It is not only the management's responsibility, but the responsibility of everyone in the utility. Many utility managers do not have access to information on the entire network, which would enable them to fully understand the nature of NRW and its impact on utility operations,



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its financial health, and customer satisfaction. Underestimating NRW's complexity – and the potential benefits of reducing NRW – often leads to the failure of reduction programs.

Insufficient allocation of finance is another cause of weak NRW management and resulting high water losses. From a utility's point of view, not allocating finance to NRW reduction is a short-sighted strategy because, effective NRW management will lead to increased revenues and profitability for the utility if done properly. The inclusion of financial Key Performance Indicators (KPIs) linked to NRW can be used as incentives to seek increased budget allocations for successful NRW management.

1.2 Water Balance and Standardized Terminology- Definitions

The water balance calculation provides a guide to how much is lost as leakage from the network ('physical' losses), and how much is due to 'administrative' or non-physical losses. The components of NRW can be determined by conducting a water balance. This calculation, which must be in balance, is based on the measurement or estimation of the water produced, consumed or lost.

Because of the wide diversity of formats and definitions used for water balance calculations internationally (often within the same country), there has been a need for a common international terminology. Drawing on the best practice from many countries, IWA Task Forces on Water Losses and Performance Indicators have produced an international best practice approach for water balance calculations, including definitions of its components, and for comparing performance between utility operators.

Since Standard Water Balance Form given in the current Regulation is based on the IWA's international format published in the year 2000, most of the definitions are very similar. Abbreviated definitions of principal components of two approaches are described in Annex B.1.

1.2.1 Current Water Balance in Turkish WSA/WUDs

In our country, there is a regulation and a communiqué on the control of water losses in drinking water supply and distribution systems. The Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems was published in the Official Gazette dated 8 May 2014 and numbered 28994. Following the Regulation; "The Technical Procedures Communiqué on Control of Water Losses in Drinking Water Supply and Distribution Systems" was published in the Official Gazette dated 16 July 2015 and numbered 29418. The purpose of this Communiqué is to determine the measures to be taken for the control of water losses in drinking-utility water supply and distribution systems.

The regulation was amended with the Official Gazette dated 31 August 2019 and numbered 30874. The communiqué was amended with the Official Gazette dated 23 September 2020 and numbered 31253.

According to the Regulation and the Communiqué all WSA/WUDs need to fill the standard water balance form given in Annex 1 of the Regulation along with other forms and submit it to the Ministry of Agriculture and Forestry once in every year by the end of February for the previous year.



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It is stated in the regulation that the table has been prepared for the following purposes.

- Guiding the water utilities in determining at which points/areas of the system the lost water is lost,
- Enabling water utilities to make regulations in more accurate areas more easily and quickly,
- To ensure investment planning and taking precautions.

Annex 1 of the Regulation has the Standard Water Balance Form (Table 1) that each WSA/WUD is required to fill and submit to the Ministry of Agriculture and Forestry. Additionally, description of the terminology and explanations to help water utilities are provided in the *ANNEX B- DEFINITIONS*.

According to the IWA description; apparent losses include all types of inaccuracies associated with customer metering as well as data handling errors, such as meter reading and billing, plus unauthorized consumption from theft or illegal use. As it can be seen in Table 1 the current regulation in Türkiye refers these losses as ‘administrative’ losses as a component of water losses as mentioned before.

Table 1 Standard Water Balance Form Given in the Current Regulation

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered Consumption	
	Water Losses	Administrative Losses	Unauthorized Consumption	
			Meter Errors	
		Physical Losses	Loss-Leakages Occurring in Supply and Distribution Lines and Service Connections	
			Leakage and Overflows in Water Storage Tanks	

Source: The Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems was created based on ANNEX 1.



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1.2.2 Recent IWA Water Balance Table

The International Water Association (IWA) is an open, yet ordered platform in which both innovators and adopters of new technologies and approaches can generate creative friction. It is a place for diffusion, benchmarking and evidence. The severe water challenges facing the world today require an unprecedented global response. IWA members are situated in 140 countries worldwide, forming the largest international network of water professionals working towards a water wise world³.

IWA's programmes develop research and projects focused on solutions for water and wastewater management. Association organise world-class events that bring the latest science, technology and best practice to the water sector at large and work to place water on the global political agenda and to influence best practice in regulation and policy making. IWA do this via the IWA's global membership⁴. Drawing professionals from 140 countries, the membership of the IWA brings together scientists, researchers, technology companies, and water and wastewater utilities, all working to address the world's most urgent water challenges when and where they arise.

The studies produced by all the experts working in IWA and its programs are accepted worldwide for the reasons listed above. The water balance form, which was published in the year 2000 and is currently used in Turkey, has been revised by the experts over the years in order to find a solution to the problem and to reduce the NRW as much as possible.

The IWA standard water balance table published in 2016 can be seen in Table 2 with standardized terminology and definitions for the components of the water balance. In order to ensure consistency of assessment and reporting of losses, it is paramount that this water balance and respective definitions of the components are adhered to when undertaking any form of water loss study, auditing or reporting.

³ IWA_Strategic-Plan-2019-2024

⁴ <https://iwa-network.org/about-us/>



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Table 2 IWA Standard Water Balance Table⁵

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Data Handling and Billing Errors	
			Underestimation of Unmeasured Consumption	
			Customer Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to Point of Customer Metering	

⁵ Liemberger, Roland & Farley, Malcolm. (2004). Developing a Non-Revenue Water Reduction Strategy, Part 1: Investigating and Assessing Water Losses.



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2 NRW MANAGEMENT STRATEGY, TARGETS AND PERFORMANCE INDICATORS

2.1 Strategy Overview

High levels of NRW are causing a loss of scarce resources and financial income in the already cash-strapped water sector. NRW has a significant impact on the financial sustainability of Water and Sewerage Administrations (WSAs) and Water Utility Departments (WUDs) through its impact on revenue loss and increased operating costs. Therefore, it is now widely accepted that the NRW is an important indicator of the operational and financial performance of a public institution. It can be seen in all applications that small savings in the NRW have a great positive impact on service delivery. As can be seen from the case studies given in Annex D.1 Case Studies and Best Practices and from the Pilot Study (See Annex D.2) conducted within the scope of the Task 1 study, it is seen in all applications that small savings in the NRW have a great positive impact on service delivery.

2.1.1 NRW Management Rationale

NRW reduction and management is a challenge in many ways. A vision and commitment of the WSA/WUDs is a must in order to achieve a sustainable NRW management system and to increase the performances of water utilities, which have crucial role on management of one of the most vital sources of life: water. Organizational commitment can only be achieved by contribution and coordination of different departments of WSA/WUDs. Another challenge with NRW management is that a significant change on technical, cultural and organizational aspects are needed.

As well as the performance of a WSA/WUD, the investments made before or to be made in the future plays a crucial role on NRW management. Therefore, the need for investments must be put forth with an effective diagnosis study.

In order to those investments occur, a positive (financial) business case is crucial. The initial business case is made by comparing the revenue currently lost to NRW to what would be lost if NRW targets are met. The calculation shall include an estimation of the investment, operational and maintenance costs of the means needed for in materials and man-hours. The business case might also have prospects on income from new service extensions enabled through increased revenues and the extra water that will become available after reduction of non-revenue water.

Institutional

NRW is a transversal topic for any water utility, which is also a difficulty.

To manage NRW, a WSA/WUD needs to be well organized, committed, and equipped, together with competent staff. Reducing NRW will improve customer satisfaction while increasing WSA/WUDs performance and credibility, as the customers will experience fewer interruptions in water supply, sufficient pressure and required water quality defined in water safety plans and national standards.



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Environmental

Less NRW will mean less water lost, resulting in less stress on water resources. It will also increase climate resilience and support the sustainability of ecosystems, decrease carbon footprint of water supply systems and eventually result in lower use of chemicals as fewer service interruptions and fewer ruptures come up in pipes, leading to improved water quality.

Technological

A sustainable NRW management plan will enable efficient use and management of assets, contributing to technological sustainability of the whole water management system.

Social

Managing NRW will increase social sustainability and equity by increasing the WSA/WUD revenues and making more water available and accessible by reducing physical water losses. In addition, NRW management will increase the awareness on the value of water, energy efficiency, climate change and sustainability both at the institutional level and customer level.

With the Sustainable Development Goals (SDGs), the UN has created a foundation for a more sustainable future. Water utilities now have a crucial role on implementing and overcoming the obstacles that occur during the pathway for SDGs. NRW management is primarily related to numerous of Sustainable Development Goals; mainly *SDG 6 “Clean Water and Sanitation”* as well as other SDGs such as *SDG 8 “Decent Work and Economic Growth”*, *SDG 9 “Industry, Innovation and Infrastructure”*, *SDG 11 “Sustainable cities & communities”* and *SDG 13 “Climate Action”* (See Figure 1 Sustainable Development Goals That the Project Contributes Primarily



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Figure 1 Sustainable Development Goals That the Project Contributes Primarily

2.1.2 NRW Management Contribution to Climate Change

The global climate change crisis is inextricably linked to water. Climate change is increasing variability in the water cycle, thus inducing extreme weather events, reducing the predictability of water availability, decreasing water quality and threatening sustainable development, biodiversity and enjoyment of the human rights to safe drinking water and sanitation worldwide⁶.

National and regional climate policy and planning must take an integrated approach to climate change and water management. Increased water stress and meeting future demand will require increasingly tough decisions about how to allocate water resources among competing water uses, including for climate change mitigation and adaptation activities. If a sustainable future is to be created, continuing along a “business as usual” pathway is no longer an option, and water management needs to be scrutinized through a climate-resilience lens.

Improved water management, including sanitation, is an essential component of successful climate mitigation and adaptation strategies, as called for in the 2015 Paris Agreement. The approaches of the Paris Agreement to “ensure development with low greenhouse gas emissions and not harm food production while realizing these” and “stabilizing

⁶ Water and Climate Change UN Water Policy Brief, 2019



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the financial flow on the path to low emission and climate resilient development" are in line with Türkiye's Green Development vision.

Water is also key to attaining the goals and targets of the Transforming our World: the 2030 Agenda for Sustainable Development and the Sendai Framework for Disaster Risk Reduction 2015–2030. Climate-resilient water management can therefore act as a mechanism of coherence among these global frameworks.

According to the Intergovernmental Panel on Climate Change (IPCC), “the relationship between climate change mitigation measures and water is a reciprocal one”⁷. Therefore, climate adaptation measures introduced to reduce GHG emissions have direct implications for water resource use and management. Conversely, water extraction and management measures have an impact on carbon emissions due to the energy intensity of water treatment and distribution systems. For example, GHG emissions reduction activities often depend on a stable supply of adequate quality water.

In parallel with all these international efforts to combat climate change, the strategies have been formed and the action plans have been developed in Türkiye. The main documents are given in Table Annex A-6.

In order to decrease water extraction and to maintain the sustainable water management should be focused on the optimization of the balance between water production and adequate water supply.

NRW reduction projects are considered as climate smart investments in all these approaches. Physical and administrative loss in the city's water supply system negatively affects resource capacity and contributes to GHG emissions. Surplus water treated, pumped and transmitted to the cities increases energy consumption and consequently GHG emissions. The other crucial negative effect of water loss is preventing water tariff optimization.

Rapid socio-economic developments and increasing climate change pressures negatively affect water resources and raise concerns about water scarcity. Specifically, the Mediterranean region was pointed out as a threatened area for water scarcity in the near future. Therefore, water utilities should have a highly efficient process to sustain a sufficient water supply quantity. Hence, minimizing water losses is crucial in getting the maximum benefit from a unit of produced water in an efficient municipal water supply system. Bringing attention to water loss may be difficult because it is mostly invisible, and it may negatively impact government budgets, environmental resources, and user's health. However, the variety of impacts can help increase the importance of real costs associated with water losses from the municipal water supply system.

⁷ Bryson Craig Bates and others, eds., “Climate change and water”, Technical Paper (Geneva, Intergovernmental Panel on Climate Change, 2008)



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2.1.3 NRW Management Strategy

NRW has a serious effect on the financial viability of water utilities through lost revenue, lost water resources, and increased operational costs. High levels of NRW reduces a utility's capacity to fund necessary expansions of services, especially for low-income consumers and causes the loss of scarce resources and financial revenue in an already cash strapped water sector. It is now widely acknowledged that NRW is a key indicator of a utility's operational and financial performance. A high level of NRW normally indicates a water utility that lacks good governance, autonomy, accountability, and the technical and managerial skills necessary to provide a reliable service.

Successful NRW reduction requires sustained commitment across the utility. There are a number of complex reasons why utilities struggle to control NRW. These include:

- Failure to understand the problem (magnitude, sources, costs),
- Lack of capacity (insufficient trained staff),
- Inadequate funding to replace infrastructure (e.g., pipes, meters),
- Lack of management commitment,
- Weak enabling environment and performance incentives.

One of the cornerstones of the NRW Management strategy is to understand the relative significance of each of the components, ensuring that each is measured or estimated as accurately as possible, so that priorities can be set via a series of action plans.

Non-revenue water management overall strategy could be defined as a set of actions to support the achievement of sustainable non-revenue water management goals. The strategy is designed to target the reduction of NRW in the most cost-efficient manner.

Reducing NRW delivers multiple benefits:

- Improves customer service levels and customer satisfaction,
- Enhances asset lives and utility management,
- Improves utility financial performance (and/or reduces local government subsidies) by reducing costs and increasing revenues,
- Makes cities more competitive when accompanied by service improvement,
- Improves climate resilience by reducing demand on scarce water resources,
- Reduces emission of GHGs – less energy/m³ delivered.

Financial constraints, limited institutional and technical capacity, and political, cultural and social limitations may be encountered during implementation. All of these factors have an impact on the extent of managing losses and demand and affect the speed with which changes are made. But the goal should always be to make some improvement in current operational



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practice. This can be achieved step by step by increasing staff motivation, through knowledge transfer or new skills.

The first step in developing a strategy is to ask some questions about the network characteristics and the operating practices, and then use the available tools and mechanisms to suggest appropriate solutions, which are used to formulate the strategy. Typical questions are⁸;

- How much water is being lost?
- Where is it being lost from?
- Why is it being lost?
- What strategies can be introduced to reduce losses and improve performance?
- How can we maintain the strategy and sustain the achievements gained?

In this Guideline, the structure of overall NRW Strategy and particular strategies to be developed by WSA/WUDs are given and these strategies are summarized below.

- Overall NRW Management Goal is a sustainable, water and energy efficient water management system with optimum NRW level.
- In this context, each NRW management component is designed as an area of action to serve the NRW management overall strategy.
- Action areas have been developed in a structure that will allow the development of strategic actions specific to WSA/WUDs. Each action area includes diagnostic (where we are), goal setting (where we want to reach) and strategy (how we will achieve it).
- Goals for each key area of actions will be set in order to streamline and focus on the action development process. For all actions, indicative activities are included to provide more information on the type and extent of interventions.
- Actions proposed in “Understanding Current Status” sections for each action area are basically self-water auditing for WSA/WUDs, in other words diagnostic of current status. Standard Water Balance Form given in Annex 1 of the Regulation⁹ will be completed as accurate as possible to understand the problem along with the use of specific Performance Indicators (PIs).
- As a result of “Understanding Current Status” in other words diagnostic (where we are), the actual status of NRW components will be identified. The questions of “how much water is being lost?” and “where is it being lost from?” are determined by using the streamline given in each action area (refers each component of NRW).

⁸ NRW – International Best Practice for Assessment, Monitoring and Control, UK

⁹ The Regulation on Control of Water Losses in Water Supply and Distribution Systems was published in the Official Gazette dated 8 May 2014 and numbered 28994. Amendments were made with the Official Gazette dated 31 August 2019 and numbered 30874.



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- The current status will show the problematic areas of WSA/WUD. Based on the causes of losing water volumes, an NRW reduction strategy can be formulated by WSA/WUD with priorities.
- A diagnostic approach that follows the practical application of viable and achievable solutions is recommended for WSA/WUDs to develop a tailored non-revenue water management strategy.
- The data gathered after “Understanding Current Status” for each component of NRW will be used to calculate PIs proposed in “PI Definitions and Calculation” section. The international limits proposed in the “PI Evaluation for Goal Setting” sections will be used for determination of targets for WSA/WUDs for the NRW management strategy.
- Specific measures/actions are proposed in the action areas in order to tackle each of the NRW causes. The actions given in each action areas are developed regarding two requirements;
 - Short-term actions for the WSA/WUD to clearly identify, monitor and control water balance components; and
 - Actions to be taken to ensure that the performance indicators determined in the understanding current status section reach the limits given in the "PI Evaluation for Goal Setting" sections.

Figure 2 below summarizes the steps and the structure of overall NRW Strategy and particular strategies to be developed by WSA/WUD.

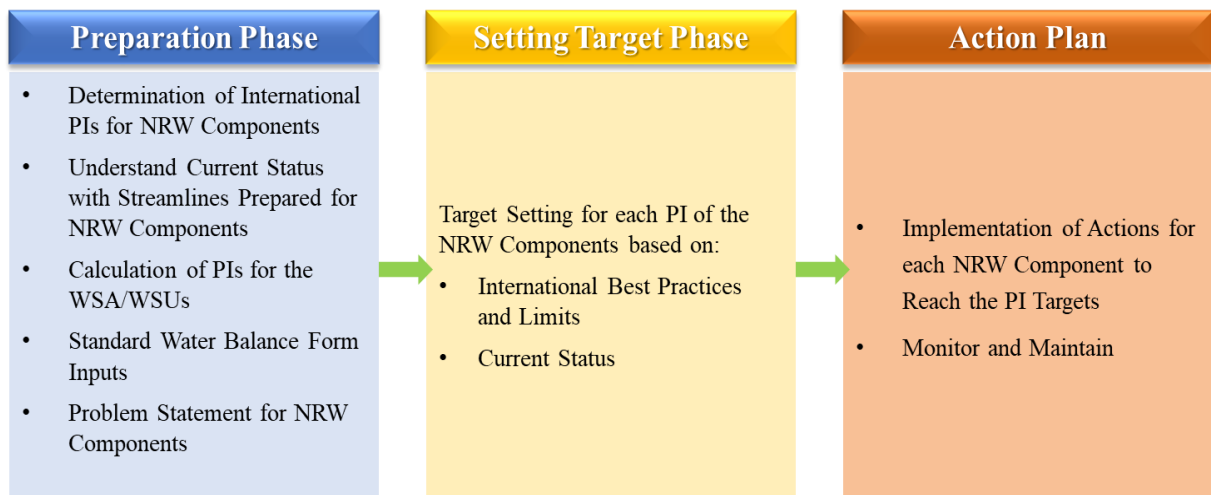


Figure 2 NRW Management Guideline Strategy

2.1.4 Targets for NRW Management

The objective of this Guideline is to develop assess levels existing NRW components, set targets and then enable WSA's to progressively achieve.



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In the last 15 years, various studies have been carried out by experts to determine the NRW targets¹⁰. Instead of setting a target for the NRW as a whole, this Guideline aims to set targets for the components by revealing the current status of complex and interacting NRW components by making analysis and evaluations.

NRW targets will be prioritized according to the status of the components whose current status is determined and target standards are given. However, it is necessary to specify the following objectives with a very general approach.

- Reducing administrative losses generates revenue,
- Reducing physical losses reduces the costs of producing the water (chemical and energy reduction).

As stated above, the Guideline is structured in such a way that a specific target and strategy is created for each NRW component along with each action area. The general NRW targets should be based on:

- Unavoidable Annual Real Losses (UARL): The magnitude of leakage that is considered undetectable will depend on the available detection technologies, availability of staff, pressure of water in the network, type of soil, etc.
- Economic Level of Leakage (ELL): The benefits of leak detection and repair depend on the amount of leakage (burst rate, flow rate), the water tariff, the cost of replacement of pipes, and the operational cost of loss-control (detection and repair).
- Furthermore, the water deficit brings the humanitarian and environmental dimension to the value of water. This might come in as a factor through the water tariff.
- Economic Level of Administrative (Commercial) Losses: The benefit of administrative loss control activities depends on the height of administrative (apparent- commercial) loss and the cost of meter replacement and repair, programs to uncover illegal connections, and programs to verify meter reading, billing and collection data transfer quality.
- Current Annual Real Losses (CARL): The target level of NRW within a project should also depend on the current status of losses and the time available for the project.

¹⁰ For example, the “Recommendations for Initial Non-Revenue Water Assessment” matrix was developed by IWA in 2010. However, the main point about this matrix is the holistic evaluation of NRW. In contrast, it is used for a basic initial assessment of the NRW as an alternative to the commonly used percentages. (R. Liemberger. Recommendations for Initial Non-Revenue Water Assessment. IWA Water Loss 2010. Sao Paulo, Brazil. June 2010.) Considering that the main focus of the Guideline is to establish the water balance, this matrix is not shared in this Guideline.



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2.2 Strengths and Challenges

Implementation of a NRW reduction strategy brings many organizational and practical challenges; however, we must recognize that NRW projects are not new to Türkiye and that there are success stories and lessons to be learned from those service providers who have in the past and continue to address this problem.

2.2.1 Strengths

There are very strong strengths in the position of the national position for the administrations to implement an appropriate NRW management. The strengths given below, such as the support projections of the national policy and the good practices of the NRW components in various provinces, will facilitate the implementation of an effective, efficient and sustainable NRW management for the Administrations.

- **Regulation and a Communiqué with guiding content**

As stated in Section 1.2.1, there are regulations and communiqués on the control of water losses in drinking water supply and distribution systems in our country (Annex A.2.2.1 Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems and Annex A.2.2.2 Communiqué on Technical Procedures Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems). In the action areas given in Section 3 of the Guideline, the Regulation and Technical Procedures Communiqué, which is referred to in many places both for the determination of the current situation and for action planning, has been prepared quite comprehensively. After the publication dates, changes have been made at various times parallel with the developments in the world. In this respect, the fact that there is an up-to-date and updated legislation in this context in our country should be defined as a strong direction for the implementation of GGS management Projects in terms of administrations.

As stated in Annex A.2.2 and explained in all actions given under Section 3, both the measures to be taken and the methods to be applied to achieve the sustainable water loss management objective are explained in detail.

- **Nationally accepted standard water balance form**

According to the Regulation and Communiqué, all WSA/WUDs are required to submit the standard water balance form given in Annex 1 to the Regulation for the previous year to the Ministry of Agriculture and Forestry by the end of February each year, together with other forms. Standard Water Balance table, which is currently in practice in Turkey, has been prepared based on the 2000 version of IWA Standard Water Balance Table. As stated in Section 1.2.2, the work of IWA and all experts working with the IWA is accepted worldwide for the reasons listed above.

The Standard Water Balance Form presented in Annex A.2.5 describes in detail each component of the balance form. Although the currently used form is IWA 2000 version, it is a form that is actively used in most places in the world and includes all



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basic explanations. It also provides a basis for Administrations to track their performance on a year-by-year basis when they have the necessary data.

- **Setted targets for WSA/WUDs for water losses**

In order to reach the water loss rates determined in the Regulation on the Control of Water Losses in Drinking Water Supply and Distribution Systems within the targeted periods, the "Work Plan Circular on Reducing Water Losses in Drinking Water Systems" was published by the SYGM on 04.10.2021. The objectives set out in the Circular and set out in Annex A.2.2.3 provide motivation for Administrations to plan for the short term. In addition, an action guide is given with Annex 4 to the Circular for the improvement of GIS systems, the implementation of the SCADA system, the development of institutional experience and capacity, and similar actions that are necessary to achieve water loss targets.

Considering the current situation of some Administrations, although it is obvious that aggressive actions and measures should be taken to achieve this target set for water losses, the fact that there is a legal obligation for Administrations is a necessary source of motivation that is accepted worldwide.

- **Good practices implemented in the country**

In institutions with increasing awareness of resource conservation in Turkey, various components of NRW holistic NRW reduction programs have been made and are carried out. With the Law No. 6360, the efficient use of water resources and the potential to generate income from administrative losses in financial terms of WSAs, whose operating capacities are quite difficult, have led to the realization of many good practices in our country.

In the meetings and workshops held during the guideline preparation phase, there was a wide sharing of information exchange between institutions in terms of good practice examples, legislation prepared on an institutional basis and implementation methods. In these studies, it has been observed that organizations with good practices are very open and eager to work together to share knowledge and experience.

2.2.2 Challenges

In addition to the strengths set out in Section 2.2.1 for keeping the NRW level at low levels or implementing NRW Management projects, there are challenges and bottlenecks facing Administrations.

- **Detection of NRW components independently of each other**

While the benefits of reducing NRW are well known, decades of effort have not delivered much improvement in the developing world. While there are many explanations and excuses, much of the failure is due to underestimating the technical difficulties and complexity of NRW management, along with the potential benefits of



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taking action. Underestimating the complexity of NRW and the potential benefits of reducing NRW often leads to the failure of mitigation programs.

The water balance form, which was published by IWA in 2000 and is currently in use in Turkey, has been revised over the years by experts in order to find a solution to the problem and to reduce the NRW as much as possible. The form used in Türkiye is an easy-to-use version with the most basic components. However, rather than the form, the data in the form should be completed with data based on real, up-to-date or at least guesses based on the data. However, the Consultant's experiences in Turkey and the interviews with the Administrations at the Workshop showed that the current Water Balance Forms do not reflect the real situation. Many WSA/WUDs in Turkey use the default percentages in the standard water balance form. Therefore, the NRW component, which is the real problem on a local basis, cannot be identified.

- **Lack of data collection monitoring and control mechanisms**

The concept of water balance of a water supply system is currently well known and commonly used to assess both physical (real) and administrative (apparent-commercial) losses. Nevertheless, the 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. The limited data and knowledge of water supply system means that NRW management, is based more on a process of “estimation” than on an objective analysis and the application of proven technical solutions. Expanding water networks without addressing water losses will only lead to a cycle of waste and inefficiency.

One of the cornerstones of the NRW Management strategy is to understand the relative significance of each of the components, ensuring that each is measured or estimated as accurately as possible, so that priorities can be set via a series of action plans.

Financial constraints, limited institutional and technical capacity, and political, cultural and social limitations may be encountered during implementation. All of these factors have an impact on the extent of managing losses and demand and affect the speed with which changes are made. But the goal should always be to make some improvement in current operational practice. This can be achieved step by step by increasing staff motivation, through knowledge transfer or new skills.

- **Lack of institutional capacity**

It has been stated in Communiqué on Technical Procedures Regulation that there will be a responsible team for losses in WSA/WUDs. However, the team must be certified and undergo necessary field and office training. Centrally support teams should be established for small administrations that have difficulties in creating and managing teams.

Teknik Usüller Tebliğ’nde SUKİ/SHB’lerinde kayıplarla ilgili sorumlu bir ekip olacağı belirtilmiştir. Ancak ekibin sertifikalandırılması, gerekli saha ve masa başı



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eğitimlerinden geçirilmesi gerekmektedir. Ekip oluşturmak ve yönetmek konusunda zorlanan küçük idareler için merkezi olarak destek ekipleri kurulmalıdır. Teams and departments within WSAs have just started to be established. In contrast, WUDs do not have teams assigned for casualties.

From an institutional point of view, deficiencies are listed, including but not limited to:

- The absence of national standard performance indicators is one of the main problems. The absence of performance indicators that are mandatory to be monitored nationally causes WSA/WUDs to accept data that are readily available or that can be easily prepared as indicators. This situation causes these non-indicative data to not be able to evaluate the performance. In addition, it is not possible to compare similar provinces on a national basis.
- Data supply, monitoring and control systems are not available in most Administrations to cover the entire system. This prevents the system from being monitored centrally.
- Since the integration of subscriber information with the Central Population Administration System (MERNIS) and the National Address Database (UAVT) has not been completed, unauthorized water theft is seen as the biggest obstacle to accruing with the previous reading in case the meter cannot be read.
- Local governments should be supported in integration with national systems on Management Information Systems, remote reading and control.
- National water loss awareness studies should be carried out periodically, primarily by Administration's personnel and subscribers. Informative and educational publications should be made, especially on unauthorized use, water theft and malfunction reporting.

In addition, the following other issues are the challenges faced by Administrations for the implementation of NRW management:

- Rapid urbanization,
- Increased the water demand & diminishing water supply,
- Inadequate operation and maintenance policies,
- Political, cultural and social influences.

2.3 Performance Indicators (PIs) for NRW Management

A performance indicator is a measurable value that demonstrates how effectively a utility is achieving key objectives. Performance indicators measure the provided services efficiency and effectiveness and are the result of several variables combination. Organizations use performance indicators at multiple levels to evaluate their success at reaching targets. They can also be used to compare performance and set targets between zones within a large utility. In addition, they can also be used to compare performance between different utilities, although



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care must be taken in their interpretation, particularly if different utilities have differing external factors, costs and constraints.

No single performance indicator will be fit-for-all-purposes or wholly indicative of water system efficiency. Performance indicators have, therefore, to be selected carefully and chosen to be fit-for-purpose for a given situation. With each performance indicator measured and monitored, a transition to better NRW management will be achieved. The performance indicators are given in the related sections with detailed explanations.

It is difficult to find a suitable PI for NRW as NRW is a mixture of both administrative losses and physical losses and the PIs for these components individually are quite different. It is common to express NRW as a percentage of system input volume and performance targets set using this measure. However, the IWA Water Loss Specialist Group (WLSG) recommends that this measure should not be used, since it causes incomplete and erroneous evaluations.

If a single PI for NRW is required, then this should be in the form of NRW per connection i.e.:

$$\frac{NRW}{\text{Connection}} = \frac{NRW_{wsp} \times (24/ST)}{\text{Number of Connections}}$$

NRW_{wsp} = NRW when system is pressurised (wsp)
 ST = Supply Time, hr

IWA PI set related to environmental and economic water loss¹¹:

- Inefficiency of use of water resources (%); Percentage of water that enters the system and is lost by leakage and overflows up to the point of customer metering.
- Non-revenue water by volume (%); Percentage of the system input volume that corresponds to non-revenue water.
- Non-revenue water by cost (%); Percentage of the system input volume that corresponds to the valuation of non-revenue water components.

As stated before, no single performance indicator will be fit-for-all-purposes or wholly indicative of water system efficiency. In order to support Water utilities to compare different systems to each other, evaluate water supply networks and prioritize alternative water losses reduction strategies IWA has recorded 170 performance indicators¹². The performance indicators consist of general indicators providing an overview of the efficiency and effectiveness and detailed indicators dealing with specific aspects of the utility functionally. They are divided in 6 groups: water resources, personnel, quality of services, operational, physical and economic and financial. All of these groups for 170 PIs and a short list of the PIs within these groups is given in *ANNEX C- IWA PERFORMANCE INDICATORS*.

¹¹ IWA, 3rd Edition (2017) of “Performance Indicators for Water Supply Systems”

¹² IWA, 3rd Edition (2017) of “Performance Indicators for Water Supply Systems”



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EU Reference document “*Good Practices on Leakage Management*” prepared in 2015, suggested the which indicator fit for which purposes. Regarding the fact that setting targets, technical and financial performance required for Physical Losses (Leakages) and Administrative Losses are given in Table 4 and Table 11, respectively.

- Set Economic Targets and Track Performance for an Individual System,
- Technical Performance Comparisons of Different Systems,
- Financial Performance Comparisons of Different Systems.



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3 NRW MANAGEMENT SYSTEM ACTIONS

3.1 Introduction

The concept of water balance of a water supply system is currently well known and commonly used to assess both physical (real) and administrative (apparent-commercial) losses. Nevertheless, the 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. The limited data and knowledge of water supply system means that NRW management, is based more on a process of “estimation” than on an objective analysis and the application of proven technical solutions. Expanding water networks without addressing water losses will only lead to a cycle of waste and inefficiency.

Action planning to reduce and control NRW is about how the water balance is expected to be changed when an action plan is carried out, and finally reach a new equilibrium represented by a new-targeted water balance. Many ways may be envisaged to meet the target: the action plan will follow the best one.

A complete action plan consists of a full range of actions to get the various components of the water balance under control.

The action plan is successful when it complies with two conditions:

- (i) The target indicators are met and
- (ii) The results are sustainable.

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.

The scheme in Figure 3 shows that NRW Management need to be considered in three dimensions: change management, project management and operational management. Sub-optimal results are achieved if the three dimensions are not considered together¹³.

- The operational dimension looks at the creation of a current and targeted water balance for the water utility. It defines the technical and operational activities that are required to progress from the current to the targeted water balance, and clarifies the corresponding resource requirements.

¹³ Guidance Notes on Apparent Loss and Water Los Reduction Planning, 2016, This document was prepared by the principal authors of draft Apparent Loss Guidance Notes created by a voluntary group of members of the IWA Water Loss Specialist Group (WLSG) between November 2007 and April 2010.



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- The project management dimension. Professional project management requires a project champion, a committed team, quantified objectives, time scheduling, resource commitment, and adequate tools and techniques for the project to be successful.
- The change management dimension looks at the readiness or willingness of the water utility to address NRW project issues, such as institutional and stakeholders' support, a clear mandate, and an established project strategy. Many action plans have failed for having ignored the essential change management dimension, the study of which should always be considered as a prerequisite for a NRW reduction program.

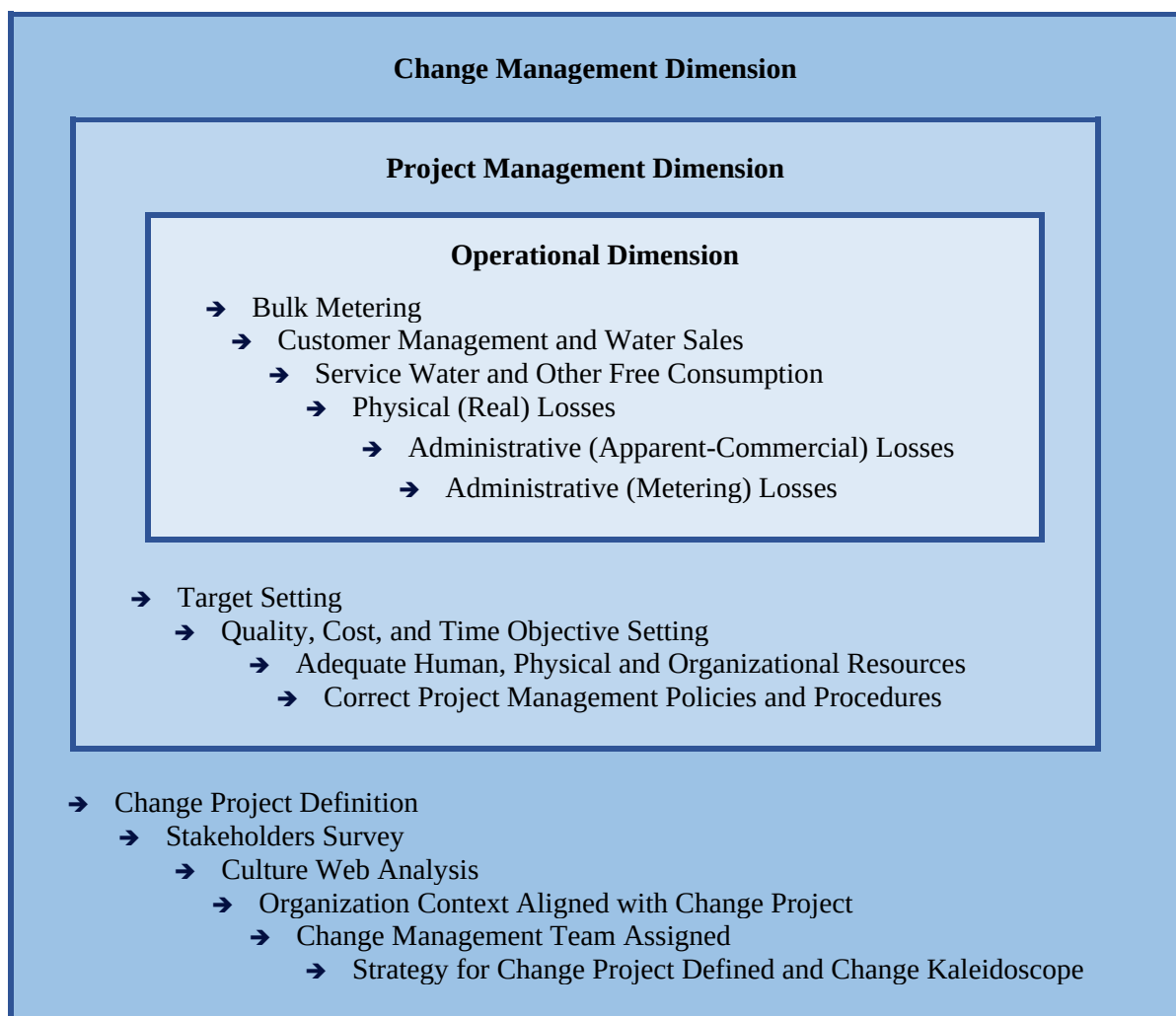


Figure 3 NRW Control as a 3-Dimension Structure

Source: Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016



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Regarding this three-dimensional requirement, each action area is structured to assess the current situation, goal setting, strategy developing for each element.

Each action area for NRW Management System suggested in this Guideline is primarily designed to consist of necessary actions for establishing a database and monitoring the system in order to have information about the system. All actions defined under the action area will be performed in the following steps.

- As a first step for a sustainable and efficient system setup and management, definitions regarding action areas are given in Annex B.
- Performance indicators for each component of NRW are assessed and explained. This step includes the followings;
 - Determination of PI related to the NRW components,
 - Determination of targets by using international and national limits for PIs,
 - Current Status Assessments: In this step, the current situation will be determined. This section is designed in the form of a set of procedures described through streamline – that can be adopted by utility managers, engineers and operations staff to plan and implement a phased, sustainable NRW program in compassing the full-service area and customer base. These recommendations include short-term actions for measurements and determinations. The procedures in the streamlines are prepared regarding the current legislation with the assistance of the experience of the Consultant and previous studies performed in both Türkiye and worldwide.
 - Together with the determination of the current situation in each action area, the following objectives will be achieved:
 - Determination of the current state of the components of the water balance table with the methods explained in the streamlines,
 - Determination of the volume of components with the water balance table, which will be revised after each due diligence,
 - Determination the causes of NRW components,
 - Calculation of indicators with component data,
 - Evaluation of PI with limit given in previous step,
 - Reaching the stage of strategy formation with problem determination and target setting.
- In the final step, actions are defined to establish a sustainable network management system.



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3.2 Action Area: Network Management

Efficient and effective network management system serves the reduction and control of physical loss (leakage), consequently the water supply system will have its sustainability.

A sustainable network management system in other words physical loss control strategy must comprise different elements working together. As suggested by IWA, there are four main elements to deal with physical losses (Figure 4):

- Asset management including pipeline management,
- Pressure management,
- Active leakage control,
- Improvement the speed and quality of repairs.

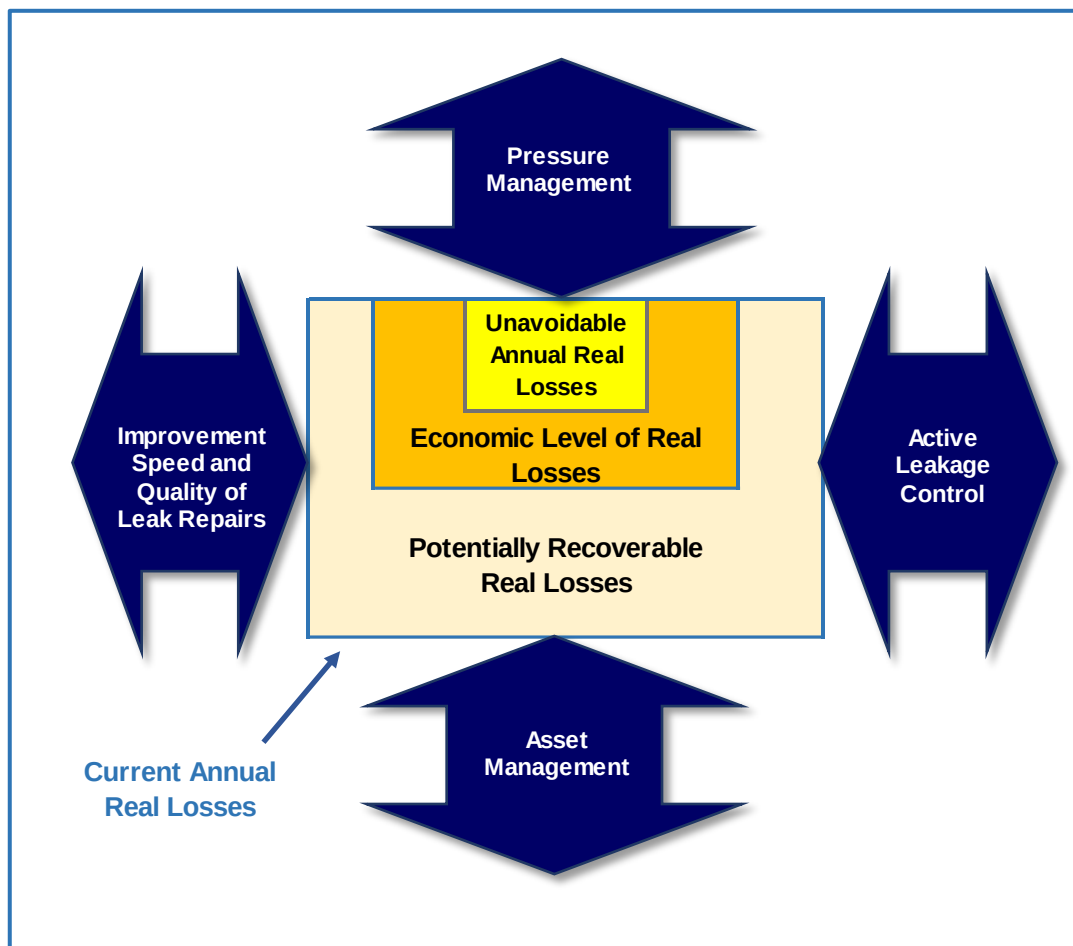


Figure 4 Methods for Managing Physical Loss (Leakage)

Source: Farley, M., & Trow, S. (2003). Losses in Water Distribution Networks – A practitioner's Guide to Assessment, Monitoring and Control. UK: IWA Publishing.

The area of the large outer rectangle represents the Current Annual Real Losses (CARL) volume, calculated from the water balance for a specific system. As the system ages, there is a



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tendency for a natural rate of rise of Physical (Real) Losses through new leaks and bursts, some of which will not be reported to the Utility. This tendency can be controlled and managed by an appropriate combination of all four of the primary components of Network-Physical (Real) Losses Management (the four arrows). The extent to which each of these four activities is carried out will determine whether the CARL volume increases, decreases or remains relatively constant from year to year. While apparent losses can be nearly totally eliminated, a certain level of real losses will always remain in any water supply system. This amount is known as unavoidable annual real losses (UARL).

This diagram is often called the ‘4-Component Approach’ and the process is often called ‘Squeezing the Box’. In the case of an inadequate leakage management policy for any one or more of the constraining policies, the arrows will move outwards and the box will expand as CARL increases.

For each of the four activities, there should logically be an economic level of investment and activity (Economic Annual Real Losses (EARL)), provisionally shown as the intermediate box, when the cost of further reducing CARL would be higher than the benefit of achieving the additional reduction.

3.2.1 Performance Indicators (PIs) for Physical Loss (Leakage)

These performance indicators will be calculated with the actions to be taken in the following sections.

3.2.1.1 PI Definitions and Calculation

Physical losses have been evaluated by the ratio of water produced in general in previous years. However, it has been seen in case studies and country practices that this performance indicator is not a suitable indicator for evaluation of system performance. For example, an increase in the amount of water entering the system with the activation of a high user over time can be considered as a decrease when defined as the ratio of water entering the system, although there is no decrease in physical loss. For this reason, the evaluations are directed to the new evaluations described in this section instead of the percentage volumetric evaluation.

Physical losses cannot be totally eliminated. It is therefore inappropriate to use a measure that implies that physical losses can be reduced to zero. In order to address this, the concept of the unavoidable level of losses has been developed. As given in Annex C, Infrastructure leakage index (ILI) is a performance indicator recommended by the IWA among 170 indicators. ILI is the ratio between the actual physical losses and an estimate of the minimum physical losses that could be technically achieved for the system operating pressure, average service connection length and service connection density.

The EU Reference Document “*Good Practices on Leakage Management*” published in 2015 and the data and functions of these indicators were evaluated as follows.

- ILI is used for technical performance evaluation of water supply systems,
- For target determination and monitoring, the following indicators are proposed:



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- Water losses per mains length ($\text{m}^3/\text{km}/\text{day}$): Total (administrative and physical) losses, expressed in terms of annual volume lost per mains length. This indicator is recommended for bulk supply and low service connectivity distribution systems.
- Water losses per connection ($\text{m}^3/\text{connection}/\text{year}$): Total (administrative and physical) losses, expressed in terms of annual volume lost per service connection. This indicator is recommended for urban distribution systems.

Three performance indicators are proposed in the Guideline for physical losses as follows:

- Physical (real) losses per connection (when system pressurized) (OP27),
- Physical (real) losses per mains length (when system pressurized) (OP28),
- Infrastructure leakage index (ILI) (OP29).

Physical (real) losses per connection (when system pressurized) (OP27)

As a faster and simpler performance index, to be used for target setting and tracking progress in an individual system, unit losses per connection can be used, usually expressed in the form of $\text{l}/\text{connection}/\text{d}$. It is therefore not necessary to know the length of mains or the pressure. The slight downside is that it tends to disadvantage systems with a very low connection density, and it is therefore not recommended for use on systems with a connection density less than 20 connections/km. If the number of connections is not known, a sensible estimate should be made based on a knowledge of likely connection ratio to billed premises. Physical (real) losses per connection are expressed as $\text{lt}/\text{connection}/\text{day}$ when system is pressurized for OP27 indicator.

For a system with continuous supply, the calculation is:

$$\text{Physical (real) losses per connection} = \text{Leakage}/N_c$$

$$\text{Leakage} = \text{Physical (real) Losses (lt/day)}$$

$$N_c = \text{Number of service connections (Nos)}$$

In the case of a system with intermittent water supply the calculation of losses per connection must take into account the supply time¹⁴. The calculation is therefore:

¹⁴ Supply Time (ST): The average period per day that the system is pressurized in intermittent water supply situations. A system is defined as being pressurized when there is sufficient pressure in the system to maintain supply to customers. The figure is used to ensure that the PI reflects the fact that the system may not be pressurized for the full day and therefore leakage will appear lower if the time that the system is pressurized is not taken into account.



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$$\text{Physical (real) losses per connection} = \frac{\text{Leakage}_{wsp} * 24 / ST}{N_c}$$

Leakage_{wsp} = Physical (real) losses when system is pressurised (wsp) (lt/day)

ST = Supply time (hr)

N_c = Number of service connections (Nos)

Naturally, systems which are metered at the property boundary will have lower losses per connection than comparable systems which are metered internally.

Physical (real) losses per mains length (when system pressurized) (OP28)

Unit losses per length of main, usually expressed in the form of m³/km/d, is more appropriate for systems with a connection density of less than 20 connections/km. Physical (real) losses per mains length are expressed as lt/km/day when system is pressurized for OP28 indicator.

For a system with continuous supply, the calculation is:

$$\text{Physical (real) losses per mains length} = \text{Leakage} / L_m$$

Leakage = Physical (real) Losses (l/day)

L_m = Length of mains including all pipelines, except service pipes (km)

For certain assessment period, the calculation is as follows:

$$(\text{Real losses during the assessment period} \times 1000) / [(L_m \times T_{wsp}) / 24]$$

L_m = Length of mains including all pipelines, except service pipes (km)

T_{wsp} = number of hours system is pressurised during the assessment period (ST)

In the case of a system with intermittent water supply the calculation of losses per connection must take into account the supply time. The calculation is therefore:

$$\text{Physical (real) losses per mains length} = \frac{\text{Leakage}_{wsp} * 24 / ST}{L_m + L_p}$$

Leakage_{wsp} = Physical (real) Losses when system is pressurised (wsp) (m³/day)

ST = Supply time (hr)

L_m = Length of mains including all pipelines, except service pipes (km)

L_p = Length of private service pipe between property boundary and customer revenue meter or notional point of delivery (km)

Naturally, systems which are metered at the property boundary will have lower losses per connection than comparable systems which are metered internally.



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Infrastructure leakage index (ILI)

The ILI is the ratio of current annual volume of real losses (CARL) to the physical losses that will occur in the ideal condition that the system can achieve unavoidable annual volume of real losses (UARL), and is a good operating metric for the control of physical losses.

CARL is the current best estimate of the average real losses over a year evaluated using the IWA Standard Water Balance. The volume of unavoidable annual real losses represents the lowest technically achievable annual volume of real losses for a well-maintained and well-managed system. Therefore, the difference between UARL and CARL shows the actual the Potentially Recoverable Real Losses.

CARL and UARL must be evaluated in the same units, typically m³/d, m³/yr. As a ratio, the ILI has no units and thus facilitates comparisons between countries that use different measurement units.

Although Figure 4 appears static, management of Physical Losses is, in practice, a continual battle to limit the tendency of CARL to increase as time passes, using an appropriate combination of all four management components.

ILI is a good benchmark for infrastructure system operation. While a well-run system may have ILI 1.0 (i.e., CARL=UARL), it may not need to be taken as a target.

$$ILI = \frac{CARL}{UARL}$$

CARL = Current Annual Real Loss

UARL = Unavoidable Annual Real Loss

CARL can be easily derived from the standard water balance. UARL equation requires data on only four key system-specific factors as follows:

$$UARL \left(\frac{L}{day} \right) = (18 * L_m + 0.8 * N_c + 25 * L_p) * P$$

L_m = Length of mains including all pipelines, except service pipes (km)

N_c = Number of service connections

L_p = Length of private service pipe between property boundary and customer revenue meter (km)

P = Average operating pressure (AOP) (m)

Note: L_p is not the same as the total length of service pipes. Losses on the service connection, between the tapping point on the main and the property boundary, are included in the allowance per service connection. The additional allowance for the private service pipe was included to take into account longer leak run-times in situations where visible leaks would not be seen by the public. If the customer revenue meter is at the property boundary, then the length of private service pipe (L_p) between property boundary and customer revenue meter will be nil.



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As stated above the difference between UARL and CARL shows the actual the Potentially Recoverable Real Losses.

$$PRRL = CARL - UARL$$

PRRL = Potentially Recoverable Real Losses

CARL = Current Annual Real Losses

UARL = Unavoidable Annual Real Loss

Standard equation for calculating UARL developed and tested by the IWA Water Loss Task Force allows for:

- Background leakage – small leaks with flow rates too low for acoustic detection if not visible,
- Leakage from reported leaks – based on average frequencies, typical flow rates and target average durations,
- Leakage from unreported leaks – based on average frequencies, typical flow rates and target average durations,
- Pressure/leakage rate relationships, with a linear relationship being assumed.

IMPORTANT

With current knowledge and experience, UARL can be calculated for any system or sub-system with:

- More than 5000 service connections,
- Density of connections greater than 20 per km of mains,
- Average operating pressure more than 25 meters.

UARL varies with the density of connections (per km of mains), for systems with customer meters located close to the customer's property limits. When Real Losses are expressed as "per km of mains", it is only possible to compare performance for systems within specified narrow bands of connections density.¹⁵

For smaller systems, the Unavoidable Background Leakage (UBL) can be calculated (working to even lower pressures and connection densities) for the analysis of night flows. (See Unavoidable Background Leakage (UBL))

Unavoidable Background Leakage (UBL)

The UBL is the estimate level of background leakage that may be expected on the area being monitored (zone, DMA or sub-DMA).

¹⁵ Losses in Water Distribution Networks – A practitioner's Guide to Assessment, Monitoring and Control. UK: IWA Publishing, Farley & Trow, 2003



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The ability to calculate UBL for most medium to large systems, and UBL for district metered areas and small systems, has significantly improved the analytical tools available to the leakage practitioner.

The recommended unit factors for UBL are given in table below.

Table 3 Unit Factors for Unavoidable Background Leakage

Infrastructure Component	UBL	Units
Mains	20	Liters per km of mains per day at 50 m pressure
Service Connection – main to property boundary	1.25	Liters per service connection per day at 50 m pressure
Service Connection – property boundary to customer meter	33.3	Liters per km of service connection per day at 50 m pressure

Source: IWA Water Loss Task Force

The formula for UBL is given as follows.

$$UBL \left(\frac{L}{day} \right) = (20 * L_m + 1.25 * N_c + 33.3 * L_p) * AZNP^{1.5}$$

L_m = Length of mains including all pipelines, except service pipes (km)

N_c = Number of service connections

L_p = Length of private service pipe between property boundary and customer revenue meter (km)

$AZNP$ = Average Zone Night Pressure (m)

Note: for AZNP description see Annex B.3

3.2.1.2 PI Evaluation for Goal Setting

Performance indicators defined and calculated in Section 3.2.1.1 will be evaluated in this section with the given limits for those PIs to determine goals and strategies to achieve those goals for a specific component.

During recent 15 years, the specialists have been focused on the best performance of water utilities for different targets. The studies show that using sole indicator for all purposes could not reach the target. Therefore ‘Fit for Purpose’ KPIs have been required to be developed.

EU Reference Document “*Good Practices on Leakage Management*” was published in 2015 and is currently widely accepted by the water loss specialists and IWA. This document categorized suitability of different KPIs for physical (real) losses according to the operational purpose they are used for. Table 4 below shows the categorizations of leakage component of physical (real) losses indicators those are recommended for the determinations of the WSA/WUDs' goals.



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Table 4 'Fit for Purpose' Performance Indicators for Leakage

OBJECTIVE	Volume per year	liters/service connection	m ³ /km mains	liters/billed property	% of System Input Volume	% of Water Supplied	ILI, with Pressure
Target Setting and tracking progress, for an individual system	Yes	Yes*	Yes*	Yes (UK)	No	No	Only if all justifiable pressure management completed
Technical performance comparisons of different systems	No	No	No	No	No	No	Yes
Draw general conclusions from single or multiple systems	No	No	No	No	No	No	Yes, together with other context factors
*Choose services connection density > 20/km; if not, choose mains; or base choice on country custom and practice.							

Source: EU Reference document “Good Practices on Leakage Management”, 2015

A grouping system given in Table 5 has been developed by the World Bank to interpret the ILI indicators and ILI used to define the physical (real) losses in the selected water systems will be assessed regarding this grouping system.

These groups and what needs to be done for real loss performance management are given in the table below.

Table 5 World Bank Grouping Table for Physical Losses

Developing countries ILI range	Developed countries ILI range	Group	General description of true loss performance management categories
<4	<2	A	Further reductions may not be economical unless there is water scarcity; Careful analysis is required to identify cost-effective improvement
4-8	2-4	B	Significant improvement potential; pressure management, better active leak control practices and better mains maintenance
8-16	4-8	C	It can only be tolerated if water is abundant and cheap; even then the level and nature of the leak should be analyzed and leak reduction efforts should be intensified
>16	>8	D	Very inefficient use of resources; leak reduction programs are mandatory and high priority

Source: Performance indicators in Distribution Systems, UNESCO, 2011

Recommended actions are suggested for each ILI range is given Table 6 below.



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Table 6 Recommended actions for each ILI group of World Bank

Recommended Actions for Each LPC Range	A	B	C	D
Investigate pressure management options	Yes	Yes	Yes	
Investigate speed and quality of repairs	Yes	Yes	Yes	
Check economic intervention frequency	Yes	Yes		
Introduce/improve active leakage control	Yes	Yes	Yes	
Identify options for improved maintenance		Yes	Yes	
Assess Economic Leakage Level	Yes	Yes		
Review burst frequencies		Yes	Yes	
Review asset management policy		Yes	Yes	Yes
Deal with deficiencies in manpower, training and communication			Yes	Yes
5-year plan to achieve next lowest band			Yes	Yes
Fundamental peer review of all activities				Yes

Source: Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016

As shown above table (Table 6), if WSA/WUD calculated ILI is in “D” band, any technical action is not proposed. Before implementing any technical action like active leakage control or pressure management, the overall management system including asset management, human resources, capacity of the institutions should be reviewed together with activity planning.

Considering the large number of missing data in the Administrations before the data collection and monitoring phase, instead of ILI; physical (real) water losses per connection (OP27) and physical (real) water losses per network length (OP28) indicators are recommended. These indicators that are also used by experts in the European Union and the sector are given in Table 7.

Table 7 Physical (Real) Water Losses per Connection Groups¹⁶

Technical Performance Category		ILI	Physical (real) water losses per connection (OP27) at pressures below; liters/connection/day				
			10 m	20 m	30 m	40 m	50 m
High Income	A	1-2		<50	<75	<100	<125
	B	2-4		50-100	75-150	100-200	125-200

¹⁶ Liemberger and R. McKenzie, 2005



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Technical Performance Category		ILI	Physical (real) water losses per connection (OP27) at pressures below; liters/connection/day				
			10 m	20 m	30 m	40 m	50 m
(Developed) Countries	C	4-8		100-200	150-300	200-400	250-500
	D	>8		>200	>300	>400	>500
Low and Middle Income (Developing) Countries	A	1-4	<50	<100	<150	<200	<250
	B	4-8	50-100	100-200	150-300	200-400	250-500
	C	8-16	100-200	200-400	300-600	400-800	500-1000
	D	>16	>200	>400	>600	>800	>1000

The studies carried out by AWWA and the average and acceptable range values for NRW and other losses constituting the sub-components of NRW are summarized in the table (Table 8) below.

Table 8 Acceptable Thresholds for NRW and Component Losses

Key Performance Indicator	Unit	Average	Range
NRW Volumetric	%	24.10%	12.20% - 45.50%
NRW Cost	%	9.30%	3.10% - 17.50%
Commercial Losses	lt/connection/day	39.34	8.94 - 78.23
Physical Losses	lt/l connection /day	222.51	98.84 - 567.40
Physical Losses	m ³ /km main line/day	4.29	1.52 - 8.23
Infrastructure Loss Index		3.51	1.24 - 12.68

Source: AWWA Water Loss Control Committee's Water Audit -2011



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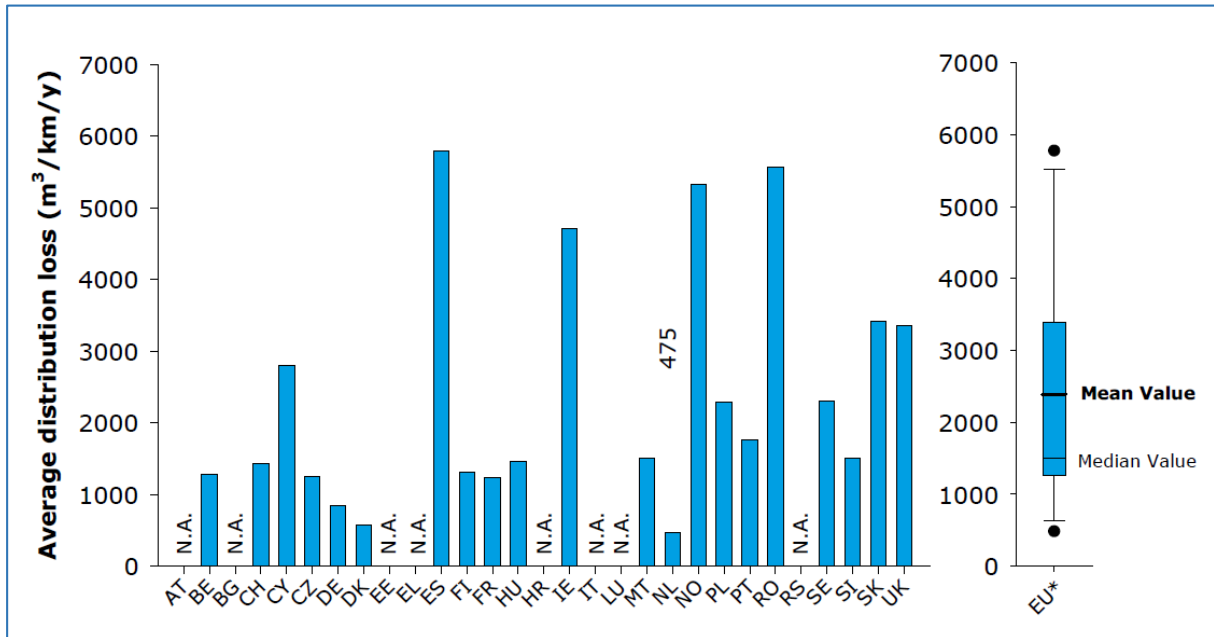


Figure 5 Average physical Water Loss in Network (m³/km/year) 2017 Statistics Results

Source: Europe's Water in Figures, EurEau, 2017

3.2.2 Asset Management

Monitoring and control of losses and leaks in existing drinking water networks has become very important in today's conditions due to limited water resources, increasing effects of climate change, and increasing cost of access to water and network costs. It is of the most critical importance in terms of economic, social and environmental aspects that existing assets are protected at the optimum level and kept in operation with the monitoring and control mechanism. For example, a WSA/WUD aiming to establish its calibration using real-time flow and pressure data should be recording and updating parameters such as the number and type of subscribers, served population, pipe lengths, diameters, installation year and material, total water volume supplied to the system, consumed water volume, daily water consumption, billed water consumption, pressure, flow, valve type, number and kind.

Asset management is a combination of software, systems and services used to maintain and control operational assets and equipment. The aim is to optimize the quality and utilization of assets throughout their lifecycle, increase productive uptime and reduce operational costs.

Asset management involves work management, asset maintenance, planning and scheduling, supply chain management and environmental, health and safety (EHS) initiatives.

Good asset management may be accomplished only when life cycles costs are well planned for in the financial model, and when the technical team keeps an asset maintenance management information system.

For an effective water supply management system, the first step is to create an asset database in order to identify the problem, target setting, controlling PIs in the process then



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develop a strategy. With this database to be created, each component of the NRW can be analyzed and managed. As an example, the one strategy for minimizing leakages in pipes and other assets in the distribution network is replacing them when their economic life is reached.

In order to determine the pipes optimum replacement time, material, diameters and age of existing pipes material are required to be known and recorded. Many pipes suffer from high breaking frequencies from the start of their operation, especially if the quality of the material and the proper installation process are ignored. Before taking the decision of the replacing pipes, the cause of the pipeline failure should be known and WSA/WUD should ensure that the new pipeline will not fail at the same frequency as the old pipeline. The spatial and time frequency of pipe failure incidents should be determined by using the right models. After determination and recording the pipes failures, their causes, both replacement program and proactive and preventive maintenance programs would be prepared and implemented.

Benefits of asset management are as follows¹⁷;

- Much longer-lasting assets,
- Reduced time asset is kept out of service for rehabilitation,
- Reduced incidence of crashes and fatalities caused by deteriorating infrastructure,
- Reduced lifecycle cost of asset by up to 70%,
- Enhanced ability to budget preservation efforts & costs over life of asset,
- Ideal basis for linking planning to performance indicators,
- Greater transparency and accountability between asset developer and asset patron over performance of asset and cost of using the facility.

Although asset management system is a component of the Management Information System (MIS), it is also recommended as a separate action area because it is necessary to use asset management when determining NRW management strategies for the WSA/WUDs. The actions given hereunder asset management actions cover the components necessary for establishing an effective, efficient and sustainable NRW Management system. Particular attention should be paid to the fact that it does not cover all the components for the transition to a full asset management for WSA/WUDs.

3.2.2.1 Understanding Current Status

Understanding the current status is necessary to identify the actual status of NRW components (diagnostic (where we are)). After setting a goal (where we want to reach), this

¹⁷ Martin, T., & Roper, R. (1997, September). ARRB Research Report 306: A parametric study of the influence of maintenance and rehabilitation strategies on network life cycle costs. Victoria, Australia: ARRB Transport Research Ltd., NCHRP (1996). Synthesis 223: Cost-effective preventive pavement maintenance. Washington, DC: Transportation Research Board.



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step will be used for developing strategy (how we will achieve it) and making more precise SWBF.

In the following streamline, green boxes are questions to be answered either with existing data or need to be determined in this stage. Each "no" answer results in an action for the practitioner. The required actions are given in blue boxes. The results with the orange boxes will be used for the entries to SWBF or to determine the PIs.

Asset management is linked to all components of NRW management. Each baseline study provided in this Guide will actually be used to identify asset management requirements. As stated in the sections above, the first stage of NRW management is to create the water balance form as close to reality as possible, and therefore to find answers to the questions of how much water is lost, where and why. For this reason, it is aimed to start the creation of the water balance form with the action flow chart given in Figure 7 below and to complete it with the data obtained as a result of each current situation determination suggested in the Guide. The action flow chart given in Figure 8, on the other hand, aims to provide the necessary data for the calculation of the PI, which is an important PI, and thus to determine the amount of physical leakage.



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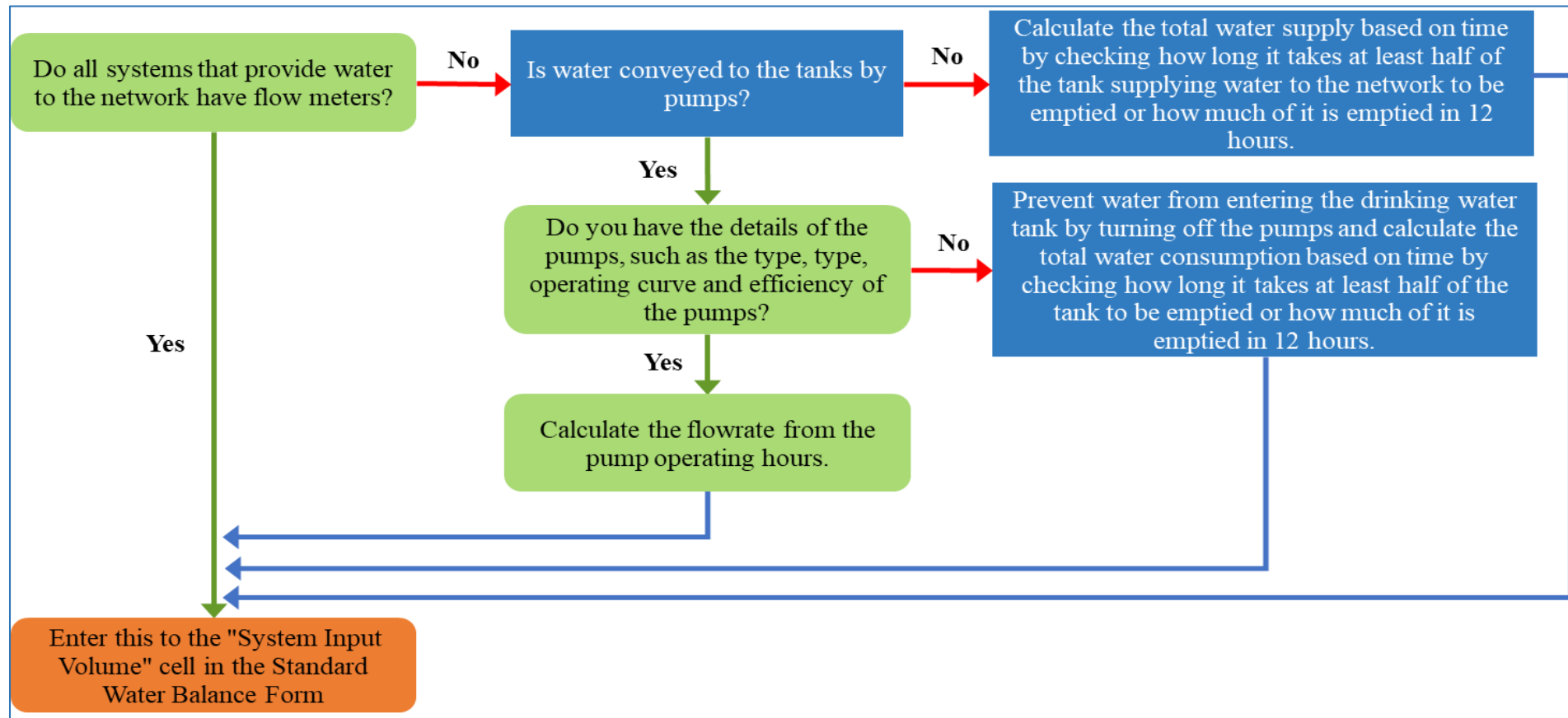


Figure 6 Streamline for Asset Management Current Status-System Input

Source: Consultant's Assessments



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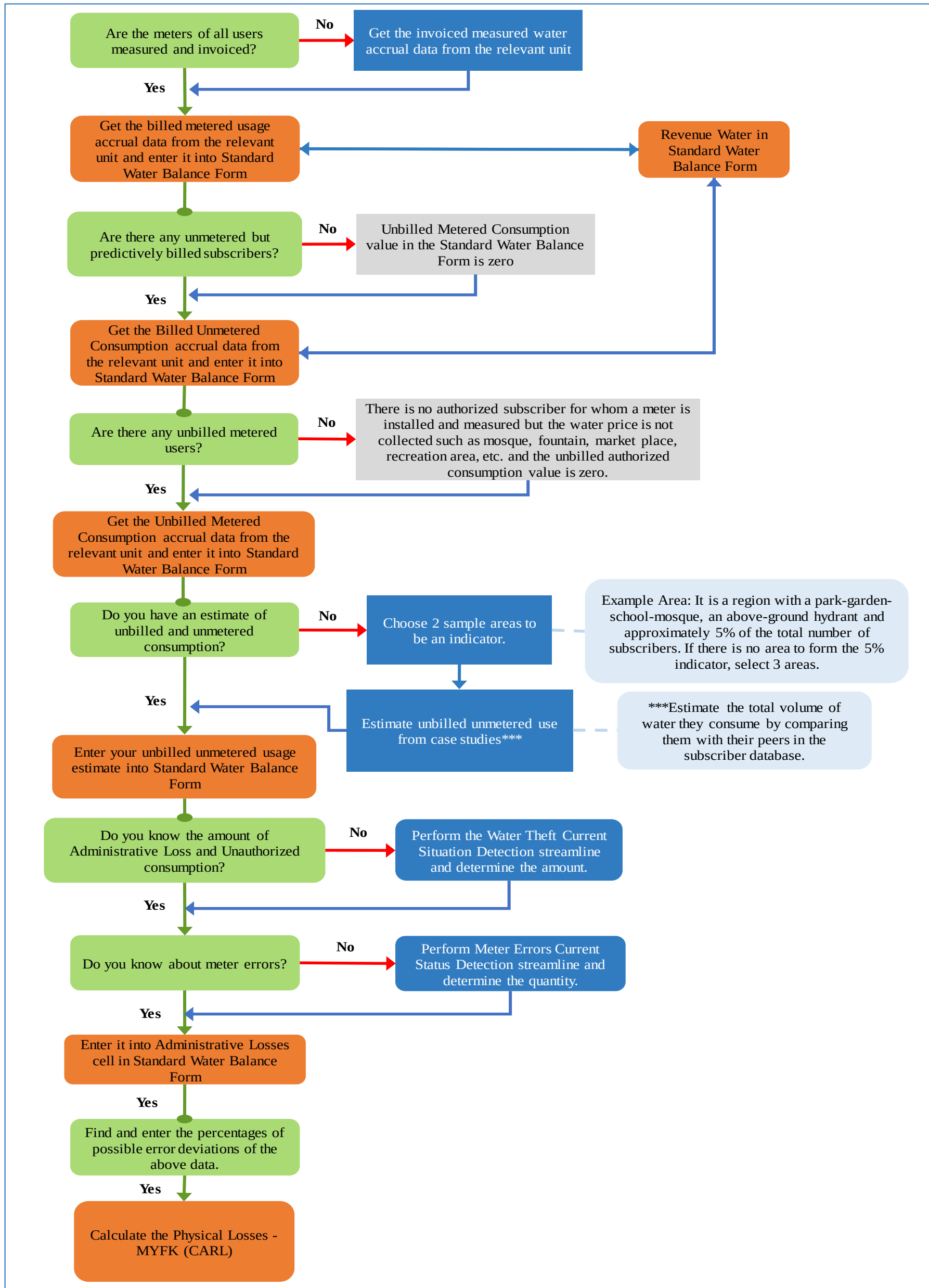


Figure 7 Streamline for Asset Management Current Status-Physical Losses

Source: Consultant's Assessments



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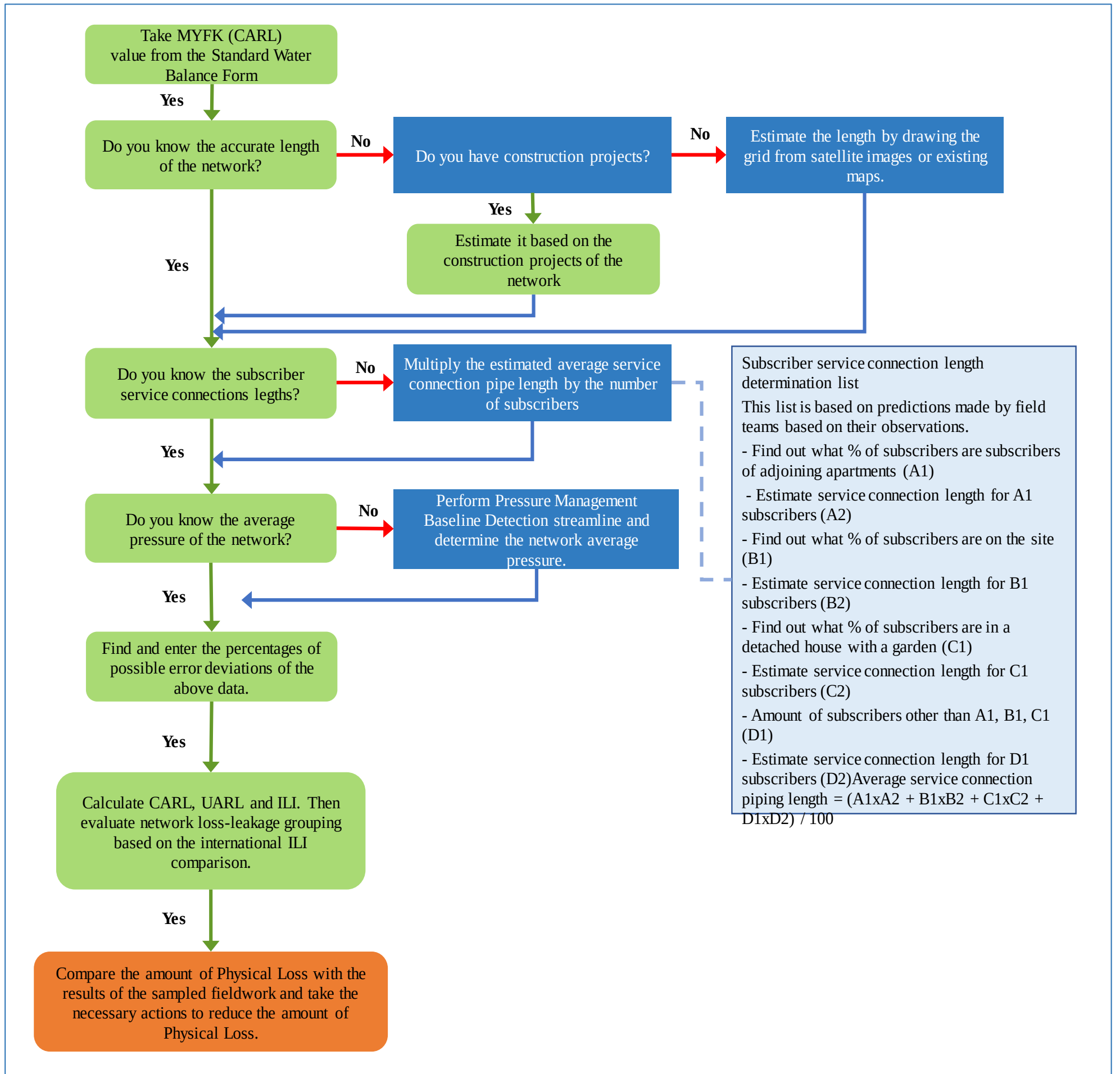


Figure 8 Streamline for Asset Management Current Status- Determination of ILI

Source: Consultant's Assessments



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3.2.2.2 Establishment of Sustainable Asset Management

Asset management is only possible with the establishment of an effective management information system. Today, when combined with the concept of smart cities, incomplete and incorrect data and the inability to provide complete data are prevented.

The water management system should include management information systems established for the most effective management of the process from the source to the end user.

Considering that WSA/WUDs provide active service 24 hours a day, 7 days a week, it is essential to switch to smart water management systems both for the active management of all components of NRW management and for providing fast and effective service to the subscriber. Smart Water Management Systems, using geographic information systems; It covers the stages of water distribution and network management, detection of losses and leaks, waste water management, asset management, subscriber accrual and collection transactions. Smart Water Management Systems with the mobile applications, the work done by the field workers is instantly updated in the central system. In addition to being able to be followed instantly, reporting and viewing takes place in real time. The most important requirement for the transition to the smart management system of the administrations is that SCADA, GIS, asset and maintenance management, subscriber management, management information system and hydraulic model integrations can be done on a single plane.

An effective and efficient water management system should include the following management systems.

- **Subscriber Information Management System:** Recording and analyzing the subscriber system that generates income for WSA/WUD should be considered as the first priority action. All financially important requirements for WSA/WUD such as meter management, tariff management, etc., other national and local systems to be integrated, and an effective subscriber information management system can be monitored, controlled and analyzed, and strategies can be determined.
- **Meter Management:** It is necessary to actively control, monitor and analyze the meters, which are an important component of water losses and income-generating water. For this reason, it is recommended that administrations immediately switch to smart meter management. Smart Meter Management includes the creation of the necessary infrastructure for online transfer and inclusion of subscribers' card and remote reading meter data to the central system, and the integration of related solutions. The operating expenses and resource costs spent for reading activities are reduced by Smart Meter Management,
- **Central Monitoring and Control System:** With the central monitoring and control system to be established, it is ensured that all data coming from the field are reflected on the screens in a way that the operators can follow and interpret. Thanks to the center, detailed management of organizations spread over a wide area is possible from a single center.



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- **Asset Management**

Details on the water management system components listed above are provided in the Management information system section (Section 3.5.2). This section describes actions related to Asset management.

Asset Management

Many water utilities act according to so-called ‘fire-fighting’: the continuous solving of problems that occur instead of undertaking activities to avoid problems that may occur in the future. A good preventive maintenance strategy will save a utility money and work, and will improve customer satisfaction by having less interruptions in water supply and less fluctuations in water quality. Part of the asset management strategy is having a structured way in which to send out work orders to technical staff to check the status and clean assets (such as valves, meters, pumps, hydrants, measuring points) on a regular basis. There are software tools on the market that can help with assessing assets, setting up maintenance plans and distributing work orders.

In order to reduce leakage and maintain the sustainability of the water supply system in this context, the appropriate work management systems to record whether leaks occur on mains, service connections, private service pipes or appurtenances are required.

This level of detailed record keeping is then be used to compare system performance to that used in the calculation of the unavoidable losses and support decisions on the benefits of pressure management, the need for refurbishment, the selection of materials and the appropriateness of construction details.

If properly implemented, asset management principles should influence all aspects of the lifecycle, including planning, design, construction, maintenance, rehabilitation, and disposal/ recycling or replacement (Figure 9).



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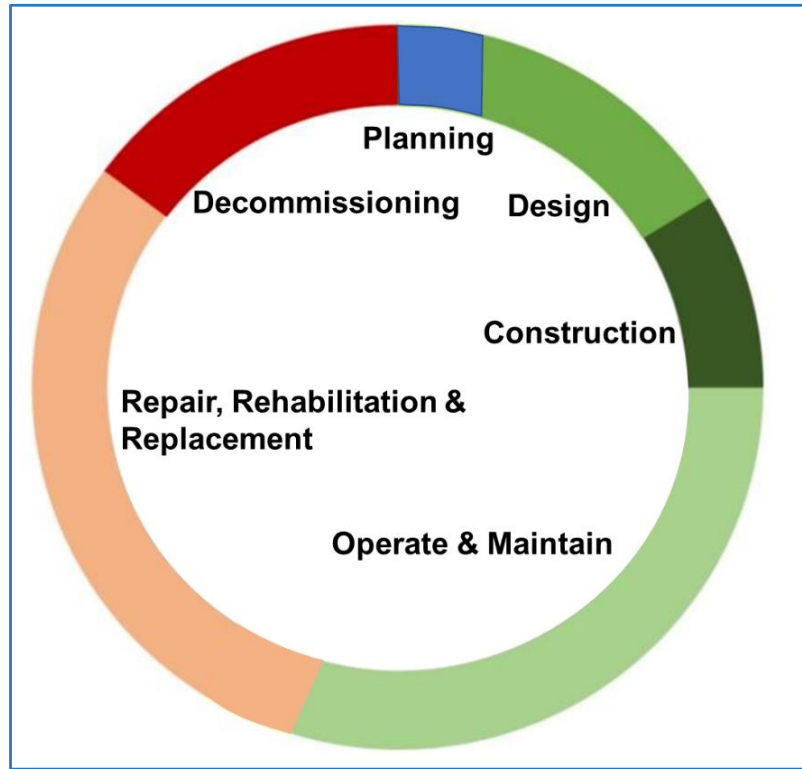


Figure 9 Steps in the Life Cycle of a Single Asset

The phases of an asset's life cycle include every time a decision or expenditure is made related to the asset. Therefore, it is important to recognize that an asset's life starts long before it is put into operation. The beginning of the asset's life is when it is first contemplated as part of *planning or conceptual design*. The next part of an asset's life cycle is design. Once design is complete, the next phase is *construction or installation*. Once the asset is installed, it is ready for *operation*. The next phase of the asset's life includes the *maintenance activities* (all types of maintenance, except corrective which is covered in the next phase under repair). If and when the asset fails, the next three stages of the asset's life come in: *Repair, Rehabilitation and Replacement*. Which of these activities occurs depends on the nature of the asset failure and many other factors. It is also possible for an asset to experience all of these at some point during its overall life. At some point, the asset will no longer be in service and will undergo its last life cycle phase – *decommissioning or disposal*. Throughout the asset's life, it is necessary to have sufficient funding to allow the asset to provide the required level of service. Without sufficient funding, it might not be possible to intervene as needed during the asset's life, and the asset might fail prematurely, reducing the overall cost efficiency.

Creating an institutional maintenance culture is only possible with an asset management system. The asset management to be implemented by the administrations should include the following components. Thus, from the purchase of the asset to its scrapping, it is ensured that its locations, malfunctions and the analysis of the works done for its maintenance and the follow-up of the warranties, including the materials used, are ensured.

- Failure-maintenance management,



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- Energy Management
- Spare parts-warehouse-material management
- Reporting, analysis, PI monitoring

Breakdown-maintenance management,

Operators, who take responsibility for tangible assets, open a work request in case of any unplanned breakdown, enabling the maintenance teams to plan for the intervention of the tangible asset. The status of the job request can be tracked with the stage information on the job requests.

Work requests are evaluated by the maintenance team and the work requests to be intervened are converted into work orders. A responsible person from the maintenance team is assigned to handle the maintenance or breakdown work on the work orders. Transactions related to the subjects specified in the work orders are carried out and processed into the work orders. In addition, interventions are made regarding other issues that are not specified in the work order but noticed during the intervention and can be processed into work orders. Detailed time information regarding the intervention is also kept in work orders. In addition, if there are spare parts or consumables used, they are also recorded.

Planned maintenance is generally applied in three categories. These:

- **Planned/Protective Maintenance:** One of the most important processes that ensure the efficient use of assets is planned maintenance. Planned maintenance periods for all assets and what actions will be taken in these periods are specified. It can be easily followed with the planned maintenance work orders created. By determining the material, labor and equipment needs required for preventive maintenance, it warns the teams about possible bottlenecks and minimizes the costs of keeping the necessary materials in stock. The process can be followed by automatically informing the relevant personnel about the opened work orders and the maintenance period.
- **Preventive\Predictive Maintenance:** This is the category in which operators, rather than maintenance teams, routinely perform checks and maintenance once a week or every two weeks in order to prevent major unplanned downtimes.
- **Autonomous Maintenance:** It is defined as an important maintenance method used to increase the total equipment efficiency by enabling the operator to perform some of the maintenance activities on a daily basis.

Autonomous Maintenance is implemented in 7 steps and is a team effort;

- Daily cleaning of the machine and learning the symptoms that will cause problems,
- Learning the methods to prevent pollution, making hard-to-reach places easy to access,
- Establishment of initial cleaning, inspection and lubrication standards,
- General training on control procedures,



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- Start of “Autonomous” controls,
- Implementation of standards,
- Start of fully autonomous maintenance.

Energy Management System

Savings in energy costs can be achieved through investment when governments implement energy-saving measures in response to rising costs. But when these measures were not made a part of normal business activities, energy costs again fluctuated and spiraled out of control. When systematically focused on continuous improvement through the energy management system, it has been seen that energy performance improvements are sustainable and costs continue to decrease over time.

Energy management means systematic attention to energy in order to continuously improve the energy performance of the organization and to maintain these improvements. It enables the organization to continually go through a cycle of planning action, implementing actions and checking results, reviewing progress, and updating policy and objectives as the case may be.

ISO 50001 Energy Management System, within the framework of the standards determined by energy experts, ensures the creation and sustainability of processes and systems that create an energy management system, save energy, reduce energy costs, and encourage environmental awareness.

The Energy Management System helps organizations of all sizes to sustainably manage their energy use. The benefits to be provided by the energy management system can be listed as follows:

- Less greenhouse gas emissions,
- Lower carbon footprint,
- Energy cost savings,
- Prioritizing low-cost and no-cost energy saving opportunities,
- Less affected by changing energy prices,
- Increasing the energy awareness of the employees and more participation,
- More information on energy use and consumption and improvement opportunities
- Conscious decision-making processes,
- Decreased uncertainty as future energy use is better understood.



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Spare parts-warehouse-material management

A spare part material stock management system is very important to ensure that the right material is available at the right time and place. With this system, while keeping track of the stock of materials, it also contains very detailed information on many subjects such as price analysis and place of use. In this way, details such as which spare part is used the most, how much is left to its expiration date, and the price information it was purchased, are used jointly by different administrative departments to provide analyzes about the most appropriate and highest quality of materials.

It offers compatibility options such as minimum order quantity, critical stock amount, material returns, automatic notification of decreasing stock amount with the codes to be given to each spare part.

It supports the institution in meeting all material needs properly and keeping inventory costs at a minimum level by following the stocks properly.

- It allows project-based, breakdown-based, location-based budget planning.
- It allows comparison with previous prices in the purchase of spare parts.
- All materials are barcoded, allowing information flow regarding material movement.
- It facilitates stock tracking and provides information about the critical stock level.
- It allows the preparation of material requirement reports for spare parts planned to be used in planned maintenance.
- Supplier analysis can be done during the material order, accelerating the purchasing process and allowing the best quality material to be purchased at the most affordable price.
- It tracks the material life according to the expiry date and reorders if necessary.

The effective use of stocks, high availability, affordable and quality material supply with the spare part material management system play an important role in reducing stock costs.

Stock: It refers to any kind of material that is at rest, that is, it is a physical asset. Spare parts, raw materials, semi-finished products, finished products, etc. on the shelves. creates stocks. In fact, stock may be affected by changes in market conditions, unexpected economic situations, seasonal fluctuations or sudden demand changes, etc. It is a precaution taken by the business against uncertainties and inefficiencies in the system.

Inventory: Covers the concept of stock but has a broader meaning. Inventory can be expressed as the monetary value of stocks. There are three types of inventories that run concurrently and in parallel in a business:

- Accounting Inventory: It is the value of the stocks in the accounting records.
- Shelf Inventory: It is the value of the stocks on the actual warehouse shelf.



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- **System Inventory:** It is the value obtained as a record in the stock control system, that is, according to stock cards or stock records.

The number of stocks on the shelves, in the stock tracking system and in the financial records, and therefore their monetary values, must be the same. An administration with different inventory values has an inventory management weakness. In other words, there are inefficiencies and, most likely, costs that cannot be measured because they cannot be controlled, and that are unknown and unnoticed.

3.2.3 Pressure Management

Pressure management is probably the most cost-efficient method of controlling leakage. Pressure management includes all the processes involved in monitoring and controlling pressures within the supply and distribution networks. The knowledge associated with pressure management is now so well developed that the savings to be expected from the deployment of pressure reduction can be readily predicted.

There is a close relationship between applied pressure and the leakage flow rate. Depending on the material of the pipe, the approximate relationship is about 1:1, meaning a 10% increase of pressure, will cause a 10% increase of leakage. Therefore, to reduce NRW to a minimum, it is important to gauge the pressure, see where (and when) it is higher than needed and reduce the pressure by limiting the exit pressure at pumping stations and/or by installing pressure reducing valves.

Pressure management is also the only element that can shrink (or expand) the minimum achievable volume of physical losses. In the past, pressure reduction was only considered in systems with excessively high pressures. Presently, pressure management is considered essential to sustain leakage reduction efforts, especially in deteriorated distribution networks with relatively low pressures. In addition to having an immediate positive effect on the volume of water lost, pressure management will also significantly reduce the frequency of explosions, thereby extending the life of the infrastructure and reducing maintenance and repair costs. Leak detection based only on pipe repairs often leads to increased pressures in other parts of the system, stimulating more leakage, much to the dismay of the utility managers. Pressure management is of utmost importance, especially in low-pressure systems with poor infrastructure condition.

Generally, designs are made to provide minimum pressure in critical areas. During design, the average pressure in the system is usually chosen quite high to meet the worst-case fire and demand flow rates. That is, the design is made according to the hour of the highest consumption and full population development, and even the design diameters are determined to eliminate the lowest pressure value at a single point.

The control of pressure zone valves, their periodic maintenance and control of their function is much more important than pressure control. When it comes to basic pressure control, it may not always be necessary or even appropriate to use high-tech products and equipment. The most basic and reliable equipment may be sufficient for a certain area.



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The key to success is ensuring proper separation and separation of pressure zones and sub-pressure zones (DMAs) rather than valves and high-tech products.

Identifying, separating and keeping sub-pressure zones is not always easy. However, it is the most basic requirement for the successful implementation of pressure control. Pressure control does not completely eliminate physical losses or repair existing losses. Since it lowers the pressure, it reduces the pressure-related losses by many folds and allows them to be detected.

3.2.3.1 Understanding Current Status

Understanding the current status is necessary to identify the actual status of NRW components (diagnostic (where we are)). After setting a goal (where we want to reach), this step will be used for developing strategy (how we will achieve it) and making more precise SWBF.

In the following streamline, green boxes are questions to be answered either with existing data or need to be determined in this stage. Each "no" answer results in an action for the practitioner. The required actions are given in blue boxes. The results with the orange boxes will be used for ILI calculation.



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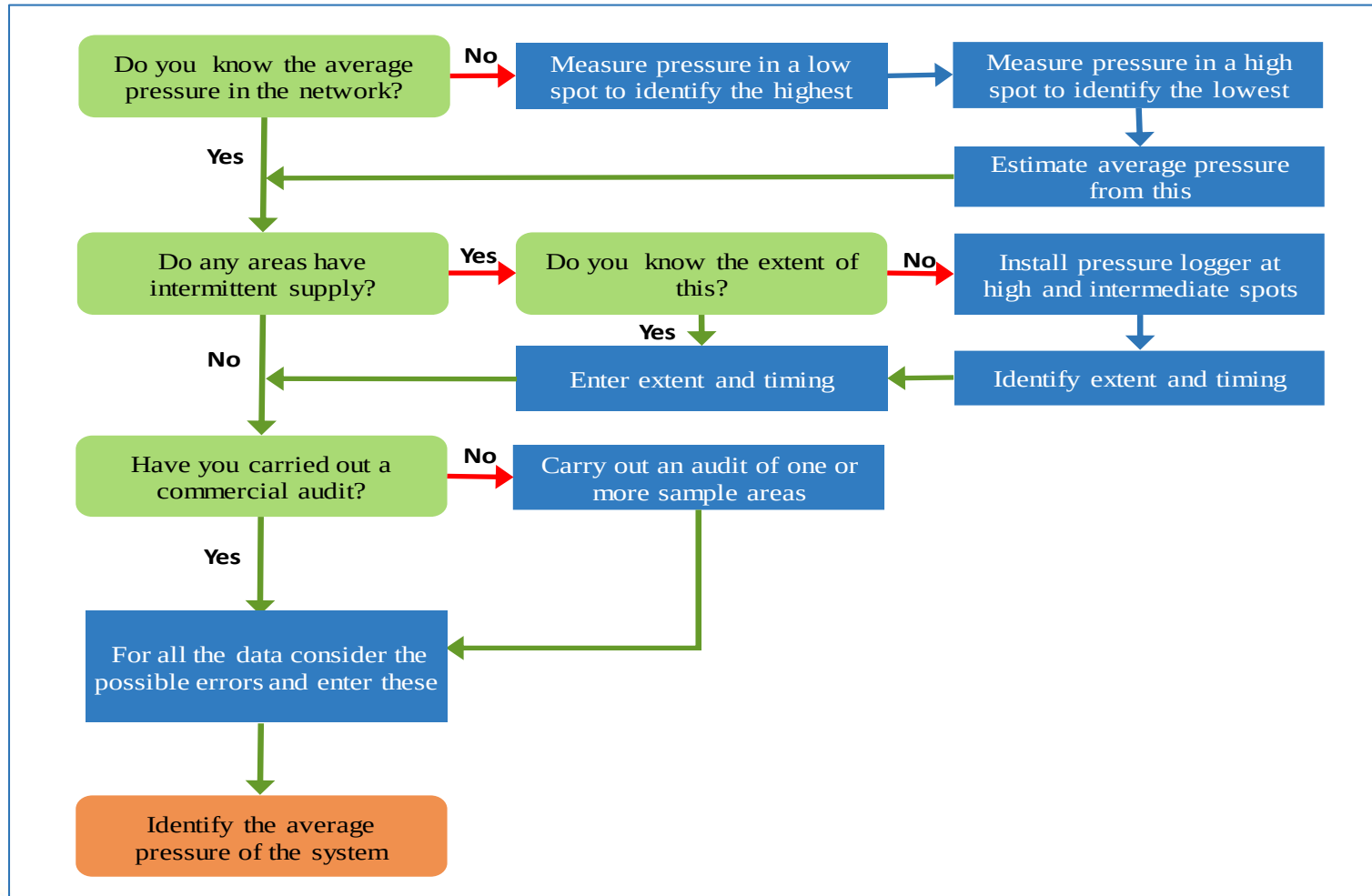


Figure 10 Streamline for Determination of System Average Operation Pressure

Source: Consultant's Assessment



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3.2.3.2 Establishment of Sustainable Pressure Management

Pressure management play an important role in solving the leakage problems. Pressure management may be achieved through the installation of break pressure tanks, pressure reducing valves or through pump controls.

Pressure management is defined as keeping the pressure under control (reducing when necessary) in the drinking water network, provided that the subscribers are provided with uninterrupted and adequate service. Pressure and flow rate are recorded with continuous observations, and arrangements are made based on these observations.

Reducing pressure in a network has a significant impact on leakage as it reduces flow from existing leaks or new leaks when they occur. It also reduces losses from background leakage and the frequency at which new leaks break out on mains and services. The use of PRVs is the most common technique.

For pressure management, Pressure Management Areas (PMAs) must be established with PRVs and regularly monitored (Figure 11). Although the simplest form of pressure management is to divide into zones by height, more advanced pressure management methods are being adopted to avoid rapid pressure drops and pressure fluctuations.

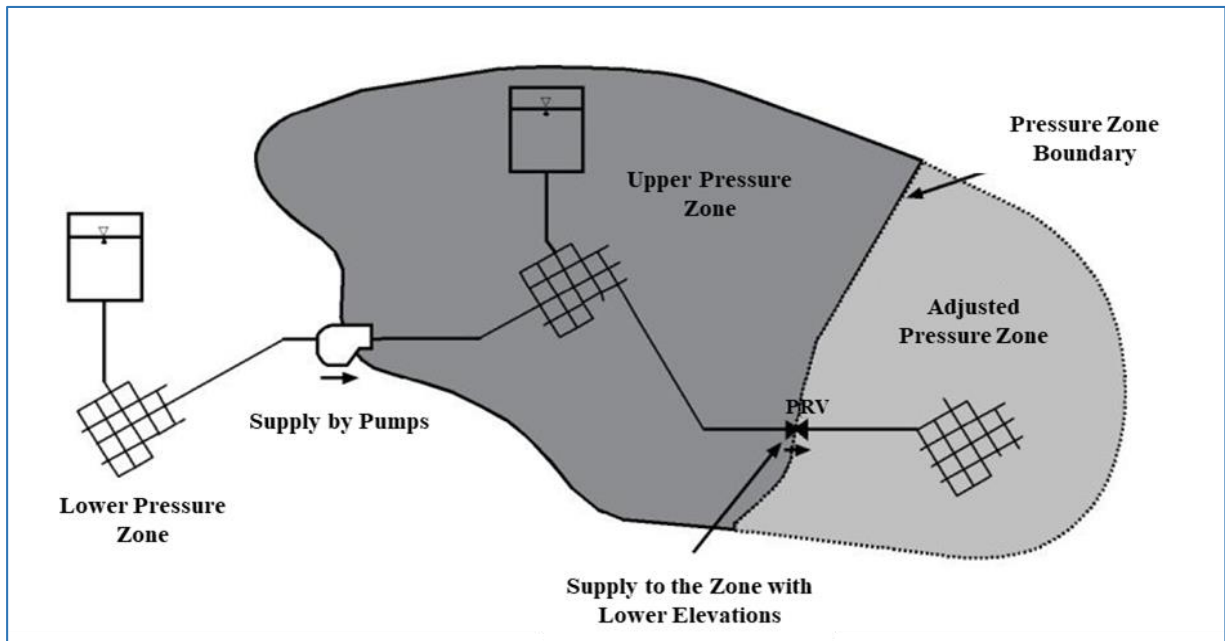


Figure 11 Representative Figure for PMAs

There are four primary methods of pressure management using a PRV; namely: fixed outlet, time modulated, flow modulated and critical pressure control. As stated below, each method has advantages and disadvantages. The most appropriate and most economical form of pressure control should be determined by the Administration, taking into account components such as current budget, technical capacity, satisfaction, operation and maintenance.



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Fixed Outlet Pressure Management: It is the pressure management applied by keeping the mains pressure constant at the pressure breaker valve at the entrance of the zone. There is always the same pressure in the network. This is the simplest form of pressure management. The disadvantage is that no night leakage losses can be reduced by pressure management in this case.

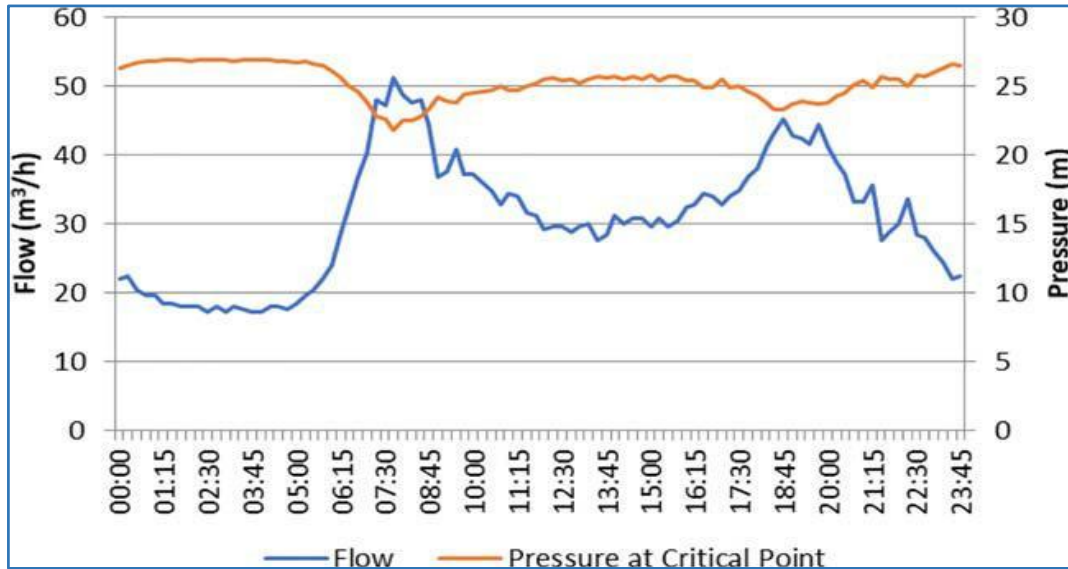


Figure 12 Example Pressure Profile with Fixed Outlet Pressure Management

Source: Pearson, D. (2019). Standard Definitions for Water Losses. (A. Donnelly) London: IWA Publishing. doi:10.2166/9781789060881

Time Modulated Pressure Management: In time modulated pressure management, the pressure setting at the PRV outlet is changed based on the time of day. The most common modulation regime is to reduce pressure at night when consumption is low and pressure would normally rise. It is common to reduce pressure between midnight and 6 am although these hours may be changed to suit local circumstances.(Figure 13)

Time modulated pressure control option provides more reduction in pressure and water loss during periods when water usage is low and therefore pressure is high. However, the Time modulated control is not sensitive to the use of water (firefighting, etc.). This system is more expensive than the conventional fixed outlet pressure control option and requires specialized operation and maintenance crews.



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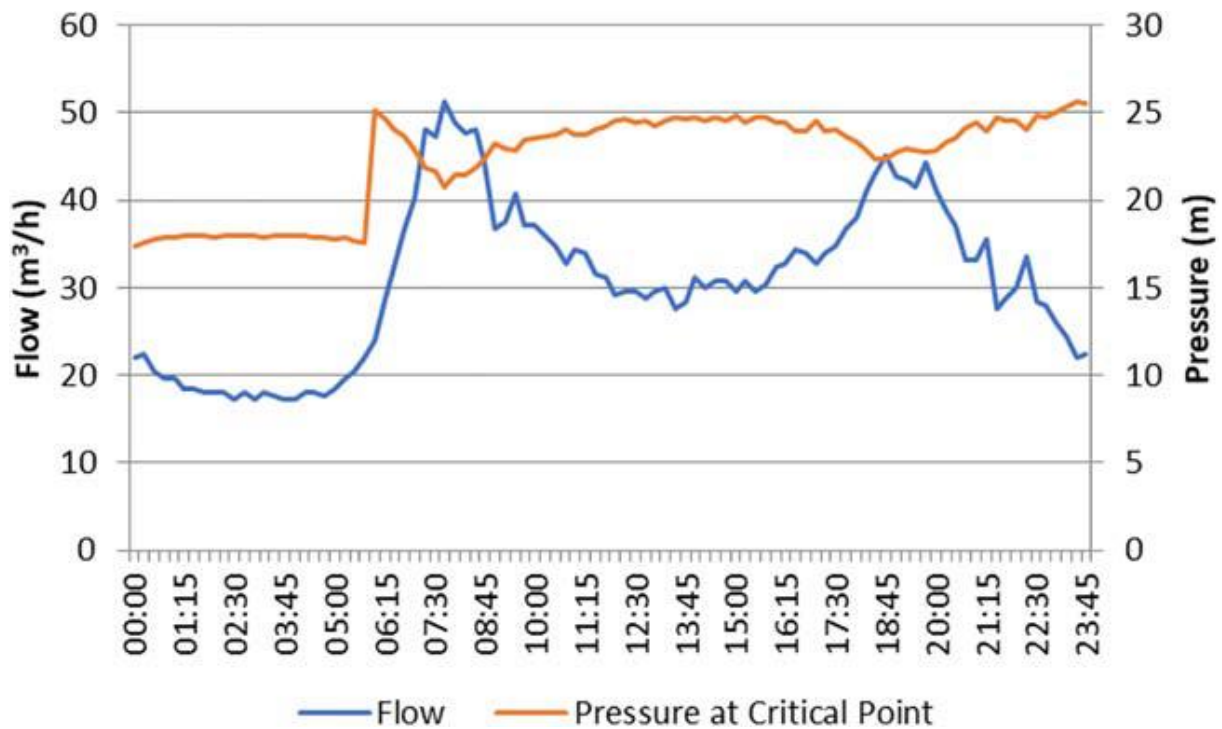


Figure 13 Example Pressure Profile with Time Modulated Pressure Management

Source: Pearson, D. (2019). Standard Definitions for Water Losses. (A. Donnelly) London: IWA Publishing. doi:10.2166/9781789060881

Flow Modulated Pressure Management: Flow modulation is a more sophisticated method where the pressure setting at the PRV outlet is based on the flow through the valve, normally being measured by a flow meter next to the PRV. With this method, a suitable pressure control can be made in areas with night flow usage. The cases where the flow decreases are analyzed and the pressure can be lowered in the relevant time period. Under flow modulation the pressure at the relevant control point will be relatively constant and vary slightly around the desired control level (Figure 14).

The Flow modulated pressure control option provides comprehensive control and flexible operation. It generally saves more water than other options but is more expensive than other options. Requires extra electronic devices and an appropriately sized flowmeter. Its most important advantage is that it does not interfere with the flow of water in any extraordinary situation (such as fire). The disadvantage is that if the night and day flow rates are very close to each other in areas with high loss and leakage, the system may not be able to analyze and control the pressure.



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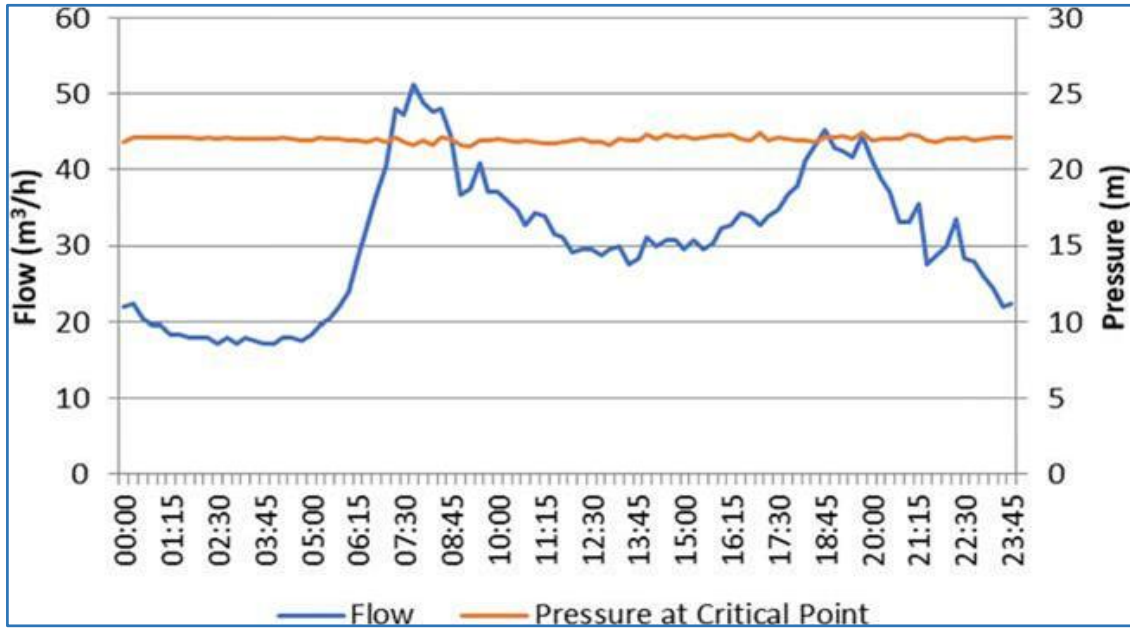


Figure 14 Example Pressure Profile with Flow Modulated Pressure Management

Source: Pearson, D. (2019). Standard Definitions for Water Losses. (A. Donnelly) London: IWA Publishing. doi:10.2166/9781789060881

Critical Pressure Control Pressure Management: In critical pressure control, the PRV or pump may be controlled to deliver a certain minimum pressure at a remote point within a PMA, usually either the average zone point or critical point. This requires a control loop and some sort of control unit such as a programmable logic controller (PLC).

Apart from the pressure control situations given above, one of the most important pressure problems to be solved for the network is the instantaneous pressure fluctuations in the network. The surges can be of very high amplitude, i.e. pressure range, and therefore can cause severe shocks and stress to the system and create leaks.

3.2.4 Active Leakage Control

The most important factors in the formation of physical losses, which are an important component of NRW, can be listed as follows;

- **Pipe material:** In addition to material failures that occur during manufacturing, inappropriate material selections can also cause malfunctions. In addition, in case of existing failures, the volume of loss due to system pressure may increase according to the type of pipe material. In other words, with the effect of pressure in plastic-based materials, the crack diameter expands and the amount of water lost per unit time increases.
- **Corrosion:** All metal pipes are subject to corrosion. Metal pipes that do not take adequate precautions cause malfunctions over time.



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- **Pipe age:** Pipes that have reached the end of their economic life will often cause failures. In systems with a high pipe age, resistance to environmental influences (traffic, vibration, etc.) and operating factors (pressure change) decreases and the risk of failure increases.
- **Improper laying of pipes:** Inappropriate manufacturing is one of the important factors of failures. In particular, the wrong selection of the bearing material and the wrong production, workmanship errors at the connection points increase the risk of malfunction.
- **Pressure:** High pressure will cause more leakage than existing failures. Low pressure will have the effect of increasing losses as it will make it difficult to detect unreported leaks. In addition, pressure fluctuations cause damage to pipes, fittings and valves.
- **Soil effects:** The type of soil has serious effects on leak detection time. Since the water will come to the ground in a very short time on the soils with low leakage permeability, the detection times will be relatively shorter than other faults. On the contrary, since the water will not come to the surface of the earth on soils with a very high leakage potential, it will significantly increase detection times.
- **Traffic load:** Traffic loads on drinking water lines remaining in the vehicle path create an additional load on the pipes.
- **Damages caused by other institutions:** Infrastructure may be damaged during the work done by other persons or institutions.

Physical losses and leaks are examined in 3 different ways according to their formation and dimensions.

- **Reported Leak:** A leak that has been reported to the water utility by means of a notification from the public, often as a visible leak, leakage management software (i.e. alarm management or critical event management routines) or other technology such as remote sensing or permanently deployed acoustic loggers, among other means.
- **Unreported Leak:** A leak that has been found that was not made aware to the water utility by any means and has had to be found by active leakage detection in response to rising night flows. It is usually found using acoustic means. An unreported leak will have a long awareness and location time, usually of the order of 100 or more days.

It is recommended that only the term unreported leak is used in the categorization of leaks, with a relatively long awareness plus location time, within a work management system and leakage management system, in order to aid the construction of a component loss model.

- **Background leakage:** Background leakage is the sum of individual small leaks, such as weeps and drips, that persist with flow rates too low to be detected by an active leakage control campaign, unless either detected by chance or until they gradually worsen to the point that they can be detected. UARL includes an allowance for losses from bursts



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in addition to background leakage. The level of background leakage depends on the overall infrastructure condition, the pipe material(s), the quality of installation and the soil. It is, furthermore, heavily influenced by pressure.

Leak duration is the total length of time a leak runs from the time of breaking out until the water loss stops, usually by it being repaired. The length of time for which a leak runs consists of three separate time components – awareness, location and repair time (Figure 15).

- Awareness time is the time from when a leak breaks out until the water utility becomes aware of its existence. The awareness time is influenced by the type of monitoring system that is adopted.
- The location time is the time between a utility being aware of a leak until it is pinpointed and the repair request issued.
- The repair time is the time that a leak runs between being pinpointed and when the water ceases being lost.

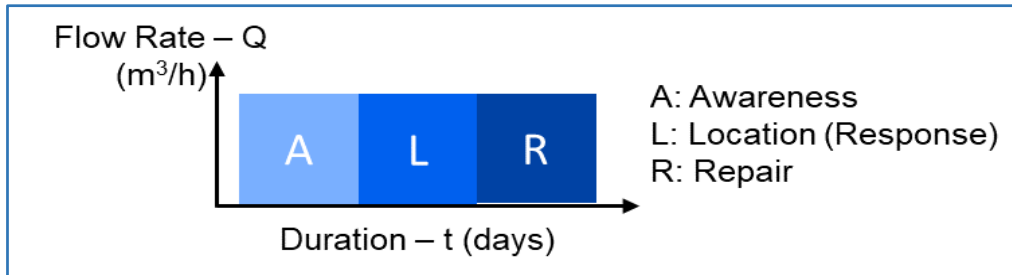


Figure 15 Representation of the Duration of a Leak¹⁸

The longer the time, the bigger the volume of lost water. Therefore, another strategy for leakage minimization is to repair identified leakages and bursts in the shortest time possible, and to ensure that the quality of the repair work is beyond doubt.

¹⁸ Source: Pearson, D. (2019). Standard Definitions for Water Losses. (A. Donnelly) London: IWA Publishing. doi:10.2166/9781789060881



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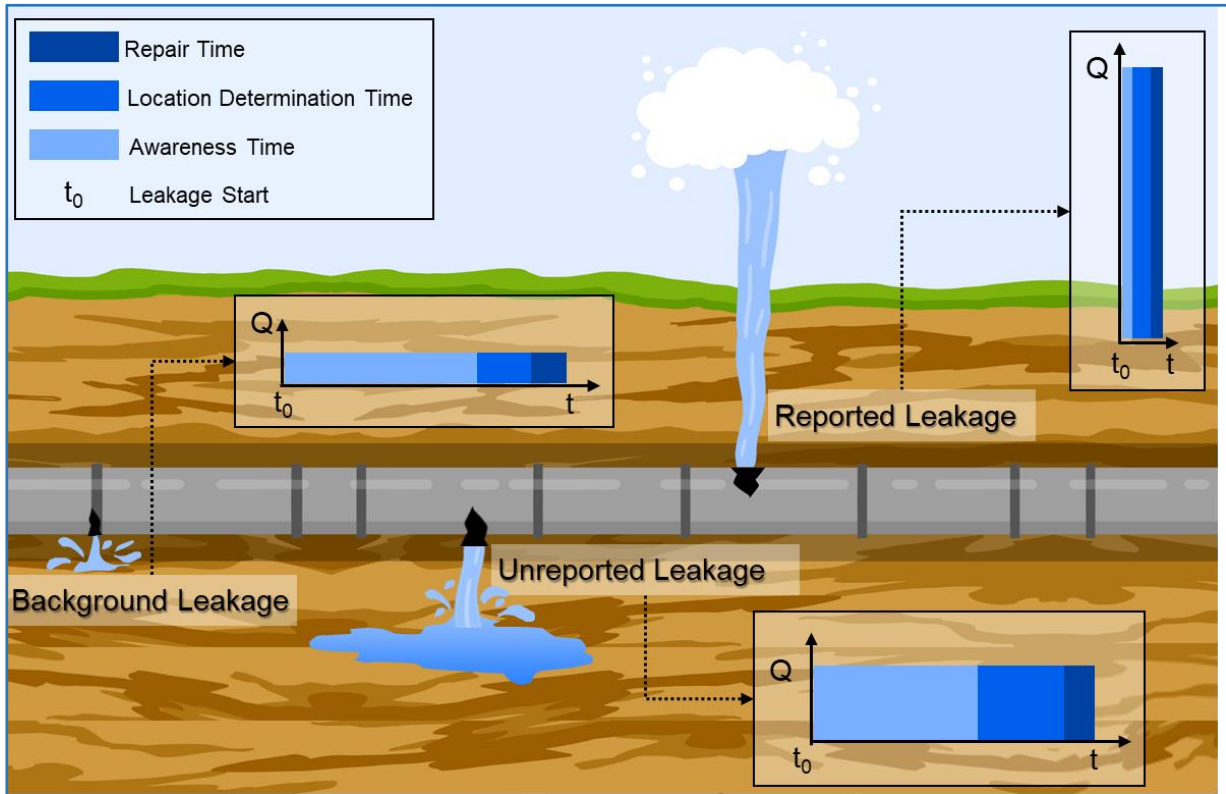


Figure 16 Flow-Time Relationship According to Leakage Types

In general, leakage management strategies can be of two main groups:

- Active leakage control (Proactive Control) is the process of undertaking leakage detection surveys on a targeted or regular basis in order to manage leakage within a water distribution network. This control refers to set of procedures and steps taken by the water utilities (with special team of dedicated staff) to monitor, repair and maintain the leakage level as an regular activity. “Active Leakage Control” is one of the methods for managing physical loss (Figure 4). This includes:
 - Regular survey (sounding, waste metering),
 - Leakage monitoring in zones or sectors (DMA monitoring and management).
- Passive leakage control (Reactive Control) is the name of the process of managing leakage purely by carrying out reactive surveys within a water distribution network. This is a reaction to visible leakage due to bursts or drops in pressure, which are usually reported by customers or noted by the utility’s staff. It has no planning, targeting or program of works.

The adoption of this policy minimizes day to day operating costs of leakage detection, but increases the risk of water being wasted. This policy is applicable if:

- The costs of leakage detection are high,



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- The costs of production are low, and there is ample capacity to supply all foreseen demands,
- Bursts are readily visible and easily repaired.

3.2.4.1 Understanding Current Status

Understanding the current status is necessary to identify the actual status of NRW components (diagnostic (where we are)). After setting a goal (where we want to reach), this step will be used for developing strategy (how we will achieve it) and making more precise SWBF.

In the following streamline, green boxes are questions to be answered either with existing data or need to be determined in this stage. Each "no" answer results in an action for the practitioner. The required actions are given in blue boxes. The results with the orange boxes will be used for the entries to SWBF or to determine the PIs.



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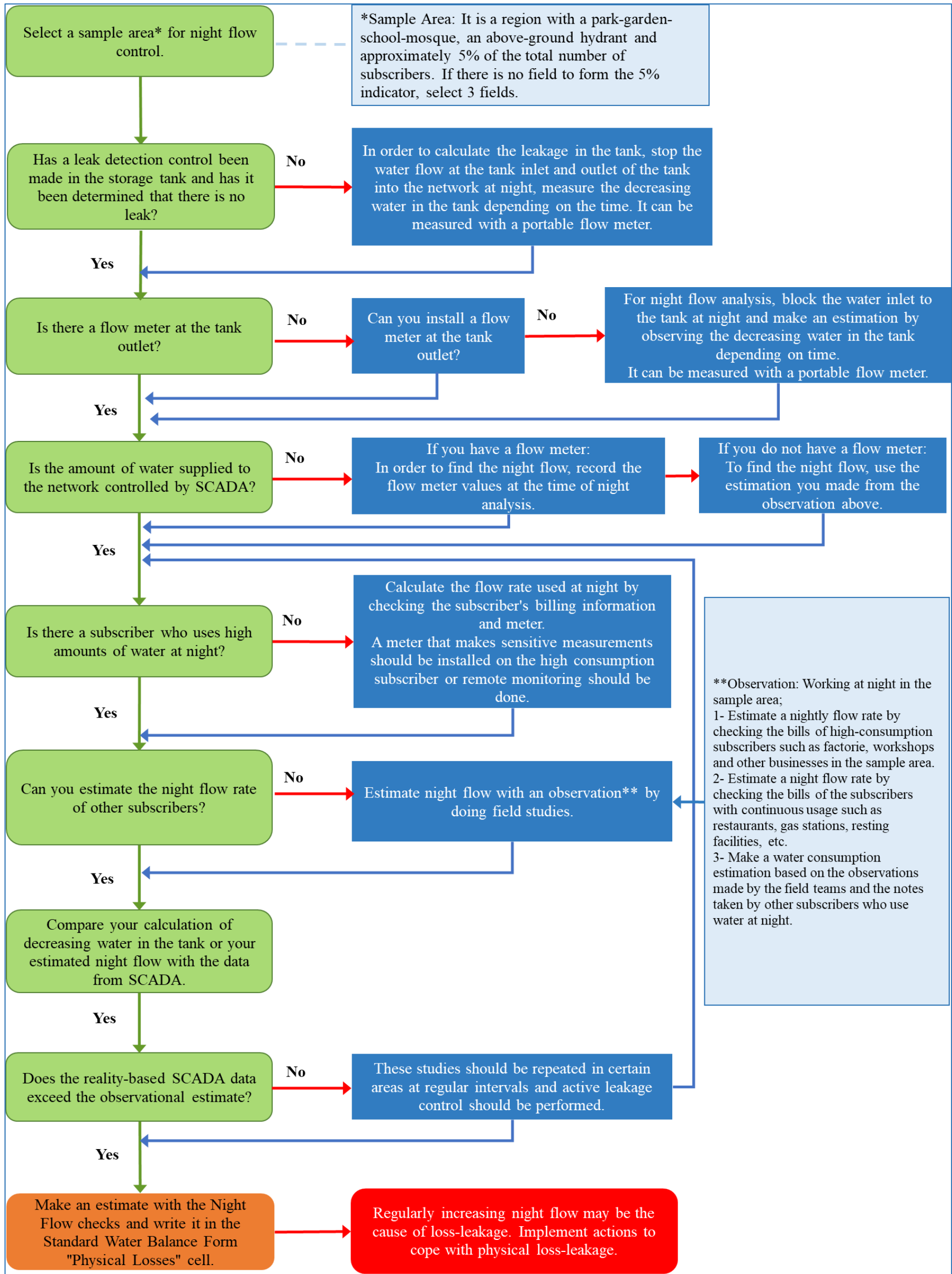


Figure 17 Streamline for Diagnostic of Leakage

Source: Consultant's Assessments



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3.2.4.2 Establishment of Active Leakage Control

Leakage control is the process of undertaking a series of activities to control the actual level of leakage. Benefits of leak detection:

- Water savings,
- Energy savings (treatment and pumping),
- Reduced O&M costs (reduced salary costs and outage times),
- Reduced consumer complaints and improved public relations,
- Reduced property damage and reduced risk of contamination.

For a given network reducing leakage to zero would be virtually impossible and enormously expensive for the consumers. Water utilities strike a balance between the cost of reducing leakage and the value of water saved. The level of leakage at which it would cost more to make further reductions in leakage than to produce the water from another source is known as "Economic Level of Leakage (ELL)".

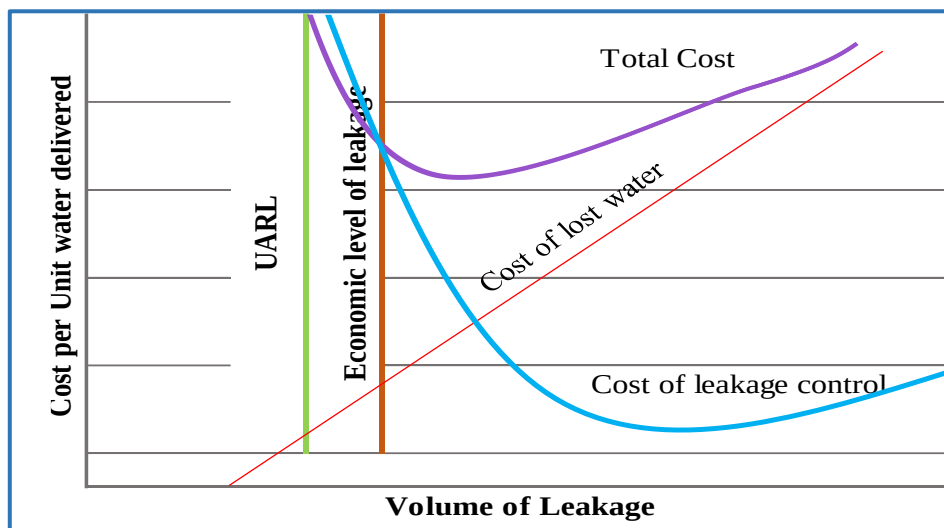


Figure 18 Figure to illustrate the concept of ELL

Source: Pearson, D. (2019). Standard Definitions for Water Losses. (A. Donnelly) London: IWA Publishing. doi:10.2166/9781789060881

In the illustration shown in Figure 18, only the level of active leakage control is varied in order to find the optimum economic balance. This is the only true operational cost that can impact on the level of leakage. This is referred to as the short-run economic level. However, as additional interventions, the economic level of pressure management and rehabilitation can and should be assessed. In this case, because capital costs are being investigated, this is referred to as the long-run economic level of leakage.



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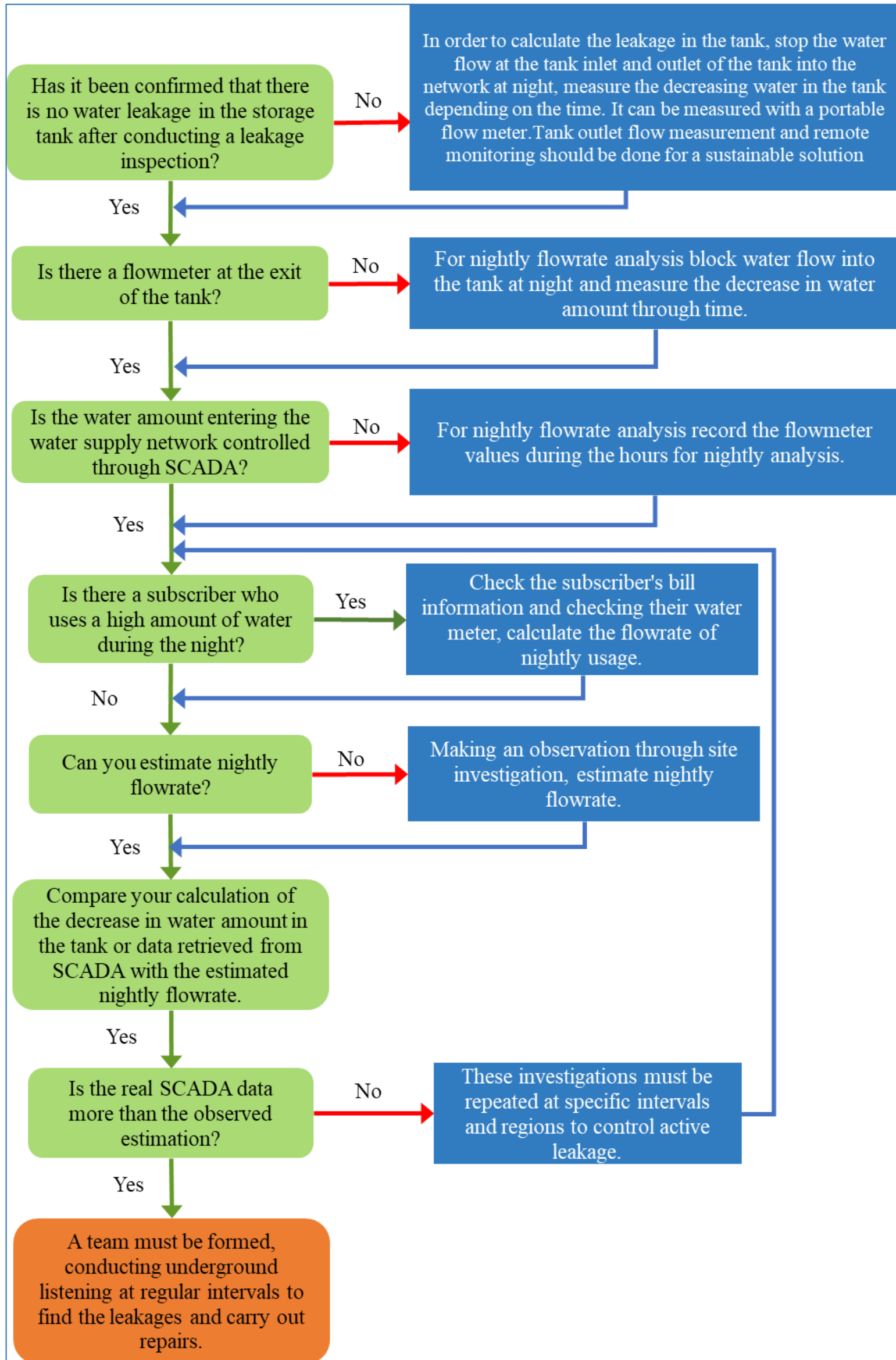


Figure 19 Action Streamline for Active Leakage Control

Source: Consultant's Assessments



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Leakage Detection Techniques

Leakage detection techniques are the methods and technologies available to leakage detection technicians to localize and pinpoint leaks during a leakage detection survey or a reactive survey.

- **Noise Loggers:** Noise loggers are devices that can be used to quickly scan a large area to locate the leak. In field applications, they are placed on all the valves in the field and listen at the time intervals determined by the operator. With these devices, it is not necessary to accurately determine the pipe material and lengths. Knowing the positions of the valves in the working area is sufficient for the application, so that the areas of leaks in the large area can be detected by narrowing them more quickly. After the leak is localized, correlation and pinpoint studies can be performed. Today, noise loggers can now perform noise logger and correlator operations as a single device. For this process, the diameter, type and numerical coordinates of the water network must be defined to the device.

These devices are implemented in two different ways;

- The first and most common method of application is distribute-collect-receive data in the field.
- The other way of use is that the data can be checked daily or instantaneously, provided that it is fixed and left on the valves and is in communication with a main receiver. For example; Noise loggers, which are permanently placed, immediately notify the administration of a malfunction with this main receiver unit. These fixed type loggers are actively used in many countries in Europe.
- **Leak Noise Correlator** (or simply “correlator”): This device needs pipe information, for example more precise information such as pipe material (diameter, type) and lengths. If the correct data is entered, the Noise logger can detect the leakage trapped between the two valves after the operation, pointwise or with a deviation of approximately 1-2 meters. There are models with dual correlation as well as multiple correlators.
- **Leak Noise Correlator:** A leak noise correlator (or simply “correlator”) is a piece of equipment that indicates the position of a leak along a main by analyzing the sound heard at two appurtenances, typically valves and/or hydrant. The correlator can use either accelerometers or hydrophones to pick up the noise. An accelerometer is attached magnetically to the fitting and will pick up noise transmitted through the pipe wall, whereas a hydrophone must be in contact with the water through an opened hydrant or connection on the pipe and listens to the sound transmitted through the water itself.
- **Correlator Survey:** A correlator survey is a mode that can be used to quickly scan an area in order to localize the position of a leak. In this mode it is not necessary to identify pipe material and lengths accurately and so the survey can be effected quickly. Once the leak has been localized, then more precise information on pipe material and lengths



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can be provided and the correlator used to more accurately estimate the location of the leak.

- **Stop Tap Sounding Survey:** Stop tap sounding, colloquially referred to as “stop tap bashing”, is the process of using a sounding stick to sound every external stop tap in order to test for noise from any leaks. It is essential in this process that the end of the sounding stick makes good contact on the head or crutch of the stop tap. This high-resolution method generally finds the greatest number of leaks.
- **Mains Appurtenances Only Sounding Survey:** This activity covers the low-resolution sounding on appurtenances only and is used mainly for locating leaks on metallic mains. This approach should not be used if the pipe material is non-metallic or the main between listening points contains a section of non-metallic material such as a plastic piece-through repair, as the sound does not travel along the pipe as well in these circumstances.
- **Surface Sounding:** The process of sounding the ground surface with a manual listening stick or electronic listening stick in order to pinpoint the position of a leak.
- **Manual Listening Stick:** A listening stick is a stethoscope that is used to sound appurtenances, stop taps or the ground surface to help confirm the presence of a leak by transmitting the sound up to the operative’s ear. There are diverse types of sticks using different materials such as wood and/or metal and some have different earpiece attachments to transfer the sound to the operator’s ear. Operatives tend to have their own personal preference of type of stick. It can also be used to check whether a sluice valve is passing water, when checking DMA boundary valves or carrying out a step test.
- **Electronic Listening Stick:** An electronic listening stick is a rod that uses electronic filtering and amplification to listen for leak noise, available in several levels of sophistication.
- **Ground Microphone:** A piece of equipment that uses a microphone together with electronic filtering and amplification to listen for leak noise when placed on the ground surface. They are used for confirming and pinpointing the precise location of a leak following a correlator survey. Often colloquially referred to as an “Elephant’s Foot”.
- **Pressure Zero Test:** A pressure zero test is a process used to confirm that boundary valves which have been shut in order to create a DMA are in fact still shut and not passing water in or out of the DMA. Initially the valves are sounded using a listening stick to ensure there is no sound being emitted from a potential water passage. A pressure gauge is then fitted to a hydrant within the DMA and the main inlet(s) and outlet(s) to the DMA are closed. The pressure on the gauge should drop gradually to zero. Should pressure be sustained or fall dramatically to zero, then this indicates that one or more of the boundary valves are open or not water-tight. It can be useful to install a pressure gauge on a hydrant outside the DMA to confirm that the pressures recorded



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are different. The pressure gauge should be left in place for a period of approximately 15 minutes to ensure that the system does not pressurize through a passing valve. It is also recommended that pressure loggers are installed along the boundary both inside and outside the DMA. These can be downloaded later as a check and also for audit purposes. In some countries, this may be referred to as a Zero Pressure Test.

- **Acoustic (Noise) Loggers:** Acoustic loggers are electronic devices used to record the noise on appurtenances, such as valves and hydrants. They can be programmed to listen at certain times of the day, such as the middle of the night, when there should be limited extraneous noise on the system. They can also be programmed to interpret sound in terms of consistency, noise level and frequency and thereby infer whether the noise would indicate that there is a leak in the vicinity. They have a magnetic base so that they can be attached to the metallic spindle of a valve or hydrant.
- **Correlating Acoustic Loggers:** These are loggers that have combined the functionality of acoustic loggers and correlators. This has been possible because of the improved time stamping on GPRS networks and the use of GPS technology. The data from the correlating loggers is combined with information about pipe lengths and materials (derived from the utility's GIS) in order to provide a more precise area of interest about a leak for confirmation and pinpointing. These loggers can be installed on a lift and shift basis or installed on a permanent basis and communicate over proprietary radio networks, or cellular (2G, 3G or 4G). When installed on a permanent basis they can change the economics of the active leakage control process significantly.
- **Remote Sensing:** Remote sensing is a generic term that is used to describe several techniques which do not involve physical leak detection on the ground. The techniques include flying over the area using a plane, helicopter or drone, as well as satellite surveillance. The technology usually uses different wavelengths, including infra-red, in order to look for areas where vegetation is being sustained or where ground reflection is different and therefore identifies an area of interest for further investigation.
- **Non-Intrusive Leak Detection:** Any leak detection technique, such as gas detection, correlation, stop tap sounding; that does not involve having a sensor passing down the inside of the pipe.
- **Intrusive Leak Detection:** The process involves a sensor travelling along the inside of the pipe. The sensor identifies the existence and location of a leak either through sound or the change in the pressure profile within the pipe. The sensors can be either tethered or free floating. The sensors are usually tracked at ground level using technology such as Bluetooth. Intrusive detection techniques require access to the water within a main in order to "launch" the sensor. This can be either through an existing hydrant, new or existing pigging chambers, or new or existing tapping points. Free floating equipment will also require some form of reception arrangement for the recovery of the sensor. There are a number of proprietary intrusive leak detection techniques and associated equipment available.



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- **Ground Penetrating Radar (GPR):** There have been many attempts at developing ground probing radar with the hope of identifying the location of a leak. Various types of ground probing radar have been investigated, either independently or combined, including ground penetrating imaging radar and surface magnetic resonance sensors. It is generally accepted that the results from the technology have been disappointing, being both difficult to interpret and often inconclusive.
- **Gas Injection:** Gas injection is a technique where gas, usually a mixture of hydrogen or helium and nitrogen, is injected into the water main or service pipe. The ground above the main is then swept using a sensor that can pick up the presence of the gas. The gas must be approved for use with potable water.
- **Step Test:** A step test is a technique used to localize a leak within a DMA. It is designed so that sections of a DMA can be shut off in sequence by the closing of a single valve. This may involve identification, usually as part of the design process, of what are referred to as circulating valves so that the DMA is reduced to a series of “branches”. When the circulating valves have been shut, the step valves are shut in sequence and the flow at the DMA meter is noted, logged or transmitted to the operatives. As each step valve is shut the flow through the DMA meter is given time to stabilize, which may only take a few minutes. As the step valves are shut, the preceding step valves can be opened or left shut. The step with the largest drop is the one that contains the greatest leakage, but if there are several steps with drops in flow, then this indicates that there are several leaks rather than a single large leak. A step test should be carried out at night or when there is minimal consumption in order to reduce any disruption to customers. Any known essential night users must be identified, and temporary arrangements made to maintain supply. In some cases, customers will need to be notified, such as by placing of cards through doors beforehand, to warn them of possible loss of supply or discolored water in the morning. However, such risks can be minimized by using real time data transmission and careful valve operation. See also temporary DMA rezoning test.
- **Temporary DMA Rezoning Test:** The temporary DMA rezoning test is a development of the “traditional” step test, which involves the sequential transfer of sections of a DMA that would have been isolated by closure of step valves in a normal step test, onto the adjacent DMA so that supply is maintained. This process therefore avoids service cuts and loss of pressure in the network.

Leakage Modelling

Leakage modelling is the generic term for the process of computer simulation and analysis of leakage using the relationship of leakage to the pressure, bursts and run times, that have now been established and understood.

- **Demand Calibration:** Demand calibration is a methodology to analyses 24-hour net flow and pressure data of a hydraulically discreet part of the distribution system, e.g., a zone or a DMA, using the pressure-leakage relationship principles and results of the Step Test. Using this technique, the net flow can be split into consumption and leakage,





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which can be further split into background leakage and leakage from bursts, both reported and unreported.

- **Component Loss Model (CLM):** A component loss model (CLM) can be constructed to estimate each of type of leakage (background, reported bursts and unreported bursts) on each of the various components of the network, such as mains, service connections, private service pipes and even trunk mains and plumbing systems. By including the relationship of leakage to the extent of the assets, the burst frequencies, the pressure and the awareness, location and repair times, and calibrating this to the existing leakage, it is possible to use the CLM to forecast possible options to reduce leakage. Also known as the burst and background estimation (BABE) model or Real Loss Component Analysis.
- **Hydraulic Modelling:** A hydraulic model is a computer representation of a distribution system which models the flows and pressures within the network. The model uses standard head-flow equations, such as Hazen–Williams or Colebrook–Wight, to relate head loss through a pipe as a function of the flow. Standard pipe roughness values based on material and age are used. Calibration is the process of adjusting the pipe roughness so that the difference between predicted pressures and actual recorded pressures are minimized. Leakage, established by a simple water balance for the period being modelled, is usually distributed evenly across all nodes within the model. Techniques have been developed which attempt to predict where leaks are on the system by changing the distribution of leakage to further improve the calibration. There are several well-developed modelling packages.

3.2.5 Improvement Speed and Quality of Repairs

In the period between the detection of any loss-leakage or malfunction and the elimination of this loss, physical loss occurs continuously. In some cases, according to the increase in system pressure, physical loss continues to increase continuously.

As stated in Section B.1, in the standard water balance form given by Annex 1 of the Regulation¹⁹, the definition of the "Unbilled Unmetered Consumption" component, which is one of the components of the NRW, states that the following losses must be taken into account along with the water used by the fire brigade from the fire hydrants.

- Water wasted due to any kind of pipe failure, starting from the moment the burst is noticed and the valve is closed, until the repair is completed,
- It describes the volume of water used or lost in compulsory situations such as water discharged during the maintenance of pipelines or auxiliaries (valves, suction cups, flow meters, etc.) and the date, operating time, pipe diameter, etc. factors of all these works are recorded and collected at the end of the year and the expression m³/year is written in this cell.

¹⁹ Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems



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By repairing leaks in a timely and efficient manner, it will be possible to manage, record and monitor this component. In order to complete the repair, it is necessary to first detect the fault. For this purpose, burst can be detected quickly in systems where active leakage is controlled and the night flow rate is continuously measured with SCADA data. Then, field studies should be detected and repaired quickly with underground acoustic listening.

Quality of repair is as important as speed of repair. After the detection of the burst, the necessary appropriate equipment and materials should be supplied and repairs should be carried out in accordance with Regulation Part-4 Articles 14 and 15.

When making repairs, the new pipe must have the same type, diameter and pressure class as the existing pipe. During the storage of pipes and fittings to be manufactured, direct sunlight exposure should be prevented. During the transportation of pipes, care should be taken not to damage their inner and outer coatings. Sand/gravel bedding, lining and filling productions in the trenches should be carried out meticulously in accordance with the specifications. PVC pipes, which have changed pipe color by being exposed for a long time, turned white, lost their elasticity and other properties, should not be used in network manufacturing since they are fragile. In the production of steel pipes, x-ray welding control should be carried out, cathodic protection should be given importance and internal and external insulation should be made after welding processes at the pipe heads.

Drinking water network maintenance and repair team should consist of well-trained and experienced personnel. In case of network failure, the actions to be taken by the field maintenance and repair team are as follows (Communiqué²⁰ in the article on integrated management of drinking-utility water supply and distribution systems (Article 12)).

- 1) Receiving a network failure notification,
- 2) Detection of the fault on site by the sub-regional responsible,
- 3) Determining which valves should be closed in order to respond to the malfunction via the mobile GIS application, determining and closing the valves in a way that will affect the subscriber at minimum level,
- 4) Reporting the approximate water-out period of the subscribers who cannot get water through the GIS application, via the contact information registered in the subscriber information system,
- 5) Following the completion of the repair, the system is reversed and normalized.

As can be seen, the operations to be performed are complex, GIS application usage information via mobile device, valve knowledge, and experience that can estimate the repair time. Only well-trained and experienced teams can quickly and successfully complete such complex and knowledgeable work in the right order. If the teams are not sufficiently trained and experienced, the repairs cannot be made quickly and with high quality, the subscribers are

²⁰ Technical Procedures Communiqué on Control of Water Losses in Drinking Water Supply and Distribution Systems published in the Official Gazette dated 16 July 2015 and numbered 29418



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not properly informed. This leads to an increase in the amount of NRW, a re-failure in the same place and the dissatisfaction of subscribers. For this reason, the training of the teams that will carry out the repair is very important.

3.2.5.1 Understanding Current Status

Understanding the current status is necessary to identify the actual status of NRW components (diagnostic (where we are)). After setting a goal (where we want to reach), this step will be used for developing strategy (how we will achieve it) and making more precise SWBF.

As stated above, the water lost between the breakdown detection and repair or the water discharged from the system during maintenance is considered as a component of the unbilled unmetered water consumption in the SWBF.

Therefore, in order to determine the current situation, it is necessary to keep records for both situations in a period determined by the administration (minimum 6 months and maximum one year). The action streamline regarding the speed and quality of the repair given in Figure 20 specifies the actions required for continuous recording and monitoring. In this section, it is aimed to provide fast data during the transition to the final system.

During the detection period, the time between the breakdown reported by the notification line or other methods and the completion of the repair will be recorded and the lost water will be calculated. Diameter and speed estimation of the faulted line is determined and the water loss in the determined period is calculated. Similarly, if a similar water loss was experienced in the maintenance during the evaluation period, this is also included in the records. This physical loss is determined by analyzing all the records kept during the evaluation period.

The estimated amount of the physical loss that occurred between the reporting of the fault and its repair is written in the unbilled unmetered water consumption cell in the SWBF.

3.2.5.2 Actions for Improvement Speed and Quality of Repairs

In order to reduce the water lost between the detection of the fault and the repair evaluated under the "Unbilled Unmeasured Consumption" component, it is important to make the fault detection and repair as high quality as the speed.

The following action streamline describes the measures and actions to be taken. These actions can be grouped into three headings.

- **Rapid detection of failure:** The presence of effective fault notification lines of the administrations will allow for the rapid detection of the fault. However, it is known that increasing the awareness of the citizen about water loss and increasing the sensitivity about the water wasted by the fault also affects the fault detection rate. Currently, 30 metropolitan municipalities have telephone numbers to report malfunctions. For example, BAŞKENT 153 in Ankara ASKİ, ALO185 in Adana ASKİ, ALO185 in Balıkesir BASKİ are few examples.



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- **Speed of repair:** By performing the actions in section 3.2.2, the transition to competent asset management will ensure a prepared approach to the relevant area. For entities that are registered with attributes to the GIS system, the team will go prepared for area. Thus, the speed of repair will be increased.
- **Quality of repair:** In order to repair the detected fault in a quality way, it is important that both the quality material in accordance with the standards of the material used is selected and the personnel who will perform the repair are specialized trained personnel. The actions related to this issue are described below.

In addition, keeping a record of all repairs performed should be done regularly to monitor the performance indicator.



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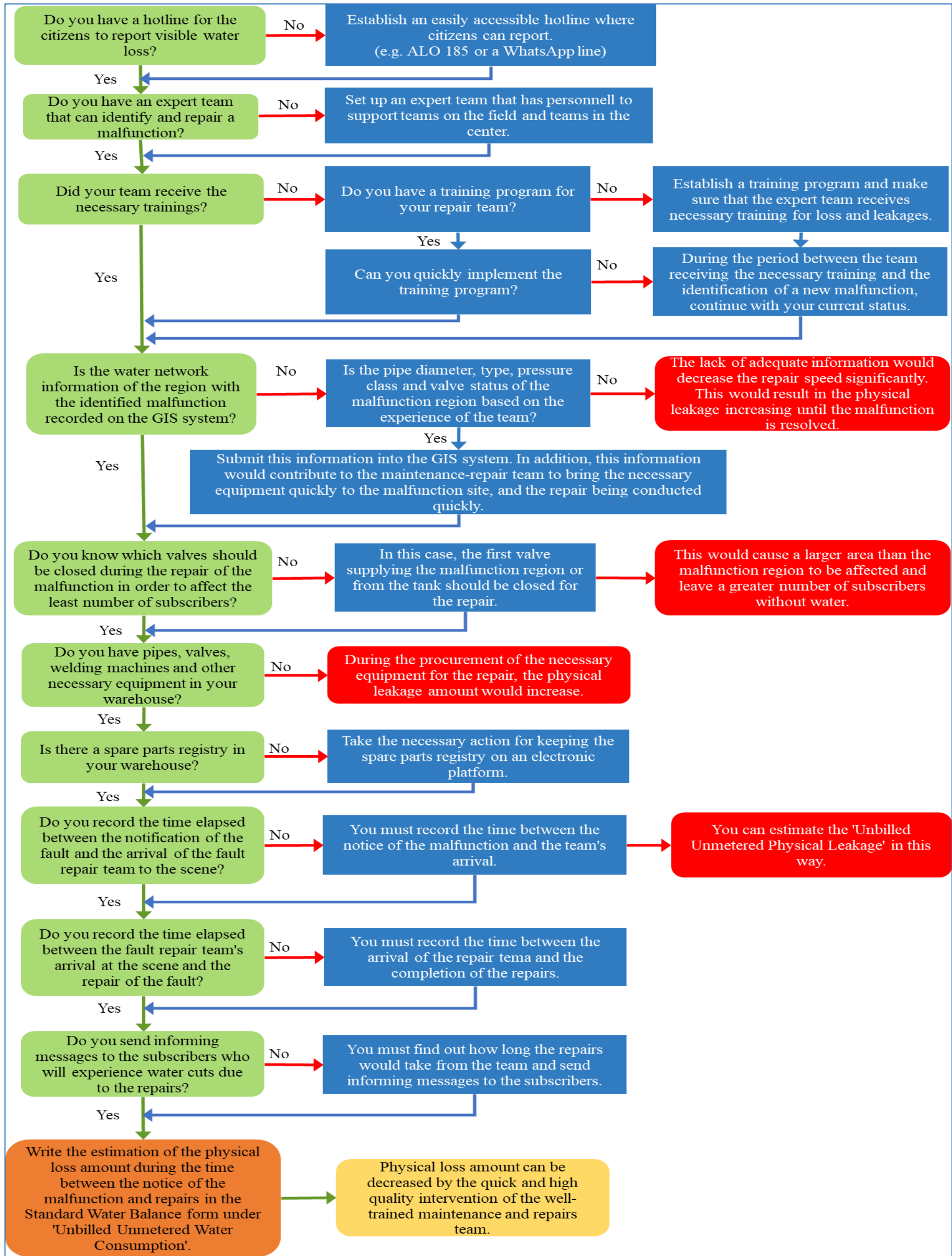


Figure 20 Action Streamline for Improvement Speed and Quality of Repairs Control

Source: Consultant's Assessments



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Training and Certification of Field Teams

In the field of water management, it should be one of the main objectives that the personnel working in the field have certificates by the accredited institutions. In our country, there is currently a training and certification for the water meter dismantling and installation element. This certificate is issued in accordance with the "Water Meter Dismantling Fitting Element (Level 3) national occupational standard" and the "Regulation on the Preparation of National Occupational Standards"²¹ and "Regulation on the Establishment, Duties, Working Procedures and Principles of the Sector Committees of the Vocational Qualifications Authority"²² issued in accordance with the Law No. 5544 on the Vocational Qualifications Authority (VQA) According to its provisions, it is carried out by the institution/institutions assigned by the VQA.

In order for the field studies described above to be carried out quickly and with high quality, as can be seen in the action streamline below, the teams working both in the field and in the center should be experienced in this regard.

It is important that the field teams that will work in the fight against water losses in WSAs are employed from the personnel who have been entitled to receive certificates by receiving qualification training. Until the completion of the team's process of obtaining a certified training on the relevant subject, it is necessary to receive trainings for the following applications related to the materials used in the networks of the personnel manufacturing in the field from an in-house or, if necessary, from an expert organization.

- Piping and fittings,
- Metal material resources,
- HDPE and PE resources,
- Installation procedures,
- Material information and management,
- Maintenance – Repair,
- Installation and calibration of DMA chambers,
- Emergency applications, etc.

At the same time, the personnel who will work as water management experts in the center off-site must have received sufficient training in the following planning and implementation issues.

²¹ Official Gazette dated 5/10/2007 and numbered 26664

²² Official Gazette dated 27/11/2007 and numbered 26713



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- Network planning and hydraulic knowledge,
- Hydraulic model usage and field calibration,
- DMA chamber design,
- GIS software expertise
- Technical specifications, installation and management of pipes and equipment (valve, tank, pumping station, SCADA, flow meter, etc.) in the field.

Leak Repairs

A leak repair is the process of repairing the fault that is causing the leak. Leaks on mains are repaired by either a single repair clamp or with a new section of pipe in what is referred to as a piece through repair. Leaks on appurtenances such as valves and hydrants usually require repacking of the gland or complete replacement of the fitting itself. Leaks on service connections are usually repaired by replacing the defective pipe section with a new one using two compression couplings, equivalent to a piece through repair. In exceptional circumstances it may be deemed appropriate to replace the whole service connection. This method is often chosen if the service connection is made of a non-preferred material, such as lead. Repairs are not normally carried out for leaks on private service pipes as these are the responsibility of the owner of the associated property, but if they are carried out by the utility for whatever reason, then they would be the same as the repair of a leaks on service connection.

Repair Clamp

A repair clamp is a fitting that normally comes in two halves and includes a gasket over the full length of the clamp. The clamp is split and placed round the main at the leak location. It is then clamped and tightened so that the gasket is squeezed around the pipe over the hole in order to stop the leak. A repair using a clamp can be undertaken without shutting off the water, thereby reducing the risk of contamination and pressure transients on refilling, though it will usually require pressure to be significantly reduced while the repair is undertaken. A repair clamp can be used to repair a hole but is not recommended for a circumferential split. A repair clamp will not significantly affect noise transmission along the pipe wall and will therefore have little impact on leak detection.

Piece Through Repair

A piece through repair involves cutting out a section of pipe and inserting a new one in the original pipe using a coupling at each end. It is common to use a short length of plastic pipe (PE or PVC) for the insert even if the original main is metallic. Unfortunately, this can make future leak detection more difficult as the section of plastic pipe acts as an insulator and reduces noise transmission along the length of the original pipe. The use of plastic pipe in a piece through will also reduce the accuracy of the location of a leak using a correlator. A piece through requires a complete water shut off and hence care with disinfection and recharging.



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3.2.6 Potential Financial Saving from Physical Loss Prevention Actions

Physical losses in drinking water supply systems include social and environmental negative impacts as well as serious economic impacts for the Administrations. Various cost approaches have been made worldwide for physical losses and for other NRW components. Due to the difficulties in controlling NRW values worldwide, academic and commercial studies and research are also ongoing.

As mentioned in many sections of the Guideline, as we progress in the process of controlling NRW components, that is, as NRW volumes succeed in decreasing, the Administrations will and should be directed to more detailed studies. In the cost studies carried out, it is very unlikely that a single formula suitable for every situation and every Administration will be applied under all circumstances. In all the cost studies and models developed by the experts, the point that is especially pointed out by the experts themselves is that the determination of data in many dimensions, from mutual confirmation of definitions to the net determination of components, with situation-specific approaches is necessary for absolute success.

The indicator "NRW by cost" (Fi47) is recommended by IWA as a financial indicator. The approach to the detailed calculation of the indicator is given in Section 3.4.3.1. With this indicator, the cost to the Administration of physical loss (RL), administrative loss (AL) and unbilled authorized consumption (UAC), which are components of NRW, can be calculated. In other words, when reduction projects are carried out for NRW components, the cost of the component to the administration will be reduced by the amount reduced by the project.

The calculation of NRW costs is important for determining the cost of the Administration's NRW volume to the Administration. However, its main importance is that NRW management is an important tool for determining the financing required to carry out its projects and actions.

In order to perform the cost-benefit analysis of NRW projects, it is necessary to know the increase in the revenues (benefit) of the Administration, the decrease in expenses (savings) as well as the NRW reduction project costs. This link is summarized below.

NRW Management Project Benefit

= Increase in Income – Decrease in expenses – Project Cost

The cost impact of NRW management components, established by international studies, is given in Table 16 (Section 3.4.6). As can be seen from the table, the volume of water and cost/gain to be gained with each component reduction/prevention study varies.

Using water balance to prioritize components for NRW reduction helps balance the financial and water supply objectives of the NRW strategy. In the unique water balance of each WSA, the volume of components of NRW with very different characteristics and their share in the total system vary greatly.



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To illustrate; Even if the physical losses of the two WSAs are at the same level, the physical losses may be due to the network pipelines, customer connections, reservoirs, or lack of pressure management. In parallel, the physical losses component will need to be reduced, either through pressure management or active leakage control. In fact, as shown in Table 5, physical investment is not recommended, especially if the World Bank grouping system is classified as "Group D". In this case, the primary action recommended by the WB is to review asset management and staff training, etc.

The same applies to administrative losses, for example, while the two WSA percentage of administrative losses are the same, the administrative water losses of one WSA may be predominantly caused by unauthorized consumption, while the administrative water losses of the other WSA may be predominantly due to meter errors. For this reason, project cost determination should only be worked on as specific to the Administration. The guideline recommends that project costs be prepared on a pilot scale in terms of the Administration, taking into account the complex nature of the NRW components and the possibility that the NPU may lead to a misassessment due to its different current situations. Recommendations for project costing work are given in Section 3.4.6.

Activities to prevent administrative (commercial-apparent) losses and unbilled authorized consumption will increase WSA's revenue, while not reducing operating expenses. In contrast, activities to prevent physical losses are not expected to generate revenue growth while reducing operating expenses. Only if the water supply is not sufficient in the current situation, income increase can be realized by physically preventing the loss of water. Regarding this diverse nature of NRW components, approaches for WSAs to be able to calculate the benefits and savings of NRW component prevention activities are provided in this section and in Section 3.3.4. To summarize the departmental approaches, physical losses are an expense issue, administrative losses and losses due to unbilled authorized consumption are a revenue issue. In line with the above approach, the Guideline presents the potential benefits of NRW reduction actions and formulas for savings.

After determining where it is in the current situation, in other words, its problem, the administration should plan the necessary actions to achieve the target set by the "Work Plan Circular on the Reduction of Water Losses in Drinking Water Systems". In cases where a target is not set in the legislation, the Administrations should set the target of moving to the upper band every 5 years. The objectives set out by the Circular will require aggressive measures to be taken for some Administrations. For these short-term objectives set out by the Circular, all of the actions proposed in the Circular are detailed in the Guideline. However, it should be noted that in most cases these aggressive measures can be financed at the savings of the project itself. As mentioned in the case study given in Annex D.1.2, sanitation service VIK SPLIT, which also manages the water distribution networks of neighbouring communities in Croatia, decided to launch a project to reduce the level of loss and optimize the management of applications.



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The total cost of the project is estimated to be €43 million over 10 years. The NRW rate will decrease from 59% to 36%. The period of return on investment is estimated to be less than 5 years. Like many projects aimed at reducing and controlling losses, the VIK SPLIT loss reduction project has an excellent internal rate of return.

Before determining the project costs for physical loss reduction actions, it is necessary to calculate the amount of savings, which will be calculated as follows. According to this amount of savings, Administrations will be able to plan.

Table 9 Savings to be Achieved by Physical Loss Prevention Activities Calculation Table

	Unit	Symbol	Formula	Expense
Operating Expense (total)	TL/year	FG_{TOPLAM}		
Sistem Input Volume	m ³ /year	SIV		
Operating expenses per m ³ given to the system (per year)	TL/m ³ /year	FG_{BIRIM}	FG/SIV	
Current Annual Real Losses	m ³ /yıl	CARL		
Unavoidable Annual Real Losses	m ³ /yıl	UARL		
Infrastructure Leakage Index	-	ILI		
Physical Loss MAXIMUM Savings	TL/yıl	ILI = 1 (where CARL is reduced to UARL)		$(CARL - UARL) * FG_{BIRIM}$
Savings when Physical Loss WB "Group A" is reached	TL/yıl	Reduction to ILI =4		$(CARL - 4 * UARL) * FG_{BIRIM}$

Explanations for the data based on the above calculation are listed below.

- In order to calculate the savings to be achieved by preventing physical losses, it is necessary to know the operating expenses first. The most basic difference between operating expenses and budget expenses is that the operating expenses consist of expenses arising from the operating activities of the institution (including depreciation expenses), so as not to include investment budget expenses.
- In the Network Management action area, the following data will be identified in Section 3.2.
 - "Determination of the Current Situation" flow chart given by Figure 6 and "System Input Volume" in the current situation,
 - The "Determination of the Current Situation" flowchart given in Figure 7 and the current "Amount of Physical Loss (Current Annual Real Loss (CARL))",
 - The current ILI will be determined by the flow chart "Determination of the Current Situation" given in Figure 8.



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Although a well-functioning system may have ILI 1.0 (i.e., $CARL=UARL$), as stated in section 3.2.1.1, this should not be the first target. The first goal is to be included in group A according to the World Bank grouping system shown in Table 5, that is, the ILI must be less than 4. According to both cases, the amount of savings to be made from expenses can be calculated by the method given in the table above.

3.3 Action Area: Administrative (Apparent) Loss Management System

Administrative (Apparent) loss management encompasses activities designed to manage, control and reduce all aspects of apparent losses. Reduction of Administrative (Apparent) losses requires many types of expertise, not only in technical and operational fields but also in human, social and management fields.

The water utilities that perform well in terms of administrative (apparent) losses consistently meet the same prerequisites:

- A clear legal environment.
- Good communication with consumers.
- Effective organization to combat the losses.
- Personnel training and incentive policy.
- Clear metering policy.

Any WSA/WUD that is in critical condition in terms of administrative (apparent) should strive to meet these prerequisites and improve its situation. However, even after the action plan to mitigate these losses has been successfully implemented, these prerequisites must be maintained to ensure long term results.

Administrative (Apparent) losses are composed of two following components as stated SWBF given in the Regulation:

- **Unauthorized Consumption** which refers to the amount of water used illegally by way of illegal connections and intervention to meters, without the knowledge of the administration. The level of unauthorized consumption can only be the result of poverty, dishonesty or cultural aspects, and the lack of strategy in terms of social participation and communication also affects the level of this loss.
- **Meter errors** which refers to all types of errors associated with the production of meters and errors arising from the age, model, type of meters, as well as data processing errors.

As described in Section B.1, in IWA approach, "Data Handling and Billing Errors" is classified as AL together with "Customer Metering Inaccuracies". In the TR application, under-measurement errors caused by technical reasons are taken into account within the scope of "Meters Errors". On the other hand, it is not generally practiced to take into account data collection and billing errors in water balance calculations. In terms of this component,



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recommendations for WSA/WUD to determine its current status and actions to take if necessary are given in Section 3.4.

In some approaches by the experts and in some countries unbilled authorized water loss is also considered as a component of AL and managed under this category. In this Guideline, unbilled authorized water consumption components evaluated in detail in Section 3.4 under financial management system.

Subcomponents and causes of administrative (apparent) losses are given table below.

Table 10 Administrative (Apparent) Losses Components and Causes

Category of AL	Sub Category	Reasons	Description
Unauthorized consumption	Registered customers	Meter by-pass and other fraud	Unauthorized parallel, unmetered flow of water alongside the meter.
		Additional Unregistered connections	Case of double connection: one is registered, the other is not
		Disconnected customers illegally/unauthorized reconnected	Very frequent source of apparent loss in case of poor customer management: specially when disconnected connection are never checked
		Non-active customers illegally/unauthorized reconnected	As above
	Unregistered customers	Unregistered (illegal) connection	Also called illegal (or clandestine) connection
		Unregistered consumption in low income areas	
	Network equipment	Water theft from hydrants or other equipment	
Customer Metering Errors	Meter errors	Intrinsic errors	Error of indication of a water meter determined under reference conditions (ISO 4064: 2005)
		Aging	Change in the performance characteristics of the meter, due to the historic operational conditions of the meter.
		Inappropriate meter installation	Installation of a meter outside the limits of the reference conditions of the meter's pattern approval and/or the installation requirements stipulated by the manufacturer



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Category of AL	Sub Category	Reasons	Description
		Inappropriate sizing	Incorrect matching of meter's specified flow range with the range of water demands associated with the particular user
		Impact of customer's in-house installation	Effect of the downstream-connected installation on the error of the metered volume passed through the meter. (E.g. domestic storage tank etc.).
	Meter management	Meter out of operation	Stopped meters
		Errors in meter reading	Error in reading of the meter display: incorrect reading of the value on the meter display.
		Invented meter reading	Intentionally incorrect reading of the value on the meter display.

Source: Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016

3.3.1 Performance Indicators for Administrative (Apparent) Loss Management

3.3.1.1 PI Definitions and Calculation

Developing a performance indicator for administrative (apparent) losses is a challenge due to the multiple and complex nature of this component and the need for considering technical, human and social aspects. Considering the diverse nature of this component, it is clear that detailed component analysis needs to be undertaken.

In some countries, “default values” for apparent loss item have been defined by the national water organizations or regulators. Any claim greater than the default value requires validated utility specific data.

No doubt, this approach may provide assistance in terms of global strategy especially with respect to regulation and tariff setting. However, the incautious use of default value within the water balance may have a negative and misleading impact. If the true value is far above the default value, it may lead to a significant over estimation of the physical loss or vice versa.

Administrative (Apparent) losses are best expressed as a percentage of the authorized consumption. In well-managed utilities with a good customer meter replacement policy, AL should be only a few percentage points of authorized consumption.

Thus: PI_{AL} can be between 0 and 100%. This is equivalent to the definition of meter under-registration (MUR).

$$PI_{AL} = \frac{AL}{(AC + AL)}$$

PI_{AL} = Performance Indicator for Administrative (Apparent) Losses (%)
 AC = Authorised Consumption
 AL = Administrative (Apparent) Losses



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It is important not to express AL as a percentage of the total system input volume because this could be very misleading in systems with high leakage.

Administrative losses can be "zero" in the ideal situation in a water administration where continuous monitoring and inspection is carried out, calibration and replacement of meters are carried out regularly, and effective policies against unauthorized consumption are developed. For this reason, "reference administrative loss value" has been developed instead of the definition of "unavoidable loss" as in physical losses.

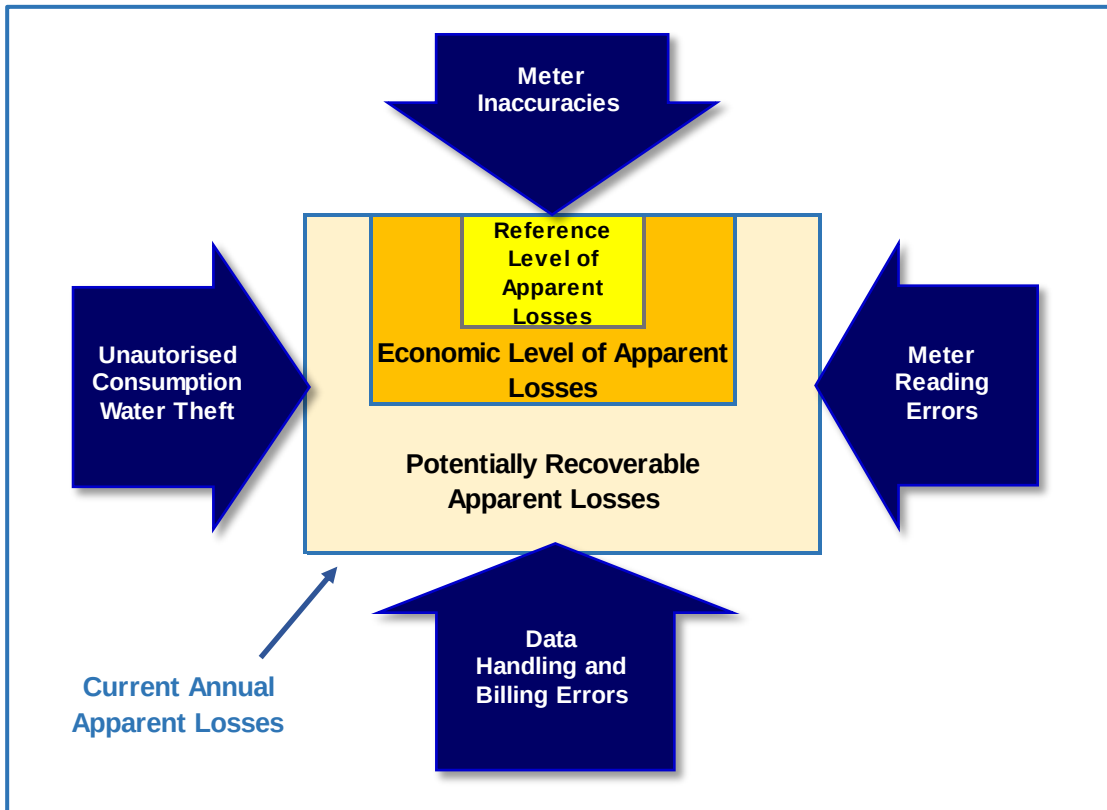


Figure 21 Administrative (Apparent) Loss Components

Source: Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016

Current Annual Apparent Loss is the current best estimate of the average administrative (apparent) losses over a year evaluated using the IWA Standard Water Balance, similar to CARL. It can be in the form of volume per year or volume per day.

The amount of Reference Level of Apparent Losses (RAAL) represents the lowest achievable annual volume of administrative losses for a well-maintained and well-managed system. Therefore, the difference between RAAL and CARL shows the actual the Apparent (Administrative) Losses.



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In the case of the Physical (Real) Losses (Figure 4), the arrows refer to four categories of actions that can be used to control frequencies, flow rates and duration of the leaks. Whereas in the case of the AL, each arrow refers to a category of causes, and for each cause, there is a wider variety of corrective actions that can be implemented²³.

The apparent loss index (ALI), an analogy of ILI, has been proposed as a result of some several researches²⁴. The ALI is defined as the ratio of the current annual apparent losses (CAAL) to Reference Level of Apparent Losses (RAAL).

$$ALI = \frac{CAAL}{RAAL}$$

CAAL = Current Annual Apparent Loss

RAAL = Reference Level of Apparent Losses

Operational Indicators for Meter Management:

The monitoring of specific “operational indicators” or “metric indicators” by field of activity is also important. Some operational indicators that are used by many practitioners are mentioned below:

- Percentage of unmetered connections.
- Percentage of meters out of operation.
- Percentage of poorly installed meters.
- Indicator on meter over sizing, etc.
- Number of flowmeters replaced per year (OP8).
- Breakdown of meters by brand (make), type, diameter, date of installation, reading index value.
- Customer meter reading efficiency (OP36).
- Domestic customer meter reading efficiency (OP37).
- Percentage of active meters (OP38).
- Percentage of non-metered water (OP39).
- Density of water meters (n°/connection) (Ph11).
- Time interval for meter installation (QD24).

²³ Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016

²⁴ Rizzo, A. (2000) Leakage Control and Unaccounted for Water Analysis. International Symposium on Efficient Water Use in Urban Areas: Innovative Ways of Finding Water for Cities. Kobe, Japan, UNEP-IETC and Thornton, J. (2005) Best Management Practice 3: “System Water Audits and Leak Detection”. Review and Recommendations for Change. Technical Report. California, California Urban Water Conservation Council. IWA Publishing.



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Above all these PIs, the most important factor of the administrative loss management is the economy of action and reaction relationship.

The Economic Level of Apparent Losses (ELAL) is the level of apparent losses where the marginal cost of carry out further measures to reduce apparent losses is equal to the marginal cost of revenue that would be gained by reducing apparent losses. The concept of ELAL is exactly the same as the concept of the economic level of leakage (ELL). The cost of carrying out the surveys increases as the frequency of the surveys is increased. Unauthorized consumption, and hence revenue lost, will be lower with more frequent surveys. There will be an economic balance where the increase in survey costs will outweigh the increase in revenue. This will then be the economic level of apparent losses. The same process has to be repeated for all the different activities that could be carried out to control apparent losses. Each activity has to be carried out at the frequency when the marginal cost of carrying out the work to reduce losses is equal to the marginal cost of revenue.

3.3.1.2 PI Evaluation for Goal Setting

Performance indicators defined and calculated in Section 3.3.1.1 will be evaluated in this section with the given limits for those PIs to determine goals and strategies to achieve those goals for a specific component.

Although there are various approaches in the studies carried out, when the targets achieved by country are examined, it is stated in the reference value “Guidance Notes on Apparent Loss and Water Loss Reduction Planning” document that 5% of the billed authorized consumption can be targeted. In this document, the components’ limit given for the well managed “reference utilities” are listed as below:

- The metering loss may be reduced to 4% of the authorized metered consumption.
- The unauthorized consumption is less than 1% of the authorized consumption.
- The other kinds of apparent losses are under control and negligible.

The levels achieved in the various countries used to estimate these percentages are shared below. Achieved levels in some countries are listed below²⁵.

- In a 2002 IWA International Report on Water Losses in 22 countries, 7 Northern European Utilities claimed zero for UAC and Apparent Losses, 9 claimed less than 2%, and 17 claimed 5% or less of billed metered consumption.
- Australia: all WSAA Companies during the 10-year millennium drought were extremely keen to identify every component of their NRW. They were the first Utilities group to agree (around 2008) to set formal (rather than informal) defaults for the auditors for the National Water Council, as 2% of Water Supplied.
- Austrian OVGW W63 Sept 2009: Water losses in water supply systems. Assessment, Evaluation and Measures for Water Loss Reduction, states that ‘Experience has shown that with correct dimensioning, correct installation and maintenance within the legal required calibration intervals for customer meters, apparent losses have to be estimated

²⁵ Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016



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at round about 0,5% (of billed and unbilled metered and unmetered consumption). In rare cases larger losses should be justifiable

- German DVGW Sept 2015 draft revision of W392 Guideline states: Without concrete valuation, no apparent losses should be assumed. Apparent losses above 0.5% of water consumption has to be justified in detail.
- Danish ILIs, published by DANVA, with most ILIs less than 1: all 36 Utilities claimed zero for Customer Meter under-registration.
- 2015 EU Reference document uses defaults of 2% of Billed Metered Consumption (excluding Water Exported) for under-metering in direct supply systems, 5% for systems with roof storage tanks (mainly Malta, Cyprus).

However, it should not be forgotten that 4% of this rate is due to meter errors and this requires periodic meter maintenance and replacement. On the other hand, since water theft and unauthorized use depend on social, economic and legal regulations-practices rather than technical factors, it would be the most realistic method for institutions to set targets based on the value they determined in the first current situation determinations suggested in the Guideline. By determining 5-year plans, 5% of the billed authorized consumption, which is the ideal situation, should be targeted for the final target.

During recent 15 years, the specialists have been focused on the best performance for water utilities different targets. The studies show that using sole indicator for all purposes could not reach the target. Therefore 'Fit for Purpose' KPIs are developed.

The authors of the "Guidance Notes on Apparent Loss and Water Loss Reduction Planning" developed the "Good practice 'Fit for Purpose' Performance Indicator for Apparent Losses Matrix" in the year 2016 as shown in Table 11 below.

Table 11 Good practice 'Fit for Purpose' Performance Indicator for Apparent Losses

OBJECTIVE	Component of AL	Current Annual AL (CAAL)			CAAL as % of billed metered consumption exc. water exported	liters/ billed property	liters/ service connection	% of System Input Volume	% of Water Supplied
		Volume	Value/m ³	Value					
Target Setting and tracking progress, for an individual system	Customer Meter Errors	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Technical performance comparisons of different systems	Apparent Losses	No	No	No	Yes: Apparent Losses Index ALI=CAAL %/5%	No	No	No	No
Financial Performance Comparisons of Different Systems	Apparent Losses	Yes	Yes	Yes: CAAL Value Running Costs	No	No	No	No	No

Source: Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016



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Some of the specialist in the loss management sector developed ALI performance bands for both developed and developing countries as shown in Table 12. This bands could be used for the 5 year target setting of WSA/WUDs.

Table 12 ALI Performance Bands

Region	Technical Performance Group	ALI	Remarks
Developed Countries	A	1-2	Acceptable performance. Further reduction may be uneconomical unless if the cost of water is very high.
	B	2-3	There is room for improvement.
	C	3-4	High revenue losses. Acceptable where cost of water is very low.
	D	>4	Very inefficient with poor water management practices and in adequate policies for revenue projections. Urgent action required to minimize revenue losses.
Developing Countries	A	1-2	Acceptable performance. Further reduction may be uneconomical unless if the cost of water is very high.
	B	2-4	There is room for improvement.
	C	4-6	High revenue losses. Acceptable where cost of water is very low.
	D	>6	Very inefficient with poor water management practices and in adequate policies for revenue projections. Urgent action required to minimize revenue losses.

Source: Mutikanga, H. E., Sharma, S., and Vairavamoorthy, K. (2010b) Assessment of apparent losses in urban water systems. Water and Environment Journal, Vol. 25

The following estimation methods are given for the relevant components of Administrative Losses in the "Standard Water Balance Program" developed by the Ministry of Agriculture and Forestry and currently required to be filled by WSAs in Türkiye. As stated in the "References" section of the program, these rates were obtained by using the data forming the water balance table of the Water and Sewerage Administrations in various periods. The estimation methods given for administrative losses in the "Standard Water Balance Program" are given below.

- **Unauthorized Consumption:** The recommended value is 0.25% to 25% of the system input volume.
- **Measurement Errors in Meters:** The recommended value is between 3% and 20% of the invoiced and unbilled metered consumption totals. By default, it is given as 8% of the billed and unbilled metered consumption totals.

On the other hand, as can be seen from the international approaches given in this section, the ratio of administrative loss to authorized billed consumption as the performance indicator to be recorded and monitored for both administrative loss components has started to become more common.



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3.3.2 Prevention and Control of Water Theft

Water theft is both an economic and social problem. Addressing it requires not only technical solutions but above all a social approach aimed at changing consumers' attitudes and imposing severe penalties. In order to change the consumer's behavioral attitude, first of all, this water loss in the water balance must be changed from "unauthorized consumption" to "water theft".

Water theft describes water losses due to the illegal consumption of water. Such consumption includes the followings.

- Legitimate connections that were never entered into the billing system and are therefore never invoiced (intentional and accidental),
- Permanent or temporary meter bypass (also meter tampering),
- Illegal connections,
- Illegal use of fire hydrants,
- Other types of water theft.

There are several technical and human factors for unauthorized consumption (water theft) as follows:

- Gross National Product (GNP),
- Water charges and household's income,
- Local legislation and regulation: laxity, impunity, right to disconnect, fines and penalties,
- Political or/and social aspects,
- Human resource policy and staff salaries in the Water Utility,
- Corruption,
- Reliability and updating of customers' database ,
- Active/Inactive customers.

More specifically in the Communiqué ²⁶ Clause 35, the unauthorized consumptions are classified as follows:

- Subscribers or non-subscribers who use water without a meter:
 - Disrupting meters by interfering,
 - Those who use water by breaking or stopping meters in any way,

²⁶ "Communiqué on Technical Procedures Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems" Published in the Official Gazette dated 16 July 2015 with issue number 29418 (Revised and published on 23 September 2020 with issue number 31253)



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- Those who use water by deactivating meters,
- Those who use water due to the dismantling of meter,
- Those who use water without passing it through a meter by drilling from the well, water mains line, service connection or source belonging to the administration, laying pipes, connecting a motor, interfering with the network by causing damage.
- Those who use metered water without subscription,
 - Those who use water by removing meters and connecting it in reverse,
 - Those who use water by replacing meter with another meter without the knowledge of the water administration,
 - Those who use water by breaking the meter union clamps, those who use water by opening the water shot down by the water administration and passing it through the meter,
 - Those who use metered water by changing the location of the service line without obtaining permission from the water administration,
 - Those who use water by changing the subscriber type without obtaining permission from the water administration,
 - Those who use water by breaking the seal of the meter.

As stated in the relevant article of the Communiqué, these uses are determined and recorded in the minutes and the penal sanctions in the regulations of the administrations are applied.

3.3.2.1 Understanding Current Status

Understanding the current status is necessary to identify the actual status of NRW components (diagnostic (where we are)). After setting a goal (where we want to reach), this step will be used for developing strategy (how we will achieve it) and making more precise SWBF.

In the case of apparent losses, field surveys and laboratory experimentation or measurements are necessary to quantify each component of the apparent loss.

At a very preliminary stage, Current Annual Apparent Losses (CAAL) may be assessed through a benchmarking approach. However, because there are so many parameters, confirmation from field surveys is needed before any meaningful strategies can be developed.

In the following streamline, green boxes are questions to be answered either with existing data or need to be determined in this stage. Each "no" answer results in an action for the practitioner. The required actions are given in blue boxes. The results with the orange boxes will be used for the entries to SWBF or to determine the PIs.



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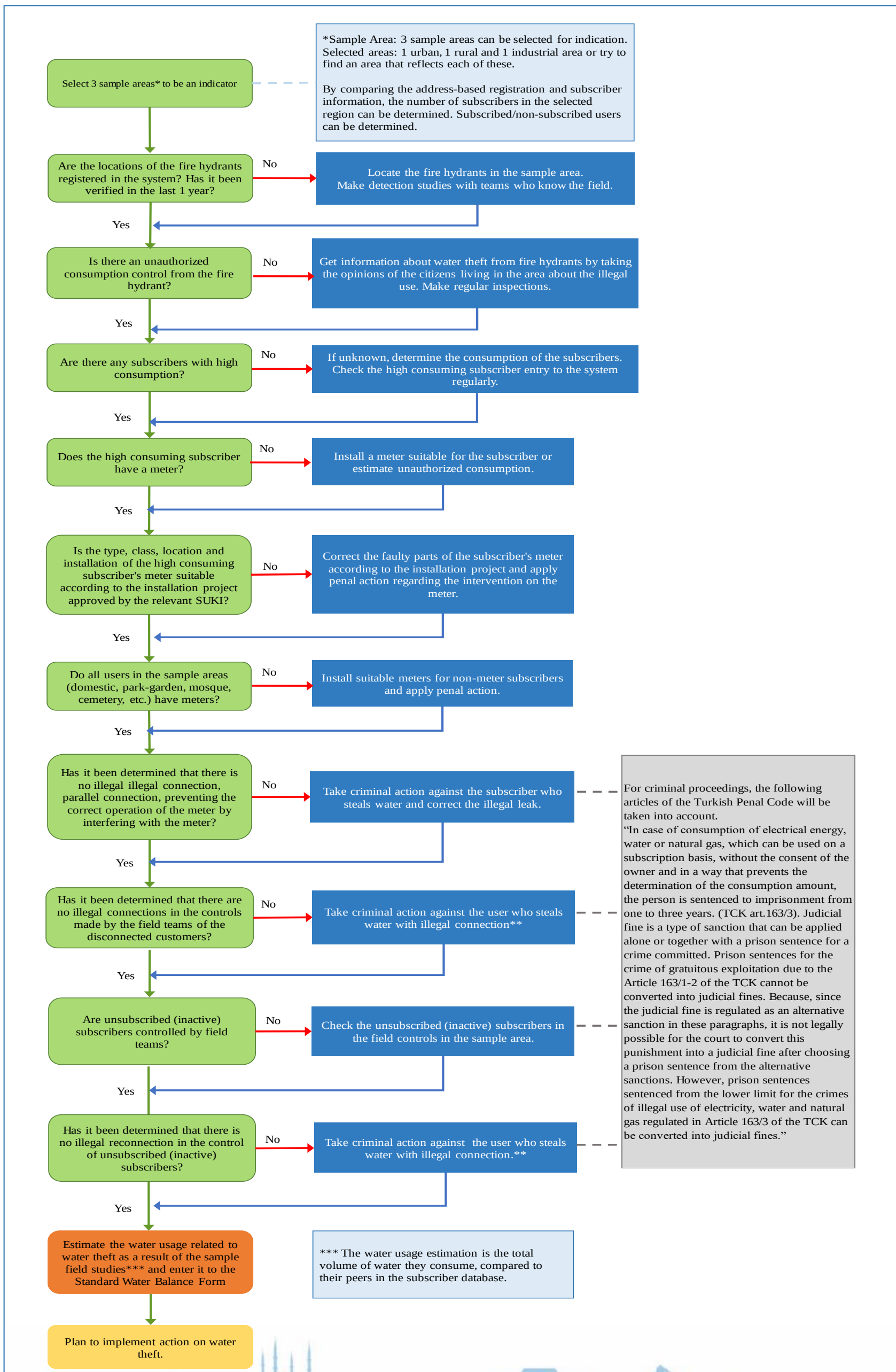


Figure 22 Streamline for Diagnostic of Water Theft

Source: Consultant's Assessments



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The following articles of the Turkish Penal Code will be taken into account for the criminal proceedings specified in the above streamline.

“In case of consumption of electrical energy, water or natural gas, which can be used on a subscription basis, without the consent of the owner and in a way that prevents the determination of the consumption amount, the person is sentenced to imprisonment from one year to three years. (TCK art.163/3). Judicial fine is a type of sanction that can be applied alone or together with a prison sentence for a crime committed. Prison sentences for the crime of gratuitous exploitation due to the Article 163/1-2 of the TCK cannot be converted into judicial fines. Because, since the judicial fine is regulated as an alternative sanction in these paragraphs, it is not legally possible for the court to convert this punishment into a judicial fine after choosing a prison sentence from the alternative sanctions. However, prison sentences sentenced from the lower limit for the crimes of illegal use of electricity, water and natural gas regulated in Article 163/3 of the TCK can be converted into judicial fines.”

Field and laboratory surveys: sample and/or pilot areas

It is unwise to assess CAAL using the limited data available from some types of periodical corporate reports, as is sometimes done for NRW percentage calculations of water input or for the total loss per km and per day. CAAL can only be determined from appropriate field surveys.

The specific studies that are needed to achieve the audit should be carried out in pilot zones or, preferably, on samples of pipes, customers, meters, etc.

- Pilot areas and samples must be selected such that the results obtained may be realistically extrapolated. The sampling approach is generally more appropriate in that respect if the samples have been properly defined and based on a scientific statistical approach.
- When a single pilot area is selected, the results generally cannot be extrapolated since this pilot area does not represent the whole of the city. It is generally necessary to select several pilot areas representing the various parts of the city and based on urbanism and social criteria.
- The other advantage of the sampling approach is that it is more appropriate than the pilot area approach because it enables assessment of individual various components of the administrative apparent loss.

Unauthorized consumption and other customer anomalies

A mini pilot census will provide a first indication on the importance of possible fraud and other anomalies, which could exist between the field reality and the technical and customer's databases.



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The investigations will cover 5% of the customers, who will be selected according to their geographical locations, their categories, and their social conditions. It is also recommended to carry out investigations that are more specific:

- On samples of customers with zero or abnormally low consumptions and
- On samples of customers that are supposed to have been cut-off or having terminated their contract.

It is recommended to ensure that the following ratios are calculated:

- Percentage of inactive clients, illegal consumption / total number of inactive customers visited
- Percentage of non-registered customers / total number of customers visited
- Percentage fraud on the water meters / total number of meters visited
- Percentage of anomalies found in the field with respect to the data on the existing files

3.3.2.2 Establishment of Prevention and Control System for Water Theft

WSA must review its regulations on the theft of water in the long run. The review takes time, as upcoming changes may be "politically sensitive". In order for WSA to make it easier for consumers facing financial problems, it can introduce a 'social tariff' at a reduced cost to socially sensitive groups. In many countries, rewarding complaints of illicit use is used as a theft remedy (Mutikanga, 2012).

In recent years, activities focused on deterrent methods such as taking water theft to court within the scope of current laws or punishing with high fines have increased in Türkiye. Some of the examples are given below.

In 2015, a Turkish citizen was charged with illegal use of water and theft of water by Istanbul Water and Sewerage Administration (ISKI). He was sentenced to 2 years and 1 month in prison as a result of the trial. The accused, who has been sentenced to prison for committing the crime of water theft, will be pursuant to Article 53/1 of the Turkish Penal Code No. 5237 in case the sentence given to him becomes final. According to Article 53/1 of the Turkish Penal Code No. 5237 in addition to time in prison he will be deprived of the following:

- a) Being employed in all civil service and services subject to appointment or election,
- b) To use the right to vote and to be elected,
- c) The right of custody, to rendering a service related to guardianship or trusteeship,
- d) The right to be the manager and supervisor of the legal entities of foundations, associations, unions, companies, cooperatives, political parties,
- e) Performing a profession or art subject to the permission of a public institution or a professional organization in the nature of a public institution, as a self-employed person or a trader under his own responsibility.



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In addition to ISKI, Trabzon Water and Sewerage Administration (TISKI) has been actively fighting against water theft. In 2021, as a result of ongoing inspections; 816 subscribers with meters, 634 subscribers without meters, 122 meters without subscription, 510 non-metered and unsubscribed illegal uses were detected. As a result of these inspections, which continue 24 hours a day, 7 days a week, a total of 345.805 TL fines were imposed on addresses found to be using illegal water.

In 2021, Ankara Water and Sewerage Administration (ASKI) officials also increased inspections for illegal water use to fight against the danger of drought and protection of water resources. As a result, ASKİ officials detected 2.990 illegal water uses in drinking water network and a total of 9.672.000 TL administrative fine was imposed for those who were using water illegally.

Before all technical measures, the customer management procedures are required to be reviewed to prevent water theft. The required customer management procedures are taken into account in Section 3.4.

“Creating a unit to prevent unauthorized consumption and the duties of this unit (Article 37)” is described in the current regulation. The methods to report in the subscriber and meter management of this unit and to prevent illegal consumption with this method are given in this regulation.

The followings precautions regarding meter readings are the tip points for the management of illegal connection/consumption- water thefts:

- Initially, WSA has to investigate how easily one can get unauthorized water from the fire hydrants.
- Illegal use of water within the boundaries of consumer ownership is not as easily detectable as in the case of fire hydrants. However, new technologies such as Advanced Metering Infrastructure (AMI) provide tools for detecting signs of illegal water use.
- Billing data should be checked to determine if there are active consumers with the same readings in their meters and therefore zero consumption in consecutive pricing cycles.
- On-the-spot checks still have to be made to consumers who have interrupted their connection to see if an illegal reconnection has occurred. For preventing this situation lead seals should be installed on meter screws/nuts.
- Water meters must be secured by malicious actions by using devices that lock them.

Relevant solutions are also listed as follows.

- Physical surveys to identify illegal connections,
 - Partial targeted (focused) field surveys in selected areas or fields,
 - Physical survey of unmeasured fire supplies to check for abusive consumption,
 - Random excavation based on billing consumption records,



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- Ground penetrating radar (GPR) to detect illegal connections,
- Targeted investigations based on preliminary analysis of the database:
 - Mapping (GIS) analysis,
 - Comparison to other utilities customer's databases (electricity, telephone, taxes, etc.).
- Increasing customer awareness and changing attitudes:
 - Self-reporting (or denunciation) under an amnesty process,
 - Community participation in the fight against illegal connections and frauds.
 - Customers' observatory.
- Detection of illegal connections in the case of large consumers.

All these actions are given as an action streamline in Figure 23 below. This action streamline is structured to reach the target for prevention and Control of water theft. However it should be noted that these actions will be carried out periodically, in other words, these actions will continue to maintain the sustainable management of this components.



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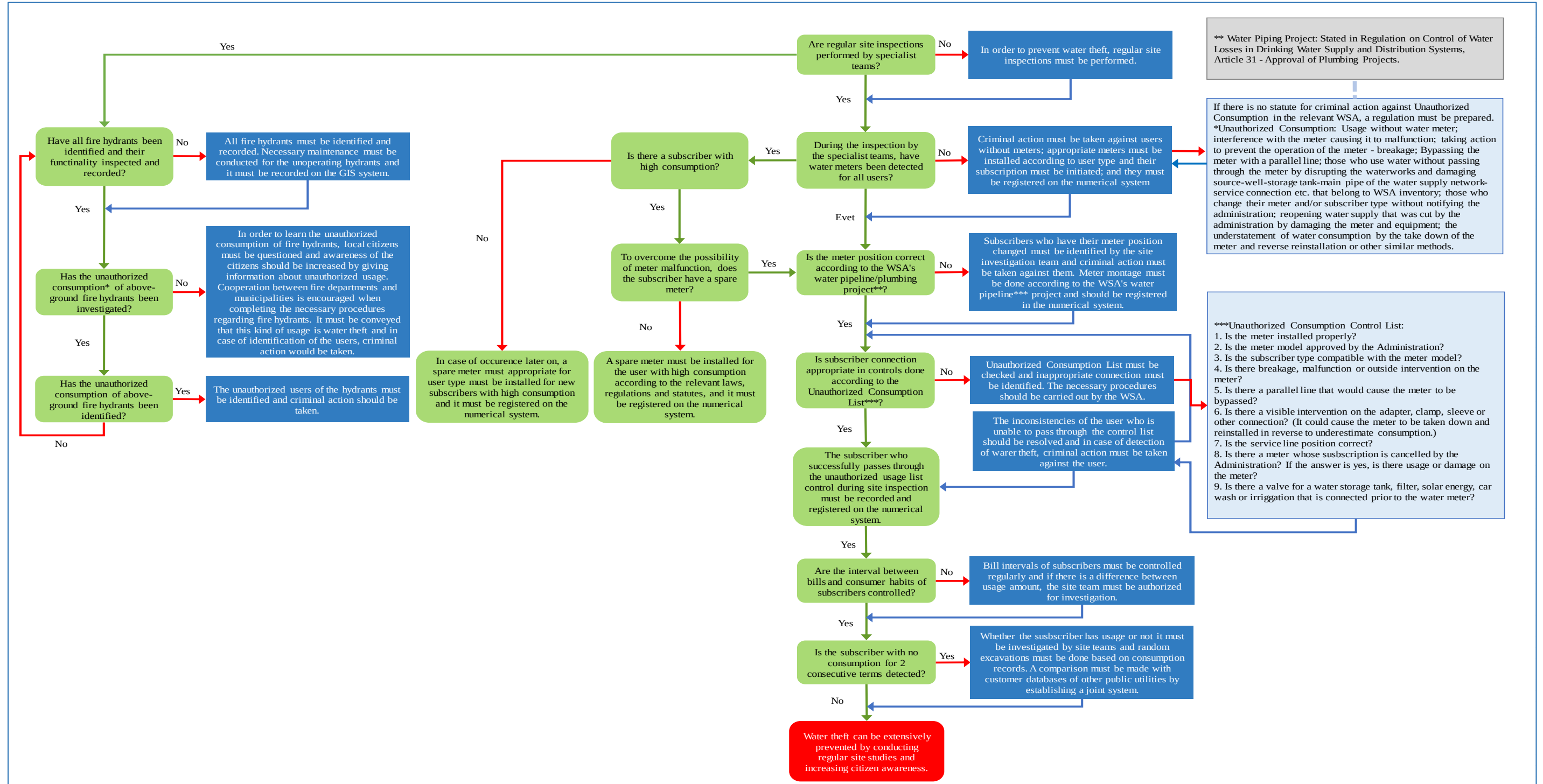


Figure 23 Action Streamline for Prevention and Control of Water Thefts

Source: Consultant's Assessments



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3.3.3 Integrated Meter Management

Customer metering errors are the consequence of meter accuracy or uncertainty. They generally lead to under registration, under metering and finally under billing. The term Metering Errors has been preferred because it is both a technical term (error graph of the meter) and a common term that anyone should understand. In addition, meter error does not always lead to under-registration, it may also lead to over registration.

Metering error is a phenomenon where water is flowing through a meter but the meter either fails to register it or else not register the whole amount that passed through it.

Metering error depends on factors such as the type and class of meter, the method of installation, the water quality, the continuity of supply, the average working life of meters and the presence (or absence) of storage tanks on customers' properties. Manufacturers produce meters that "on paper" meet the specifications but deteriorate at an amazing rate in the field. This is one of the major obstacles for sustained improvement of customer meter accuracy.

Usually, a very small part of the apparent losses is due to in-house leakage, a water volume not metered due to low flow. The factors responsible for this leakage are the dripping tap, flushes and roof tanks.

The technical reasons for "Measurement Errors in Meters" are stated generally in the SWBF given in Annex I of the Communiqué²⁷ (See Annex B.1).

Technical and human factors for customer metering losses include the following:

- Make (brand) and type of meter
- Metrological class
- Historical application
- Meter age (or date of installation, or reading index value)
- Sizing procedures
- Installation procedures
- Customer consumption (demand) profiles
- Category rating of large customers
- Water quality
- Water pressure of service
- Discontinuous supply status (i.e. partly pressurized system)

²⁷ "Communiqué on Technical Procedures Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems" Published in the Official Gazette dated 16 July 2015 with issue number 29418 (Revised and published on 23 September 2020 with issue number 31253)



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- Occurrence of meter frauds
- Domestic installations (in-house leakage, domestic tanks, etc.)
- Contractor-usage meter enforcement practices

In addition to above factors, the followings should be accounted as factors for the data handling and billing errors those are classified in the factors for metering errors according to some approaches.

- Customers data base structure,
- Quality of meter reading data,
- Meter reading procedures,
- Retail price of water.

These factors are assessed in Financial Management Section (Section 3.4).

3.3.3.1 Understanding Current Status

Understanding the current status is necessary to identify the actual status of NRW components (diagnostic (where we are)). After setting a goal (where we want to reach), this step will be used for developing strategy (how we will achieve it) and making more precise SWBF.

In the following streamline, green boxes are questions to be answered either with existing data or need to be determined in this stage. Each "no" answer results in an action for the practitioner. The required actions are given in blue boxes. The results with the orange boxes will be used for the entries to SWBF or to determine the PIs.



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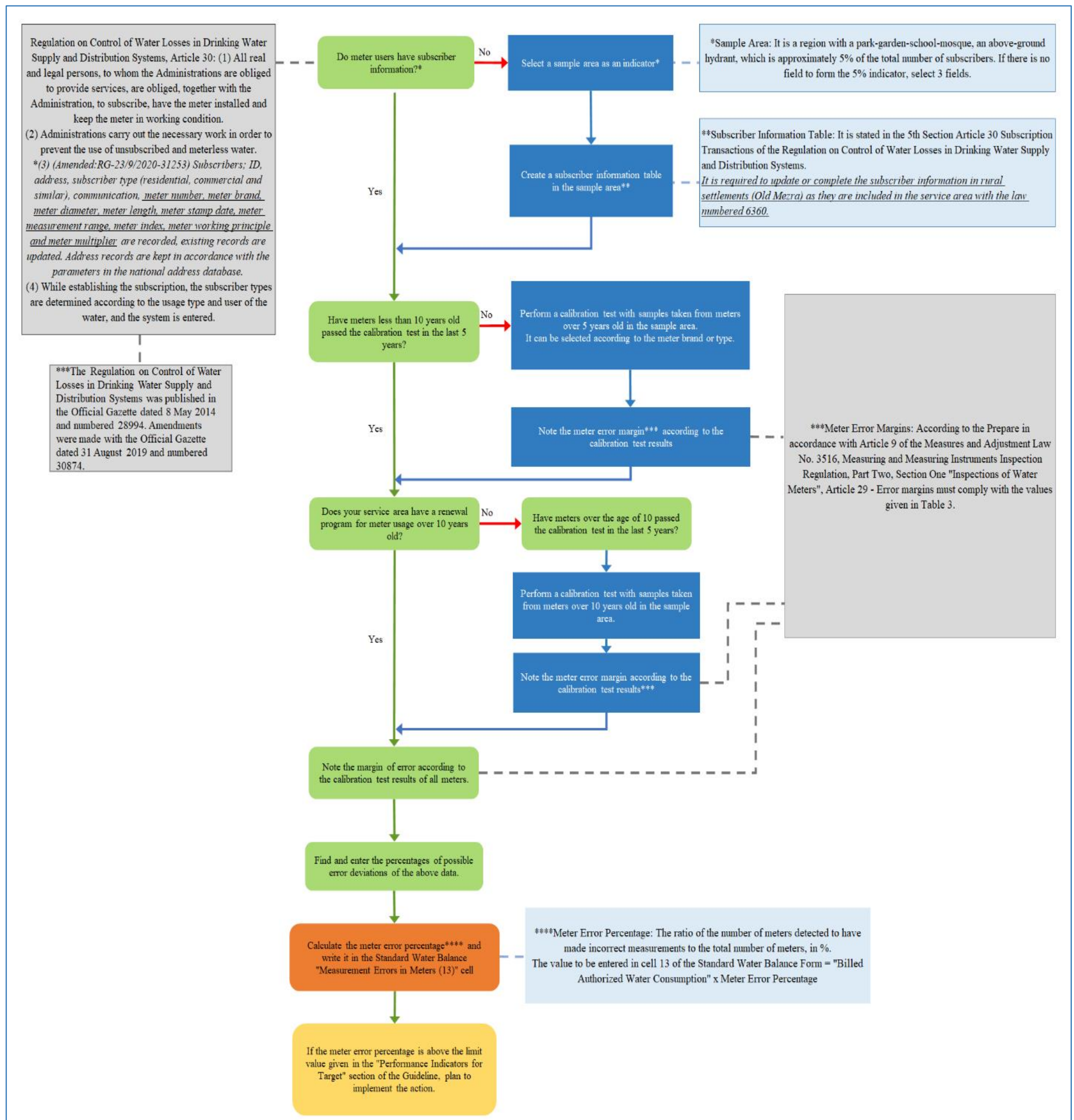


Figure 24 Action Streamline for Diagnostic of Meter Management

Source: Consultant's Assessments

Note: The meters must be located in places in accordance with the rules specified in Article 28 of the Regulation on the Control of Water Losses in Drinking Water Supply and Distribution Systems, which was published in the Official Gazette dated 16 July 2015 and numbered 29418.



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3.3.3.2 Establishment of Integrated Meter Management

Proper water meter management effectively reduces apparent water losses, thereby making much economic sense.

The Actions proposed for Metering Errors (customer metering inaccuracies) are listed below;

- Programme to replace meters on a regular cycle
- Correct sizing verification of average flow volume against meter size
- Programme to replace meters with those of a higher class
- Physical surveys to check for installation arrangements
- Physical site check of meters with zero and/or low consumption registered in the billing system

The first step in implementing an integrated meter management is to collect data for meters and create files. This can be accomplished by investigating historical meter supply and installation details, pricing records, customer complaints history, and results from their accuracy checks.

It is known that, like all devices, water meters lose their precision over time. The decision to replace the water meters is a result of econometric models. It is generally accepted and research proved that the optimum lifetime of a water meter is 10 years and their economic life from 5-10 years (Lambert & McKenzie, 2002). The age of the meter is not always related to the time the meter is used (age), but with the aging factor of the meter, also influenced by other factors (e.g. water quality).

Innovative solutions to water metering include technological advancements that need to be combined with economic criteria related to new technologies. In the absence of a fixed predetermined renewal period, the optimal life of the meter is the one that maximizes the benefits of WSA. The use of economic models in order to determine the optimum time for meter replacement is necessary.



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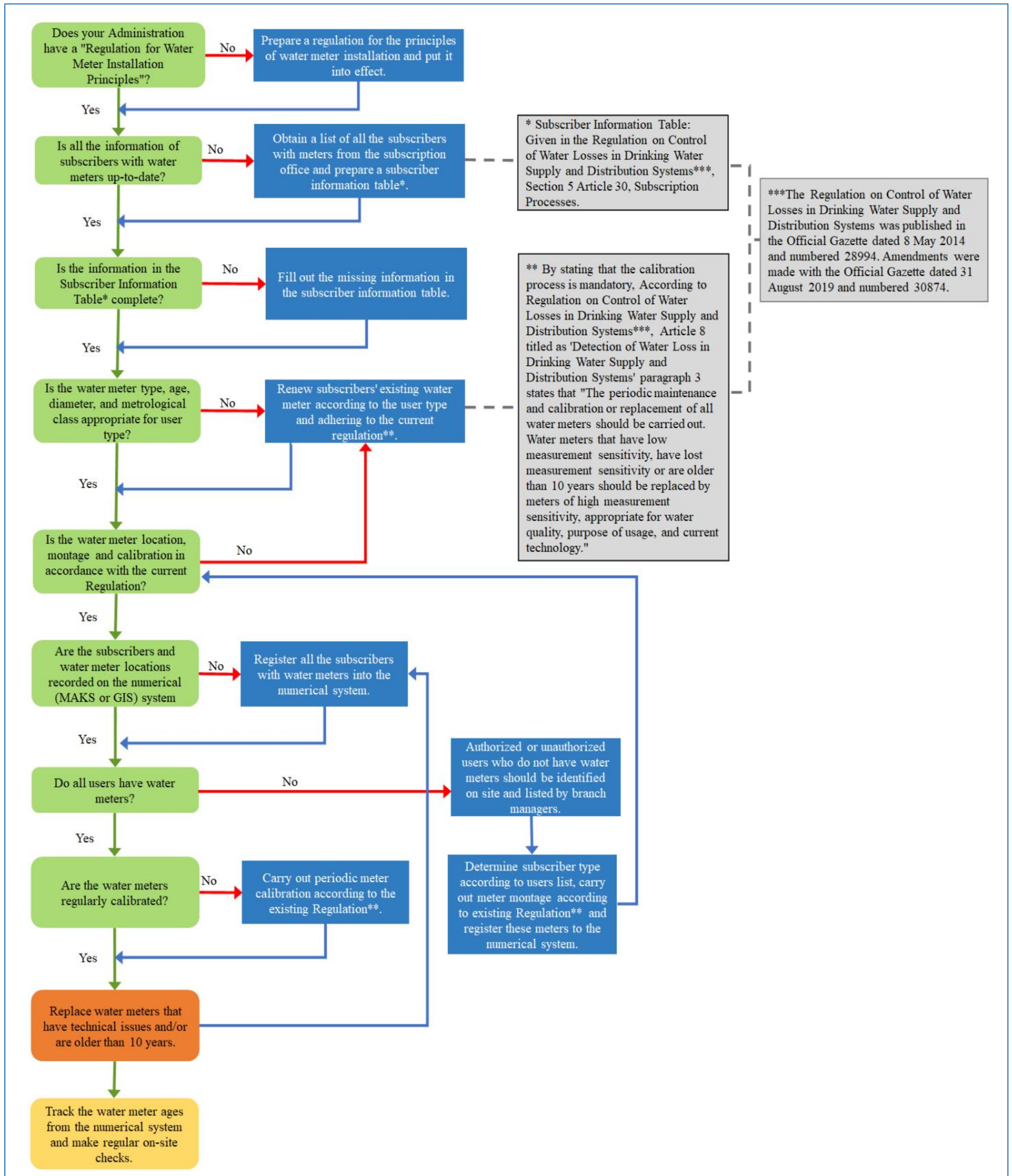


Figure 25 Action Streamline for Actions for Meter Management

Source: Consultant's Assessments



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The factors taken into account in calculating the optimum time for the replacement of water meters are (Arregui, Cobacho, Soriano, & García-Serra, 2010):

- The initial cost of purchasing and installing the meter, as well as the administrative costs associated with replacing them: It is taken into account that the value at the end of the life of the water meters is zero. Usually, the high initial cost entails an increase in the optimal renewal period.
- The cost of water not recorded represents a real cost to the water company. These costs must be taken into account for the entire lifetime of the meter.
- The standard error curve of the meter: This curve differs according to the operating principles and design features of the meters.
- User consumption profile.
- The weighted error: The error of the meter is related to the flow rate. If small amounts of water are consumed at a specific rate of supply, then their effect is lower than if larger volumes are consumed at the same rate of supply. For this reason weighted error resulting from the study of the error at different delivery rates are used.
- The structure of the water bill: To convert the unrecorded water volume into a loss of revenue, the appropriate selling price of water must be taken into account. The loss of revenue caused by cash inaccuracies will be the cost of the last cubic meter consumed but not invoiced.
- Prepayment Rate: To calculate the cost of unrecorded water volume, the present value of future economic losses should be calculated. The known formula of the nominal discount rate is used to calculate the present value.

In conclusion, if the volume of water consumed at low water supplies is high and the water company provides water with a high price, then the need for more accurate water meters is increased, with particular sensitivity to low supplies, but they also have a higher purchase price. In addition, the planned replacement period for these meters will be relatively small. On the other hand, when the water sales price is low and the leakages occurring in the consumer networks are limited, the meters to be used are not required to have increased sensitivity and measurement accuracy at very low supplies and therefore their purchase price will not be high.

When losses in residential consumption are high, it is necessary to carry out a comprehensive meter replacement programme²⁸. It is based on the results of the ageing

²⁸ Comprehensive replacement programmes need to be associated to some other actions:

- It would be of little benefit to replace an old oversized meter by a new oversized meter
- It is also an opportunity to correct meter installations when the initial installations did not comply with particular international or national standards.



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surveys. This survey will show that the replacement of the meters installed before Year “n” is highly cost effective and that the rate of return on investment will be high. All the meters installed before Year “n” will be systematically replaced²⁹.

Many utilities carry out massive replacement programmes instead of using a more selective approach because it is simpler and more cost effective. However, the targeted meter replacement may be carried out in some cases.

- **Specific meter replacement programme for large customers:** The number of large consumers is generally fewer than the number of small residential consumers, but their consumption may represent a significant part of the total water consumption and, consequently, a significant part of the WSA’s income. These meters must always be treated as a priority. Considering that oversized meters generates under registration, large meter resizing programs generally provides significant reduction in NRW and increase in financial input.
- **Targeted meter replacement programme:** Generally, water utilities use a large range of meters, in terms of technology and brand. These various meters do not have the same life expectancy: the optimum replacement period may not be the same. This need to be taken in consideration and following strategy may be considered as more efficient than implementing a massive replacement programme only based on the date of installation of the meter for instance.

Targeted replacement program may be based on one criterion only or on a multi-criteria analysis:

- Brand or type criteria: replacing brand or type that present the higher rate of loss, or shorter life expectancy.
- Technology: replacing volumetric meters in areas where velocity meters are proved to be more convenient.
- Metrological class: class C may be reserved to some category of users only.
- Category of consumers.
- Range of consumption: for instance replacing a meter when the consumption is lower than 5 m³/month is not a priority when the Utility bills a minimum rate of 10 m³/month.

-
- It can also be considered as an opportunity to use the latest generation of meters incorporating recent technological advancements.

²⁹ Instead of using the date of installation as an ageing criterion, it is also possible to use the accumulated volume that has flowed through the meter since it has been installed for instance replacing all the meters that have registered more than 3000 m³.



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- Resizing programme.

Meter Accuracies-Audit:

More information on specific meters can be collected by trained staff who will visit consumer meters on the spot. The data required to be collected for the audit are:

- The serial number, the manufacturer and the model;
- Length, nominal diameter and flow rate;
- The reason why the audit is carried out;
- The identity of the customer, the city and the date of installation of the meter;
- The characterization of consumption (domestic, industrial, etc.) and infrastructure (direct connection, storage tanks, etc.);
- How they were installed in the field and their location during the audit;
- Photos during the test.

3.3.4 Potential Financial Benefits of Administrative Losses Prevention Actions

As stated in Section 3.3.1.1, "default values" are recommended for the components of administrative losses for SWBF data in Turkey, as in some countries. However, as stated in the same section, in an ideal situation in a water administration where continuous monitoring and inspection, regular calibration and replacement of meters are carried out, and effective policies are developed against unauthorized consumption, administrative losses can be "zero". The gradual achievement of the goal set as "zero" as the ultimate goal should be the main goal of the Administration. Several percentages of permitted consumption points can also be obtained for transition phases.

As stated in Section 3.2.6, activities to prevent Administrative (Apparent) losses and unbilled authorized consumption will increase WSA's revenue, while not reducing operating expenses. It can be seen as the components that should be focused on first for all Administrations experiencing financing difficulties. However, as in the rest of the world, unauthorized consumption and unbilled authorized consumption losses in our country are a social and political problem rather than a technical difficulty. Therefore, the "Change Management" mentioned in Section 3.1 is the necessary condition for the implementation and success of the mitigation project. It will also require the Administration's dedication and determination to ensure the sustainability of the improved system, as well as its adaptation to continuously evolving international methods.

After the current due diligence of Administrative Loss by Figure 21 and Figure 23, the benefits to be obtained by carrying out the Administrative Loss reduction projects proposed in



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Sections 3.3.2.2 and 3.3.3.2 to achieve the above-mentioned objectives can be calculated by the approach given in the table below. According to the amount of this benefit, the Administrations will be able to plan.

Table 13 Potential Income Calculation Statement of Administrative Loss Prevention Activities

	Unit	Symbol	Formula	INCOME
Total accrued (invoiced) water sales revenues	TL/year	THK		
Billed Authorized Consumption Amount	m ³ /year	Q_{FIT}		
INCOME per m ³ sold (unit revenue)	TL/m ³	$INCOME_{UNIT}$	THK/Q_{FIT}	
Unbilled Authorized Consumption	m ³ /year	Q_{FMIT}		
Amount of Administrative Loss	m ³ /year	Q_{IK}		
INCOME from Unbilled Authorized Consumption	TL/year	$INCOME_{FMIT}$	$Q_{FMIT} * INCOME_{UNIT}$	$+INCOME_{FMIT}$
INCOME from ADMINISTRATIVE LOSS	TL/year	$INCOME_{AL}$	$Q_{AL} * INCOME_{UNIT}$	$+INCOME_{AL}$

Source: Consultant's Assessments

Explanations for the data based on the above calculation are listed below.

- "Total accrued (invoiced) water sales revenues" and "Billed Authorized Consumption Amount" will be received from the relevant units of the administration.
- In Section 3.2 and Section 3.3 the following data shall be identified.
 - "Determination of Current Situation" flow chart given in Figure 7 and current "Unbilled Authorized Consumption Amount",
 - Water Theft Current Situation Determination Action Flow Chart given by Figure 21 is currently "Unauthorized Consumption Amount",
 - With the "Determination of Current Situation" flow chart given in Figure 23, the existing "Meter Errors" will be determined.

When Meter Errors and Unauthorized Consumption are determined, the Current Annual Administrative Losses (CAAL) will be determined.



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3.4 Action Area: Financial Management System

Effective NRW management will lead to increased revenues and profitability for the utility if done properly. The ‘Vicious Circle’ of NRW is one of the key reasons for poor company performance and results in both physical and commercial losses. Physical losses divert precious water from reaching customers and increase operating costs. They also result in larger investments than necessary to augment network capacity. Commercial losses, caused by customer meter inaccuracies, poor data handling, and illegal connections, reduce income and thereby financial resource generation. The challenge for water utility managers is to turn the Vicious Circle into the ‘Virtuous Circle’. In effect, reducing NRW releases new sources of both water and finances. Reducing excessive physical losses results in a greater amount of water available for consumption and postpones the need for investing in new sources. It also lowers operating costs. Similarly, reducing commercial losses generates more revenues.

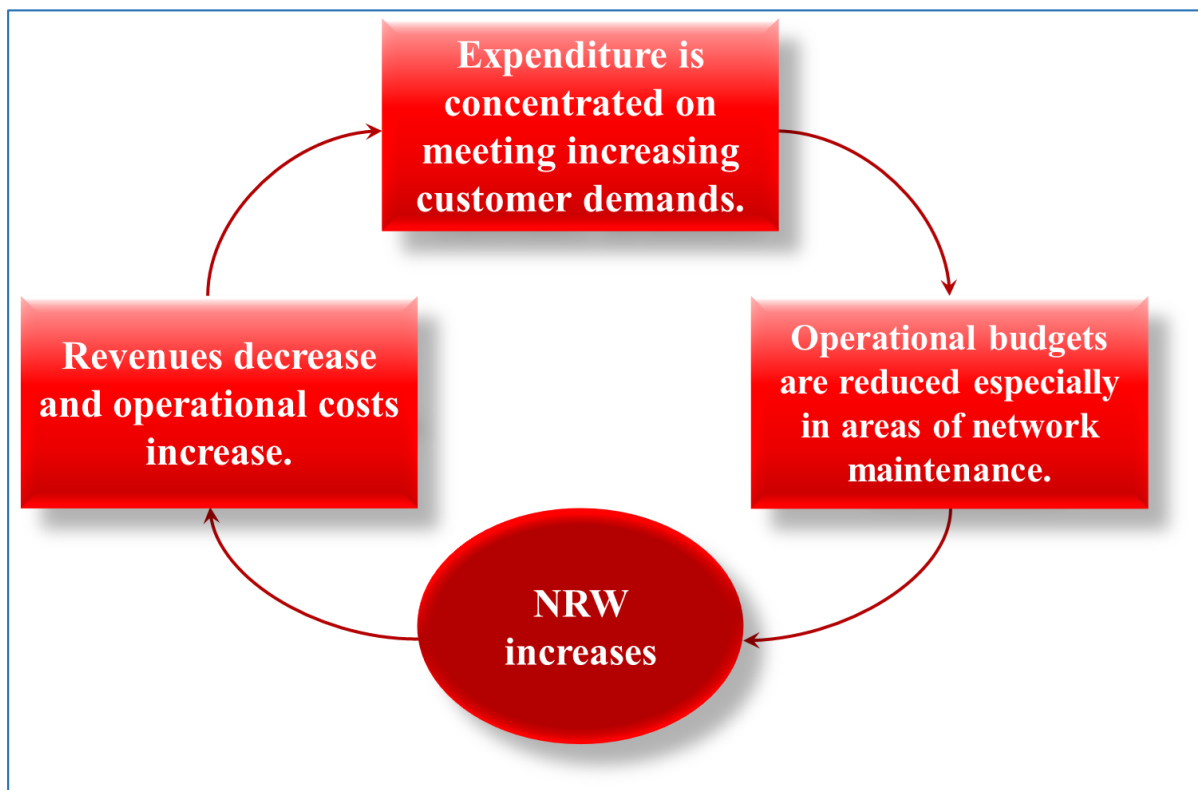


Figure 26 The Vicious NRW Circle



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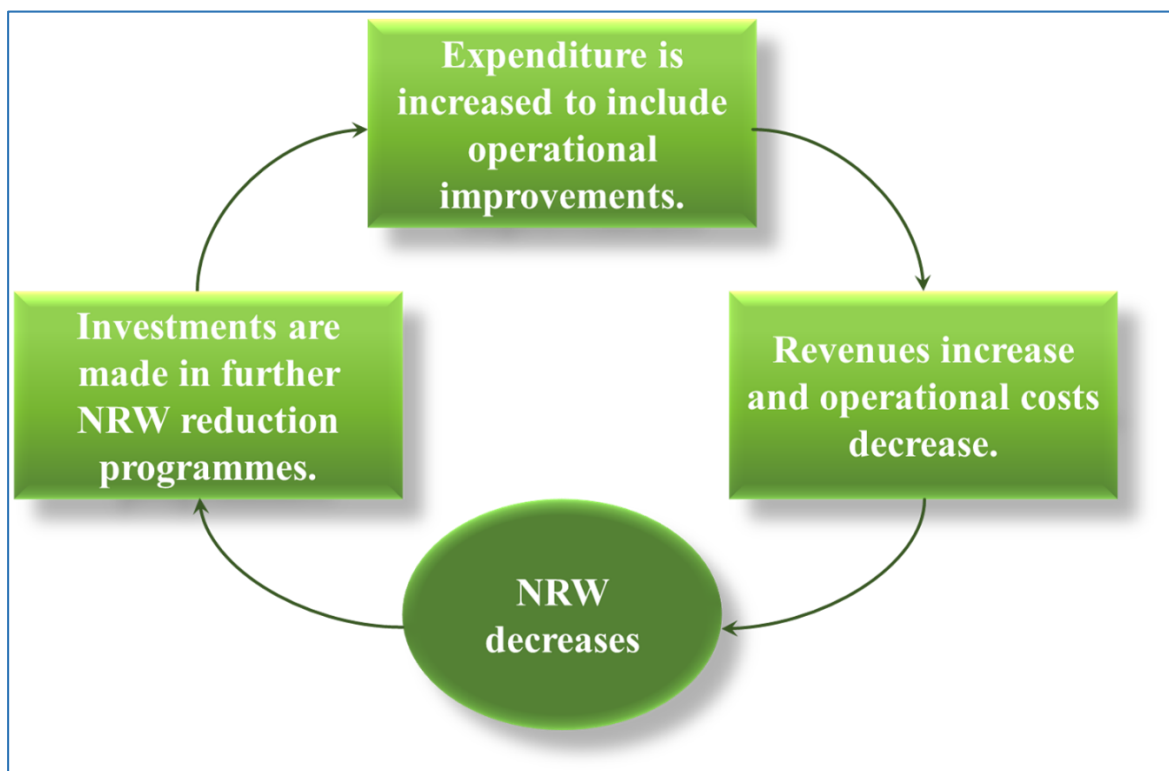


Figure 27 The Virtuous NRW Circle

When developing an NRW reduction strategy, costs differ substantially, depending on the activity being undertaken. A brief cost-benefit assessment of the strategies has to be prepared, made on the basis of a reliable water balance. Reducing commercial losses is always cost-effective and offers fast payback. The activities are technically easy to carry out, but politically difficult, because it often requires taking a strong stance against the population benefiting from the status quo. On the other side, reduction of physical losses through leakage control can be expensive, requires significant technical know-how, and must be carried out extensively to bring results. Water companies must seek to achieve an economic balance between the costs of leakage control and the benefits that accrue.

3.4.1 NRW Components Related to Financial Management System

In the scope of financial management the following problems are assessed and the required measures are proposed in Section 3.4.5.

- Data handling and billing errors,
- Unbilled authorized consumption,
- Unpaid bills and outstanding debts.



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3.4.1.1 Data Handling and Billing Errors

Data handling and billing errors are classified as the components of apparent losses in the IWA Standard Water Balance as stated in Section 1.2.2 and Annex B.1. On the other hand, these are not accepted as NRW components in the current Regulation. In order to complete the water balance, the ‘lost’ water volume from billing and data handling errors have to be identified. Furthermore it is clear that there is no need to have a recent fleet of excellent water meters if the meter reading process is not reliable.

According to IWA approach, data handling and billing errors could include transcription errors, consumption on premises that have not been registered on the billing system due to internal procedural errors, premises incorrectly flagged on the billing system (e.g., flagged as demolished but still live), etc.

The following factors should be accounted as factors for the data handling and billing errors.

- Customers data base structure,
- Quality of meter reading data,
- Meter reading procedures,
- Retail price of water.

There are many chances of introducing errors when reading consumer meters and processing the measurements. The meters are usually read either manually or through remote or Automated Metering Reading (AMR). Manually reading readings by meter readers visiting consumer homes and collecting their meter readings is the traditional approach used by the majority of water companies.

Data handling and billing losses generally comprise followings:

- Reasons of data handling errors (meter reading errors):
 - Corruption meter readers (collusion with customers),
 - Meter reading errors (mistakes, or unreadable meters),
 - Faulty meters.
- Reasons of billing errors (accounting errors):
 - Legal connections not recorded on the billing database (accidental or on purpose),
 - Billing errors due to broken / tampered customer meters,
 - Data errors between the meter reading and the customer’s bill,
 - Data handling errors in billing department,
 - Bills sent to wrong address.



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3.4.1.2 Unbilled Authorized Consumption

Those components of Authorized Consumption are legitimate but not billed and therefore do not produce revenue. Unbilled authorized consumption is equal to unbilled metered consumption plus unbilled unmetered consumption. Metered Unbilled Consumption might include metered consumption by the utility itself or water provided to institutions free of charge, including water transferred across operational boundaries (water exported) which is metered but unbilled.

Unbilled Unmetered Consumption typically includes items such as firefighting, flushing of mains and sewers, street cleaning, frost protection, etc. In a well-run utility it is a small component.

3.4.1.3 Unpaid Bills and Outstanding Debts

Unpaid bills and outstanding debts are not an apparent loss, and are not included in the water balance, which is a volumetric calculation, but there is no doubt that they generate real financial losses. “Unpaid bills” and “outstanding debts” are very real issues that need to be addressed under certain circumstances where this has been identified as a problem.

The problem of the unpaid bills should be included for NRW management strategies, since unpaid bills are a significant source of apparent losses. Sometimes, consumers who are disconnected for non-payment reconnect their house connection illegally and become illegal consumers. In that case, the Utility is losing twice: through outstanding debts and through apparent losses³⁰.

NRW and revenue collection cannot always be considered as completely independent issues: it can be relatively easy to reduce apparent losses by issuing bills to customers in low-income areas for instance but it is much more difficult to get the payment of these bills from bad payers and defrauders. Cost benefit analysis of apparent loss reduction should be based on collected revenue and not only on billed revenue. The improvement of the water utility financial health is dependent on reducing NRW rate and increasing Revenue Collection Ratio.

3.4.2 Definitions Related to Financial Management System

The definitions of the system components together with actions are given in this section. Although some of the definitions are well known by WSA/WUD, these definitions are also given in order to adequately understand each action suggested in the Guideline and to avoid a gray area.

Property

The definition of property can be complicated in practice. For the purposes of leakage management, it is easier to obtain the count of billed accounts from the customer billing system

³⁰ Guidance Notes on Apparent Loss and Water Loss Reduction Planning, 2016



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and it is therefore sensible to use a definition that reflects this, i.e. a property is synonymous with a billed account; be that a house, flat, industrial premise or commercial unit.

Active Property

A property that is occupied, either continuously or occasionally, and which therefore could have consumption. A second home would be classed as active, as it will have consumption even if only occasionally.

Inactive Property

A property which is vacant and therefore has no consumption. Sometimes referred to as a void property.

Property Density

The ratio of the number of billed properties (i.e. customers) per unit length of main, i.e. no/km.

Occupancy

Occupancy is the estimated population in an area divided by the number of domestic properties (billed accounts) in the same area. The estimated population can be difficult to obtain but some countries have good quality census data. The billed accounts are obtained from a mapping of the area boundary between the GIS and the customer billing system.

Customer Contact System

A computer system that records and tracks all customer contacts with a utility. This will include all contacts including no water, poor pressure, visible leak and water quality concerns, among other issues. The system is relevant to leakage management as it records when customers report a visible leak and tracks progress and results of subsequent inspections.

Customer Billing System

A computer system that has information on consumers and their consumption. This is critical for leakage management. The customer billing system will usually also include all information on the revenue meters including type, manufacturer, model, class, date purchased and date installed for example, in order to assist with all aspects of managing the meter stock.

Water Resource Zone (WRZ)

A water resource zone is an interconnected area of supply, often with multiple sources, where all customers have the same reliability of supply. The ELL should be evaluated at the WRZ level.

Marginal Cost of Water (MCW)

The marginal cost of water is defined as the additional cost of producing or purchasing and distributing an addition unit of water. Marginal cost is calculated by dividing the change in



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total cost by the change in quantity. In the case of a water source, it is the marginal cost of power used in the abstraction, treatment works and distribution pumping, the marginal cost of chemicals and the marginal cost of sludge disposal from the treatment works. It does not include any capital items, such as treatment works, or revenue items, such as manpower or maintenance costs, which would not be readily saved by reducing output by 1 m³/d. The marginal cost is often derived by adding the annual costs of the items mentioned and dividing by the annual output. This is the unit cost of water. It is not necessarily the same as the marginal cost when the cost-vs-output relationship is not constant.

The marginal cost of water is used when evaluating the short run economic level of leakage (ELL). The ELL should be evaluated at WRZ level. In theory the maximum marginal cost of water of any sources or supply feeding a WRZ should be used in the calculation of the ELL on the basis that it would be sensible to pass on leakage reductions by reducing production or purchase at the most expensive source or supply of water. However, the average marginal cost of all sources in or supplies to a WRZ is often used instead of the maximum. The marginal cost of water for the WRZ is either the maximum or average marginal cost of water of the sources feeding the zone plus the marginal cost of distribution pumping.

The units of MCW are typically TL/m³.

Marginal Value of Water (MVW)

Where the headroom in a WRZ is very low, it may be necessary to evaluate whether it is more cost efficient to carry out additional leakage control activity rather than develop a new resource. In this case, the additional cost of constructing the water resource and associated treatment works (including annual maintenance) has to be added to the marginal cost of water of the WRZ. This total is referred to as the marginal value rather than cost of water. This is then used in the ELL assessment to evaluate the level of additional leakage measures, such as additional active leakage control and additional pressure management. The units of the marginal value of water are the same as those for the marginal cost of water.

Marginal Cost of Revenue (MCR)

The marginal cost of revenue is the loss in income when a unit of water is not charged/recovered. It is therefore the volumetric charge on the tariff. The cost of revenue is used to judge the value of carrying out activities to reduce administrative (apparent) losses. At the economic level of apparent losses, the marginal cost of additional administrative (apparent) loss control will equal the marginal cost of revenue. The units of the marginal cost of revenue are the same as those for the marginal cost of water.

Capital Expenditure (CAPEX)

Capital expenditure or CAPEX is the cost of developing or providing non-consumable parts for the product or system. Capital expenditures is the cost to purchase major physical goods or services that will be used for more than one year. For example, a utility may have



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capital expenditure to increase or improve its fixed assets. Examples of capital expenditure associated with leakage control and water loss management would include the purchase of PRVs, DMA meters, pressure loggers, flow loggers, correlators and acoustic sensors. In the case of municipal utilities, capital expenditure will be controlled, and hence possibly limited, by central or local government. In the case of corporate or private utilities capital expenditure will be controlled by internal budgetary control and the ability to raise money on the financial markets.

Operational Expenditure (OPEX)

Operational expenditure or OPEX is the ongoing cost for running a product, business or system. It may also be referred to as revenue expenditure. Examples of operational expenditure associated with leakage control and water loss management would include staff salaries, rent, administration, travel and cost of outsourced leakage detection resources.

Discounted Cash Flow (DCF)

Often it is necessary to combine the effect of both operating and capital costs. This process is referred to as discounted cash flow (DCF) analysis if the capital cost is discounted into an equivalent revenue stream or net present value (NPV) analysis if the revenue stream is converted into an equivalent lump sum. In either case, a discount rate must be used to carry out the conversion and is usually provided by national, federal or local government.

3.4.3 Performance Indicators for Financial Management System

3.4.3.1 PI Definitions and Calculation

Main indicators for economic water losses proposed by IWA are the followings:

Non-revenue water by volume (Fi46)

$$\text{Non-revenue water by volume} = \frac{NRW}{UARL} \times 100$$

$CARL = \text{Non-Revenue Water Volume, m}^3 / \text{assessment period (days, year etc)}$

$SIV = \text{System Input Volume, m}^3 / \text{assessment period (days, year etc)}$

Non-revenue water by cost (Fi47) (during assessment period)

$$\text{Non-revenue water by cost} = \frac{\text{Valuation of NRW Components}}{\text{Running Costs}} \times 100$$

$\text{Valuation of NRW Components} = (UAC + AL) \times \text{Average water charges for direct consumption} + RL \times \text{Attributed unit cost for real losses}$



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Running Cost = Total operation and maintenance cost and internal manpower net costs, regarding the water supply service (annual costs of the water distribution system)

UAC = Unbilled Authorised Consumption

AL = Apparent Losses

RL = Real (Physical) Losses

Average water charges for direct consumption = Ratio between the water sales revenue for direct consumption and billed water, TL/m³

Attributed unit cost for real losses = Highest of the variable component of improved water charge or long run marginal cost (LRMC) for own sources, TL/m³

*(i.e. not including the capitalized costs of self-constructed assets)

Operational Indicators for Customer Management:

The monitoring of specific “operational indicators” or “metric indicators” by field of activity is also important. Some operational indicators that are used by many practitioners are mentioned below:

- Percentage of active and inactive connections.
- Percentage of connections disconnected for non-payment.
- Number of frauds detected by meter readers.

The PIs for WSA/WUDS to be calculated, monitored and controlled for NRW management are proposed as shown in Table 14.

Table 14 Financial Management PIs (%)

	Performance Indicator		Explanations
Composition of running costs per type of costs	Electrical energy costs	Fi10	(Electrical energy costs / running costs) x 100
Composition of running costs per main function of the water undertaking	General management functions costs	Fi12	(Running costs of general management functions / running costs) x100
	Human resources management functions costs	Fi13	(Running costs of resources management functions / running costs) x 100
	Financial and commercial functions costs	Fi14	(Running costs of financial and commercial functions / running costs) x100
	Customer service functions costs	Fi15	(Running costs of customer service functions / running costs) x 100



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	Performance Indicator		Explanations
	Technical services functions costs	Fi16	(Running costs of customer service functions / running costs) x 100
Composition of running costs per technical function	Abstraction and treatment costs	Fi18	(Running costs of the abstraction and treatment / running costs) x 100
	Transmission, storage and distribution costs	Fi19	(Running costs of the transmission, storage and distribution / running costs) x 100
	Meter management costs	Fi21	(Running costs of the meter management / running costs) x 100
Efficiency	Total cost coverage ratio	Fi30	Total revenues / total costs
	Operating cost coverage ratio	Fi31	Total revenues / running costs ³¹
	Delay in accounts receivable	Fi32	(Accounts receivable from drinking water at the reference date / sales revenues during the assessment period) x assessment period (days equivalent)
Water metering	Customer reading efficiency	Op36	[(Number of effective meter readings carried out during the assessment period x 365) / assessment period]/(number of residential customer meters x residential customer meter reading frequency + number of industrial customer meters x industrial customer meter reading frequency + number of bulk customer meters x bulk customer meter reading frequency)
	Residential customer reading efficiency	Op37	[(Number of effective residential meter reading carried out during the assessment period x 365)/assessment period]/(number of residential customer meters x residential customer meter reading frequency)
	Operational meters	Op38	(Number of direct customer meters installed that are not out-of-service at the reference time / number of direct meters) x 100
	Unmetered water	Op39	(System input volume-metered consumption / system input volume during the assessment period) x 100

Source: Performance Indicators for Water Supply Services, Third Edition, IWA, 2016

3.4.3.2 PI Evaluation for Goal Setting

Performance indicators defined and calculated in Section 3.4.3.1 will be evaluated in this section with the given limits for those PIs to determine goals and strategies to achieve those goals for a specific component.

The international literature provides some limits for the unbilled authorized consumption as shown in Table 15.

³¹ The acceptable range stated in by IBNET is 1.3-1.6.



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Table 15 Critical Limits for Unbilled Authorized Consumption³²

Limits	Actions to be implemented
Up to 1%	Considered within acceptable limits
1-5%	Introduce new tariffs
5% and above	Review overall billing policy

3.4.4 Understanding Current Status for Financial Management System

As stated in the above section, all components of the financial management NRW are in mutual communication. In the table below, the methods for detecting data acquisition and processing errors, which are considered as administrative loss in the Standard Water balance form, are given.

Table 16 Subcategories of Data Handling Errors

Subcategories	Cases	Method for evaluation
Errors in customer metering	Manual or semi manual Meter reading	Sampling and Field survey Technical audit
	Automatic Meter reading	
Data processing errors	Billing system errors	Billing system and procedures audit
	Errors in other data manipulation	Customer management procedures audit

However, it has been determined that there are both human and systematic problems in data collection and recording, both in the experience of the Consultant and in the information sharing in the Workshops. It is recommended that WSA/WUDs that have not passed yet should switch to a smart meter and tracking system, which will have a very fast financial return. As suggested in other action areas for current situation determination, a stepwise current situation determination is not recommended for this topic. If the administration has a request to make an inspection as soon as possible, it should be done by expert organizations. However, it should not be forgotten that when the smart meter system is switched, the system will be quite open to control and audit and evaluations can be made in the short term.

³² Charalambous & Hamilton, 2012



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3.4.5 Establishment of NRW Oriented Financial Management System

Estimating Unmetered Consumption:

A small number of service connections are not metered. This occurs when all the customers are metered and some meters are out of order. In that case, WSA/WUD should have specific procedures: for instance, they should bill the same amount as during the same period last year. It does not create big issues when the procedures are correctly implemented (but it is necessary to check that they are).

In some cases, unmetered consumers are billed based on a flat rate, which may be varied with size or value of the property. In that case, one method consists in comparing the consumption of metered consumers and unmetered consumers. The rate will depend on the type of water supply: continuous or intermittent. The over consumption of the unmetered consumers will be considered as an apparent loss (consumed but unbilled).

The danger with billed unmetered consumption is that customers may start to sell water and therefore consume a lot more than projected. This type of practice may be found out by surprise visits to these houses, or checking if there are large tanks on the premise. However, best is to avoid such situations by installing water meters.

There are some consumers that will not pay for water. These might be public agencies that water parks, fire fighters or governmental buildings. Even though these consumers remain unbilled, it is better to meter these connections as well as it will help the understanding of where the water flows.

Reducing Billing Errors

Using the same methodology for reducing illegal connections, identify legal connections not on the billing database

- Audit the end-to-end processes and make improvements (if any) for:
 - Meter read to the bill being paid,
 - Estimated readings,
 - Replacing meters,
 - Billing reports.
- Rotate meter readers to avoid customer collusion.
- Use hand held meter reading devices to avoid data errors.

3.4.5.1 Reducing Data Handling and Billing Errors

There are many chances of introducing errors when reading consumer meters and processing the measurements. The meters are usually read either manually or through remote or Automated Metering Reading (AMR). Manually reading readings by meter readers visiting



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consumer homes and collecting their meter readings is the traditional approach used by the majority of water companies. It is necessary to read the meter in an efficient way. It is required to :

- Implement awareness programs for meter readers and data analysts on the importance of reading the meter correctly and verifying data respectively.
- Get rid of old meters that are hard to read.
- Avoid corruption, for instance by putting the meter readers on a rotation scheme (changing their working area every so many months).

Before final pricing, consumption levels must be verified in the pricing system.

AMR and AMI (Advanced Metering Infrastructure) methods are increasingly being applied, providing water companies with the opportunity to minimize the apparent losses due to meter read errors. Automated Meters Reading, or AMR, is the technology of automatically collecting consumption data, as well as other information from water meters or energy metering devices (gas, electricity) and transferring these data to a central basis for pricing, troubleshooting, and analyzing the recorded data.

For the implementation of this technology, it is required:

- A meter that has the appropriate infrastructure for AMR integration.
- A pulse or pulse generator that produces the digital signal that ultimately determines the measured value. These devices are usually energy autonomous.
- For the communication of the meters with the rest of the system a data acquisition system is used.

Three are the main types of data acquisition and processing systems:

- Get walk-by system: Data is downloaded via a portable handset at a specific range from the point of installation of the meter (usually 10-200m).
- Drive-by system: The data are downloaded by a portable device installed on a vehicle moving at low speed and within a certain range from the point of installation of the meter.
- Receiving data over a fixed network: Data is downloaded through a fixed infrastructure consisting of signal repeaters and collectors.



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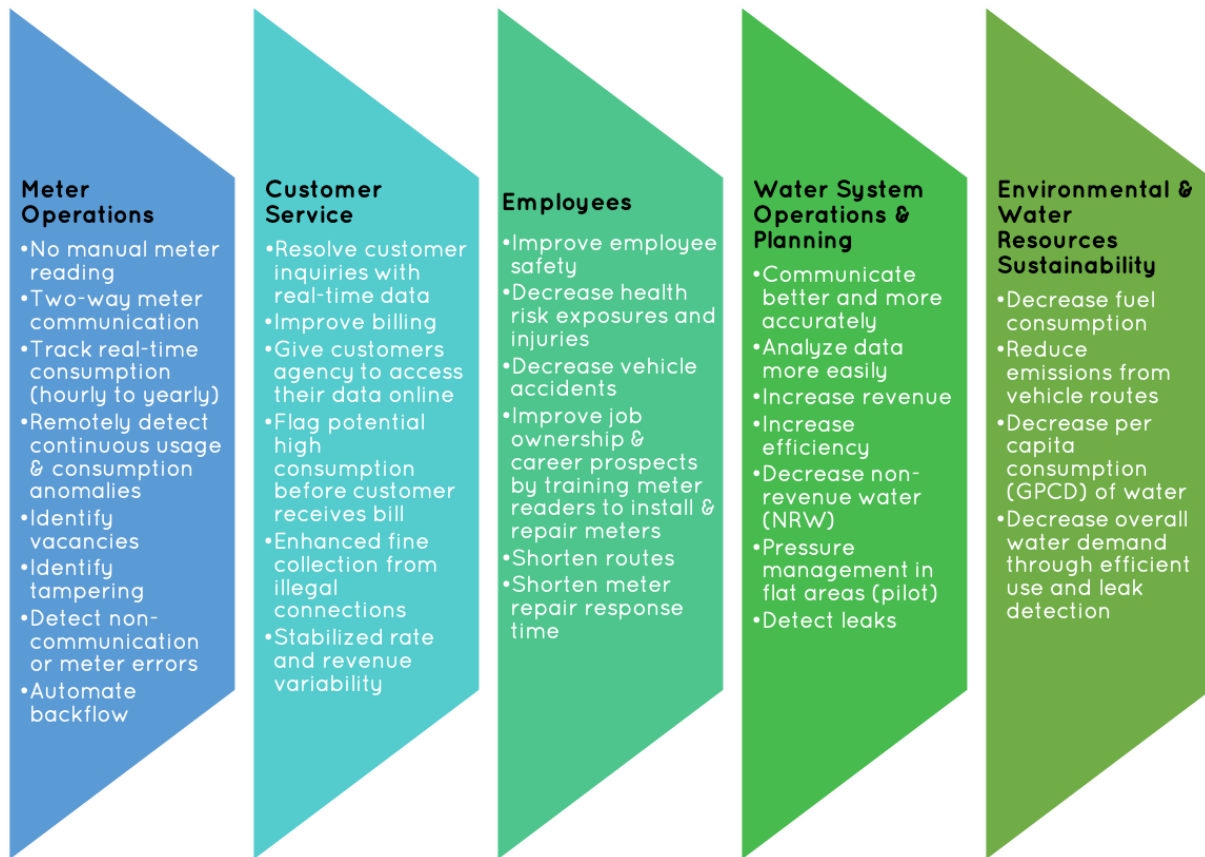


Figure 28 Benefits to the Water Authority of switching to advanced metering infrastructure (AMI) from conventional or drive-by advanced meter reading (AMR) meters.

In all three cases, the transfer of data is done over radio frequencies or through a mobile network, while the first two categories can be done by physically connecting the device to the computer.

There may be also billing data errors, such as wrongly transferred meter data or bills sent to the wrong address. To avoid such problems, it is recommended that:

- The billing department is trained on how to analyze and verify data
- Staff that goes out into the field shall report back when people are continuously not found (on the registered address) or the gate is always locked
- Keep the customer database updated

Billing losses

In addition to the unauthorized consumption (illegal service connections or frauds), billing losses may be the result of different causes:



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- Incorrect tariff application,
- Meter reading errors or absence of reading,
- Billing corrections – or discounts for example - not taken into account.

The customer services management must rely on clear procedures that are regularly audited at the different levels of the personnel concerned: installation of a meter, meter reading, back office and front office, bill delivery etc. The errors and the anomalies must be the subject of detailed investigations that will sometimes call into question, and improve, the procedures.

Concerning the meter reading procedures, the following points must be the subject of a specific analysis, or even an audit:

- Quantity of unread meters (why? and since when?);
- Critical analysis of the meter reading;
- Control on unread meters (second reading, inspection etc.);
- Quantity of estimated bills;
- Factors used for the estimation.

3.4.5.2 Collection Efficiency and Debt Management

In many developing countries the collection efficiency plays a large role in the monthly revenue of water utilities. With collection efficiency the ratio between the amount of water billed and the amount of water paid for is meant. Although the collection efficiency is not part of the IWA definition of NRW, it is a very important issue to take into consideration when implementing a NRW strategy as cash always counts. Therefore, it is advised to actively engage with customers that are not paying and have a debt. There are a number of elements that should be looked into:

- Reach out to all customers with debt and, depending on the height of debt, how long it has been standing for and how many warning they already had, disconnect them or give them a deadline for payback.
- This activity requires the team to pro-actively engage ‘gate-locked’ consumers through phone/SMS/email and (subsequently) disconnect non-compliant consumers.
- In developing countries debt management issues may become ethical questions: is someone not unwilling but unable to pay? Ways to deal with such issues could be to:
 - Work out a payback scheme with the customer. Instead of disconnecting the customer if the debt is not paid before next month, it could be agreed the customer pays off a little bit every month over a longer period (say 6 months or a year).



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- Depending on the situation of the customer and the utilities' policy, the debt can be pardoned. This would not lower NRW but would close the case and reduce the value of VAT to be paid by the utility.
- Look at the number of clients that receive bills based on estimates and see if water meters can be installed. Billing based on estimates can encourage customers to tap as much water as they like and sell it to other people.
- Pre-paid meters are often expensive and many water utilities can't afford to install them to the largest part of their customers, however, with infamous clients (and especially those that are large water consumers) it might prove beneficial to install them.

3.4.6 Budget Considerations for Implementing NRW Reduction Strategy

The development and implementation of activities to achieve the targeted level of NRW incurs a financial cost. Usually NRW management strategies last years and the overall cost can be quite substantial. Many NRW strategies start off at full speed but often fail due to budget cuts over time. Undertaking pilot projects to demonstrate the effectiveness of the NRW strategy is useful. The pilot should cover a smaller area, be substantial enough to ensure that all components of the NRW strategy are tested, and operate under financial conditions that can be replicated when activities are implemented throughout the entire network. The analysis of the pilot results should be used in the development of the economic level of NRW for the entire system. The budget should identify the following costs:

- Staffing: Include staff for both direct NRW works (e.g. leakage technicians) and indirect support (e.g. procurement staff).
- Equipment: Include equipment installed permanently (e.g. DMA meters) and those used on a day-to-day basis (e.g. leakage detection equipment).
- Vehicles: Include transportation costs, which can become an important issue in maximizing the work rate of all staff. Small teams generally cover the entire supply system for undertaking NRW works.
- Works: Include the costs for installing all equipment, such as meters and pressure reducing valves, and also detecting and repair all leaks.

Identifying the economic level of NRW should be the basis for setting the initial utility-wide target for NRW reduction. Using the water balance to prioritize components for NRW reduction helps balance the financial and water supply objectives of the NRW strategy.

NRW reduction is a long-term process and the strategy may cover a period of 4-7 years. Pilot projects can help water managers understand the full budget required to implement the entire strategy.

For the development of the strategy, the impact of each action area on the cost should be taken into account. The effect of the NRW management components, which are revealed by



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international studies, on the cost is given in the table below. As can be seen from the table, the component with the lowest cost but with the largest return in terms of volume is the "unbilled measured consumption" component.

Table 17 Volume and Cost Analysis for NRW Management

		Cost		
		High	Medium	Low
Volume	High	Leakage on mains Leakage on service connections (P)	Unauthorized Consumption (Adm.)	Unbilled metered consumption (U)
	Medium	Customer meter replacement	Customer metering inaccuracies and data handling errors	Errors management (P)
	Low	Reservoir leakage (P)	Unbilled unmetered consumption (U)	Reservoir overflows (P)

NRW Type: U=Unbilled authorized consumption, Adm.=Administrative losses, P=Physical losses

3.5 Action Area: Management Information System

Management requires complete information relating to a problem or issue in right time in order to make effective decisions. The proper collection, handling and providing the right information to the right manager in right time not only reduce the risk of wrong decisions but also work as an effective controlling technique. Complexities involved in business and economic activities create the need for supply of right information to the right manager in the right time.

Management Information System (MIS) is defined as, “a formal method of making available to management accurate and timely information necessary to facilitate the decision-making process and enable the organization’s planning, control and operational functions to be carried out effectively.” The system provides information on the past, present and projected future and on relevant events inside and outside the organization.

Generally, an organization’s MIS consists of a series of information systems of varying degrees of complexity, competence and scope.

There are different kinds of information and various ways of describing an entity object or situation. The general attributes of information and item of information are as follows:

- Unambiguous: It should carry the same meaning and convey the same to everyone.
- Precision: Information should not carry too much details.
- Frequency: Frequency is measure of how often information is needed, collected or produced.



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- Breadth- Breadth of information defines its scope.
- Origin: Information may originate from sources inside the organization or outside it.
- Accuracy: Information may be true or false, accurate or inaccurate some time inaccurate information treated as an accurate which is harmful in organization.
- Promptness in availability: There is a famous quotation Information delayed is information denied means there is no use of that information which is received after the need of that is over.
- Completeness: Complete information is that which cover all the key issues and is sufficient to support the decision making without omitting any critical issue.
- Validity: Information should be valid, then only it will be effective.
- Reliability: Reliability means the information is accurate without any error. Reliable information can be collected from an authentic source only.
- Consistency: The information must relate to a consistent base or a pattern.
- Mode and Format of Representation: In business the mode of representation of information is either visual verbal or in written form.

Information and data that are necessary for the management and that have all the above features must be monitored, recorded, controlled and analyzed. Section 3.5.2 gives the MIS systems necessary for the management of an efficient and effective water management.

In the Internet of Things (IoT) era -with everything from valves to vehicles connected by sensors and systems- practitioners are incorporating advanced analytics and artificial intelligence (AI) into asset management. Data gathered from instrumented assets is analyzed using AI techniques. The resulting insights help maintenance teams make better decisions, enhance efficiency, perform preventive maintenance and maximize investments in their physical assets.

3.5.1 Definitions Related to Management Information System

The definitions of the system components together with actions are given in this section. Although some of the definitions are well known by WSA/WUD, these definitions are also given in order to adequately understand each action suggested in the Guideline and to avoid a gray area.

Geographical Information System (GIS)

A geographic information system (GIS) is designed to capture, store, manipulate, analyze, manage and present spatial or geographic data, for example, providing information on the location and attributes of water mains or DMAs.



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Work Management System (WMS)

A computer system used to record physical work undertaken on assets and track the progress of work. Also sometimes referred to as an asset management system or maintenance management system. It is common to have separate systems for “point” assets such as pumps, treatment works, for example, and “linear” assets such as water mains or sewers. A linear asset management system is useful in leakage management as it is the primary source for information on the number of leaks on the various assets and the time that leaks run prior to repair. It is feasible, but not common, to include non-revenue meters, PRVs and, say, air valves on a point asset management system so that warranty issues and regular maintenance schedules on these assets can be managed. A point asset work management system can be designed to record and manage activity on leak detection surveys or this may be held on a separate system or possibly the leakage management system.

Leakage Management System (LMS)

A computer system for managing all aspects of leakage management. It will have access to all flow and pressure monitoring data on the network. It can be separate from or integrated with the GIS, work management and customer billing system so that relevant information on DMA boundaries, property counts, lengths of main, leakage detection surveys, leaks found and repaired, can be viewed and compared against the flows and pressures on the system. The leakage management system will have details of the network hierarchy so that leakage can be reported at multiple levels within the utility.

Waste Notice System

A computer system used to manage the process of issuing and monitoring waste notices issued to owners of premises for the repair of leaks on private service pipes or repair of plumbing losses. Also sometimes referred to as leak notice systems or defective fittings notice systems.

Small Area Monitor (SAM)

A small area monitor is used to estimate either PCC or PHC of unmeasured customers. Each SAM usually comprises approximately 50–100 domestic properties in order to reduce the risk of leakage on the mains or service connections. Flows are monitored into the area and the PCC or PHC evaluated. A mix of property types and socio-economic groupings of occupants across the SAMs should be used in order to ensure a representative sample of the population as a whole.



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Individual Household Monitor (IHM)

An individual household monitor is used to estimate either PCC or PHC of unmeasured customers. An IHM comprises a number of domestic properties (usually several hundred), distributed across the area being considered, where the customer is metered, either internally or externally, but is not charged on their consumption, with the hope of them not changing their water use. Consumption is monitored and the PCC or PHC evaluated. An IHM needs to include a mix of property types and socio-economic groupings of occupants in order to ensure a representative sample of the population as a whole.

Smart Network

A smart network contains built-in diagnostic equipment or systems, such as remotely monitored flow, sound and pressure sensors or remote-controlled valves, which allow the system to be managed or controlled from a remote location for efficient management, thus allowing it to perform in an economic and efficient manner. With ever developing technology, digitization has accelerated the collection and dissemination of actionable information both on the supply and the demand side to all stakeholder groups including utilities managers themselves, their workforce, their contractors, their customers and owners. This will have a profound effect in the future and the phrase “digital water” has been coined to reflect this. In many respects the more sophisticated leakage management systems could be considered as being a “digital twin” of the network holding, for example, a hydraulic model of the network as well as inventories and details of all the sensors and assets within the network.

3.5.2 Establishment of Management Information System for NRW Management

Smart water management applications carried out by water and sewerage administrations provide the Administration with the ability to manage and control all data over a single infrastructure. Due to the difficulty of controlling the production and distribution systems spread over a wide geographical area, continuous monitoring of water resources and distribution lines is required.

The main goal is to provide water at a lower cost, with a healthy structure and sustainably. With smart water management, it is aimed to increase the revenues of the administrations, to increase the energy and water efficiency at the water supply and distribution points, to increase the water quality, to reduce the operating costs and, as a result, to provide high standards of service to the subscribers. In this context, design and implementation projects are carried out to identify the points with high energy costs in the water supply and distribution network and to reduce these costs. In project planning, it is ensured that the operational status of the assets are examined, and that inefficient infrastructure and equipment that has completed its economic life are renewed when needed.



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Smart Water Management Systems are end-to-end modern water management systems established for the most effective management of the process from the source to the end user. Technologies used in Smart Water Management can be listed as the following management systems;

- Subscriber Information Management System,
- Smart Meter Management,
- Central Monitoring and Control System,
- Geographic Information System and Infrastructure Management,
- Asset Management (See Section 3.2.2.2)

Subscriber Information Management System,

The subscriber information management system is used to perform meter readings quickly, to issue invoices quickly and without errors, to quickly identify problems and take precautions, and to respond quickly to subscriber requests. With subscriber management, it is aimed to provide high standards of service to citizens. All subscriber status and transactions are managed with the subscriber information management system.

The following can be provided with the subscriber information management system.

- The smart subscriber information management system works in integration with online meter reading processes. By taking the accrual and collection transactions combined with bank payments as reference, administrations real-time subscriber tracking capability will be provided.
- Invoices will be prepared quickly and without errors, thus preventing invoice errors.
- Problems related to the subscriber will be detected quickly and the problem will be resolved quickly,
- In the process of receiving requests from citizens, the addresses of the subscribers to which they apply through the corporate web portal or any communication unit are taken as location information on the map. In case of malfunction, rapid intervention will be possible.
- With the integration of the Central Population Administration System (MERNIS), correct transmission of subscriber information will be ensured. With these data, household unit water usage information can be drawn and used in analysis.
- National Address Database (UAVT) integration will be done to match the subscriber locations with the address so that unauthorized use-water theft can be accrued with the previous reading in case the meter cannot be read.



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- Within the scope of the Subscriber Management System, subscriber registration procedures can be carried out, and related documents can be added to the system with subscriber connection agreements.
- Subscribers' meter information is kept, and calibration requests and results related to the meter are recorded. With the water meter and calibration station, high consumption objections and meter failure notifications of the subscribers are quickly tested and resolved and the grievances of the subscribers are eliminated.
- Tariff management is one of the important components in the subscriber management system. In this context, the benefits can be listed as follows;
 - Having a flexible tariff model,
 - Managing regional tariffs,
 - Determining the durations of tariff types,
 - Parametric determination of revenues, VAT rates and levels of tariffs,
 - Automatic matching with the accounting codes related to the tariffs and determining the lower and upper consumption limits for the tariffs,
 - Consumption accruals can be determined by online meter reading,
 - To be able to detect illegal usage with missing information of the subscriber
- Collection transactions of the subscribers can be managed and various payment options such as cash, credit card, bank transfer and installments are offered to the subscribers. Within the subscriber management system, there is also a receivables management system where the processes can proceed automatically for receivables that cannot be collected.
- Illegal and irregular uses can be detected automatically by the system as well as by field operators and directed to the relevant services as business.
- Another feature of the system is the ability to manage the legal processes of subscribers who do not pay their debts. Enforcement requests are directed to the work list as a legal follow-up work order. During the execution phase, the related legal expenses and standard expenses can be included on the debt, and a lock-in action can be made. All printed correspondence related to the execution processes can be produced in this system. The necessary XML file can be sent automatically to the Enforcement Directorate so that the enforcement file can be transferred to the UYAP system. A guarantor can also be defined.
- In the breakdown management system, which constitutes the most important part of the subscriber management system, the notification address is first determined on the map. Instant information can be given to the owner of the notice regarding the created work



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order. Work orders are managed in a mobile environment. Team, vehicle and material management is done and excavation permits are managed and the operations are documented with pictures. Planned interruptions are determined on the map. Repair completion times can be monitored. The location of the work order can be changed and the work order can be assigned to the most suitable team.

The benefits provided by the Subscriber Management System can be summarized as follows;

- Location-based subscriber information, work order information, index reading plans, instant coordinates of teams, work order finalization and index reading coordinates, drinking water / waste water network plans, relations of components in the network system, geographical / thematic reporting are made.
- In addition, debt follow-up process, legal follow-up process, new subscription request process, line manufacturing process, meter movements process, work order processes, laboratory processes are monitored.
- In terms of mobile workforce, significant benefits are provided in breakdown notification processes, line manufacturing processes, new subscription discovery processes, meter work order processes, and index reading processes, thereby accelerating the operational process.

Smart Meter Management

Smart Meter Management is a system based on the principle of remote reading of meters and opening and closing of valves without going to the residence where they are located. Meter consumption information is automatically collected by a computer system. The information read from the meters is transmitted via GPRS, and after being recorded by the administrations, it is transferred to the system and billed according to the consumption amounts read.

The advantages of the system can be listed as follows:

- The system can be accessed and tracked from anywhere with an internet connection. It provides faster and lower cost meter reading. There is no limit on the number of counters in the system. Meters in different residential areas can be read from a single center.
- Since the read data is recorded, retrospective accrual, collection, opening - cutting etc. operations such as faster and easier to control.
- It provides high quality and fast customer service to the subscriber. It provides the opportunity to see certain information such as subscription information, water consumption, past debts with a password to be given over the Internet.
- Network problems that may arise are immediately detected and corrected. By preventing illegal interventions, income increase is provided.



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- Data is transmitted using Radio Frequency and GPRS without the need for complex cable connections. Since the water company will use the 868 MHz frequency license-free ISM band, it has a lower cost compared to other AMR technologies.
- It is an easy to use, lower cost meter reading system. It saves personnel and time.
- Since it is not necessary to go to the residence where the meters are located, the safety of the personnel who will read is also increased. With the database, subscriber consumption information can be followed instantly or daily.
- It eliminates reading errors because it makes completely secure electronic communication. Water consumption is controlled and monitored in a healthy way.

Water Management with Central Monitoring and Control System

The central monitoring and control system to be established ensures that all data coming from the field are reflected on the screens in a way that the operators can follow and interpret. Detailed management of organizations spread over a wide area is possible from a single center.

Data control and subsequent follow-up processes are carried out as a system and this system is called “Administrative Control and Data Acquisition (SCADA). The SCADA system ensures the efficient use of resources due to the fast, reliable and planned data communication and the labor, time, material and energy savings that the system will provide.

The components of SCADA can be specified under 3 headings. These;

- RTU is the device where all the measurements and inspection processes needed in the field are made.
- The central unit is the unit where information from the field is collected, monitored, evaluated and all decisions regarding process management are taken.
- The communication media is the communication infrastructure between the field and the central unit.

SCADA provides the opportunity to monitor the water levels of the water tanks, their current volumes, the amount of water supplied to the network from the water tanks, the line pressure values in the pumping stations, the status positions of the motors and valves, and to intervene immediately. In addition, with this system, water, energy and labor savings are ensured, and faults can be intervened quickly.

In the smart grid system, the project area is divided into flowmeter zones with an average of 2-3 thousand subscribers, the areas are constantly monitored by flowmeters, and the loss and leakages are easily controlled by comparing the amount of water supplied to the region and the amount of the bill that can be collected every month. In this system, it is ensured that



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interruptions are made in the event of a malfunction with valving in such a way as to affect the minimum subscriber.

While the Geographic Information System (GIS) stands out as the most important element in the management of the infrastructure; Geographical mapping, management and combining with other “Smart Water Management” components of all assets that are within the physical responsibility area of an administration and used are carried out.

GIS provides benefits such as the development of more effective planning and management applications, the ability to take decisions quickly and on-site, the creation of data management with current and time-dependent changes in the short and long term, reduction of costs, and easier explanation of facts that are difficult to explain with visual analytical methods. With GIS applications, up-to-date or newly created data can be shared instantly, and labor and cost expenses can be minimized.

Online Infrastructure Information System, Cadastral Information System, City Information System, Superstructure Facilities Information System, Address Information System, which are defined as GIS applications, serve effectively in subscriber management and asset management.

In the GIS application, studies are carried out to organize the subscriber information system according to the UAVT (National Address Database) codes, and it is ensured that the GIS plays an important role in the detection of lost leakage by acting as a bridge between SCADA and Subscriber Management.



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3.6 Action Area: Monitoring and Ex-post Evaluation System

For effective and efficient NRW management implementation, the Guideline proposes the five major steps as shown in Figure 29. First three steps composed of target setting, strategy development and action implementation is defined in the above sections. The most crucial steps of NRW management is the monitoring and evaluation steps of the system. As defined in previous four action areas, the actions will be implemented for the problematic components. Keeping NRW components at the targeted level is an important goal of NRW management as well as reaching the target.



Figure 29 Steps of NRW Management Implementation

Periodic monitoring of the realization values of the targets and performance indicators suggested in the Guideline and implementation of the strategies regarding the evaluation and targets according to the monitoring results will increase the implementation success of the NRW Management.

Monitoring is the routine collection of high-priority data and information on activities and operations. Monitoring helps the administration to track how effective and efficient the management is using its resources towards operations and whether the management is on track to meet its objectives.

Evaluation is used to compare actual project results against strategic plans. Unlike monitoring, evaluation is not done on a routine basis but done at specific times (i.e. monthly,



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bi-yearly, yearly etc.). Evaluation refers to a range of activities that are undertaken to determine if the project activities had the desired impact.

Monitoring and evaluation (ex-post) activities deliver data about the progress of the NRW management development process and the impact of the actions. They are carried out before, during and after implementation of NRW reducing measures. Providing regular information to decision makers, potential funding bodies and local stakeholders can help to demonstrate that a NRW management has delivered, or will deliver, benefits to the community, provides value for money, is worth continuing or requires modifications to be successful.

3.6.1 Sustainability of Actions

Systematic monitoring and evaluation increase the efficiency of the planning process and implementation of measures, helps to optimize the use of resources and provides empirical evidence for future planning and appraisal of measures.

The five steps for successful monitoring, outlined below, help ensure effective and successful project monitoring.

- Project familiarization,
- Determine information requirements and information needs,
- Establish a Management Information system,
- Report to relevant organizations within the Government,
- Intervene to improve project performance.

The evaluations will answer the following questions for all project activities:

- Determine if and analyze the reasons why the goal, objectives and outcomes were or were not achieved.
- What are the unintended (positive or negative) results of the project?
- What is the cost effectiveness or re-estimated project rate of return based on realized activity benefits and costs?
- What is the likelihood that results will be sustained over time?
- How do the project's benefits and/or costs accrue differently to a) poor and non-poor, b) urban, peri-urban and rural communities, c) men and women? What is the reason for these differences?

Many strategies developed through the several countries showed that implement of local process will require the ongoing input of the national support. Therefore the recommendations for national strategy are listed as follows:



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- Complete high level audits, benchmark service providers, develop national priority list(s) of target areas,
- Ongoing reporting and NRW projects, national forum and national NRW working groups, public awareness and education campaigns,
- Dedicated a team to manage the national strategy,
- National NRW forum for the exchange of information – (requires representation of all service providers),
- Dedicated NRW practitioner teams – (Exists within some large utilities, roving teams required to help smaller utilities).

It is vital in leakage management that the advances made in water loss reduction are sustained. Considering the need to reduce the high water losses in our country and the many gains that can be achieved accordingly, the legislation on the control of water losses has been published and put into practice.

WSAs are responsible for keeping and reducing water losses at the same level on a regular basis after doing the necessary work according to the law. For this reason, it is necessary to carry out active leakage control on a regular basis. It is necessary to regularly check the active leakage control from the given actions. WSAs can determine the duration of the actions to be taken if the night flow rate is constantly controlled and regular data are kept on physical leaks, and losses are controlled with a water balance form to be made at least 3 times a year.

This can be achieved by:

- Ensuring appropriate staffing levels,
- Staff education and training,
- Operation and maintenance,
- Assessing and monitoring performance,
- Strategic monitoring,
- Facilities monitoring and maintenance,
- Operational performance monitoring.

3.6.2 Performance Assessment System

Local governments are assigned as important tasks as central administrations in the preparation and implementation of “Sustainable Development and Urban Development Policies and implementation frameworks” in accordance with the sustainability principles set out in the international development agendas after 2015. In order to improve the quality of life at the local level, central and local administrations need to establish coordination cooperation, communication and partnerships, and develop new institutional and legal capacities in



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determining and monitoring service standards. Thus, an urban development integrated with the national sustainable development and economic growth targets will be achieved and the pressure that urbanization creates on many areas such as the natural environment, housing, quality of life, transportation, rural life, and the achievement of development and growth goals that can solve the known problems that it causes will be supported. This strategic approach needs to be comparable, traceable, measurable and sustainable. In this context, the Sustainable Development Goals and New Urban Agenda and the preparation of indicator sets for monitoring and reporting of internationally comparable data collection and calculation tasks given to central government and local governments³³.

With the Public Financial Management and Control Law No. 5018, public institutions and organizations are obliged to create strategic plans and programs that will cover their mission and visions for the future within the framework of development plans and annual programs and organizational laws in line with the principles of financial transparency and accountability, as well as the effective, economic and efficient use of public resources. Article 9 of the Law envisages the preparation of Performance Programs that include the activities to be carried out by public administrations and their resource needs, performance targets and indicators.

The Performance Program is a program that forms the basis for the preparation of the Administration Activity Report. It covers a one-year period of the goals and objectives envisaged in the Strategic Plan. While the performance program is being prepared, priority ones for the fiscal year are determined among the aims and targets included in the Strategic Plan of the institution.

The monitoring and evaluation process not only provides institutional learning and the continual improvement of activities / projects, but also contributes to the establishment of accountability. The most important factor in the success of the implementation of the strategic plans prepared by public institutions/local administrations is the existence of an effective and stable monitoring and evaluation system.

The performance of WSA/WUDs is evaluated using performance indicators. Performance indicators are measures of efficiency and effectiveness of the delivery of services by an undertaking that result from a combination of several variables³⁴. Performance indicators can be analyzed interpreted and compared by taking into consideration context information and the quality of data for each utility.

Benchmarking, collecting performance indicators and then comparing performance between facilities of similar size and conditions is an important tool for improving NRW Management performance.

³³ “Eleventh Development Plan 2019-2023, Local Governments and Service Quality Specialization Commission Report”, TR Ministry of Development, Ankara 2018

³⁴ 2 Enrique Cabrea Jr, Peter dane, Scott Haskins and Heimo Theuretzbacher - Fritz (2011), Benchmarking of Water Services, IWA Publishing, London, UK



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The following figure shows the consistency linkages between the intervention logic and the other evaluation elements, evaluation questions and indicators. These must be decided prior to the start of an evaluation.

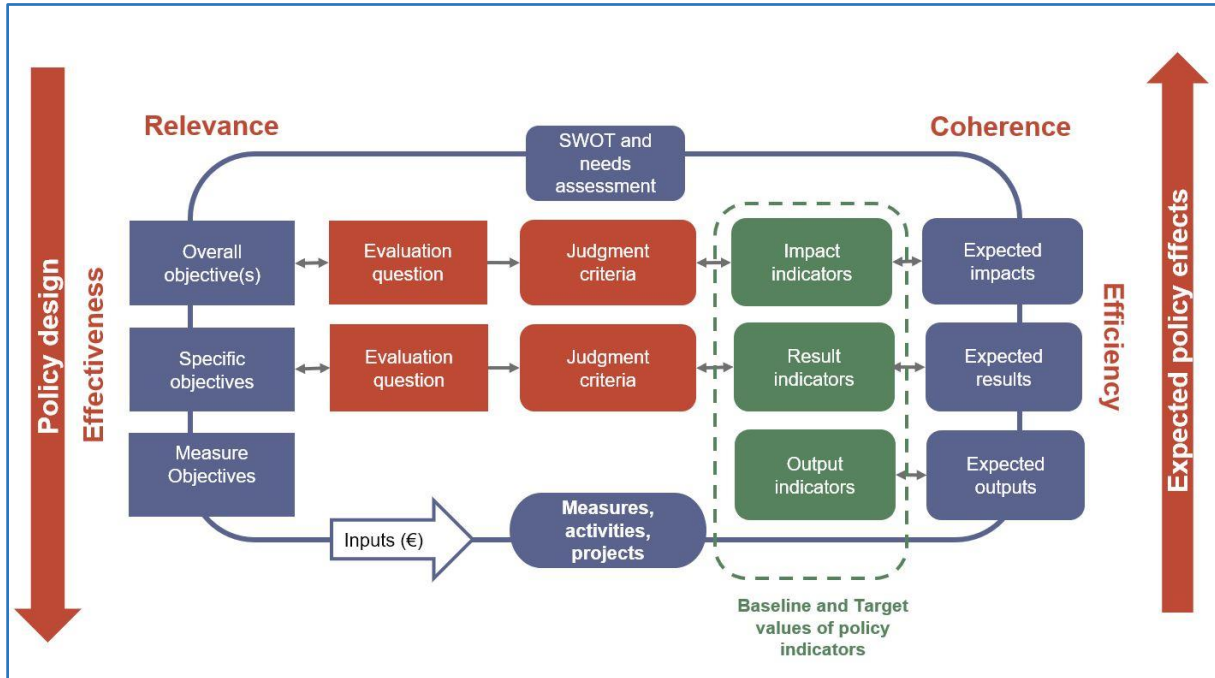


Figure 30 Effectiveness and Efficiency Relationship in Monitoring

The blue boxes show the relationship between the needs identified in the SWOT analysis and needs assessment (formulated as objectives), the actions (measures, activities, projects) supported with the budget that will be undertaken to achieve these objectives and the expected effects. These blue boxes make up the intervention logic. The expected effects are defined as outputs, results, and impacts:

- Outputs are actions financed and accomplished with the money allocated to an intervention. Outputs may take the form of facilities or works (e.g., building of a road, farm investment, tourist accommodation). They may also take the form of immaterial services (e.g. trainings, consultancy, information).
- Results are the direct advantages/disadvantages which beneficiaries obtain at the end of their participation in a public intervention or as soon as a facility funded through an intervention has been completed. Results can be observed when a beneficiary or operator completes an action and reports on the way in which the allocated funds were spent and managed. This can take the form in many ways, such as, it may be reported that accessibility has been improved due to the construction of a road, or that the firms which have received advice claim to be satisfied. These results should be regularly



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monitored. Policy makers can adapt the implementation of the intervention according to the results obtained.

- Impacts typically refer to the changes associated with a particular intervention over the longer term. Such impacts may occur over different timescales, affect different actors and be relevant at different scales (local, regional, national and EU).

The red boxes are evaluation questions, which are usually cause-effect questions asking for net effects and linked to the objectives. Evaluation questions might be further specified with judgment criteria which define how the success is to be achieved under each objective (overall and specific). They link objectives to indicators.

The green boxes are indicators, which should be consistent with the judgment criteria or evaluation questions, as well as with the expected effects (outputs, results and impacts).

Several types of indicators can be used:

- Output indicators measure activities directly realized within the programme. These activities are the first step towards realizing the operational objectives of the intervention and are measured in physical or monetary units (e.g. number of training sessions organized, number of farms receiving investment support, total volume of investment).
- Result indicators measure the direct and immediate effects of the intervention. They can provide information on changes in, for example, the behavior, capacity, or performance of direct beneficiaries and are measured in physical or monetary terms, (e.g. gross number of jobs created, successful training outcomes). Result indicators are used to answer the specific objectives related to evaluation questions.
- Impact indicators refer to the outcome of interventions beyond the immediate effects. Impact indicators are normally expressed in 'net' terms, which is realized through subtracting the effects that cannot be attributed to the intervention itself from the total and accounting for indirect effects (e.g. total factor productivity in agriculture, emissions from agriculture, water quality, degree of rural poverty). Impact indicators measure the programme's effects on the area in which it is implemented. Impact indicators are used to answer the evaluation questions related to the overall objectives.

Target values are often assigned to indicators. These targets are values established based on existing information, which programmes try to realize in order to achieve the expected effects, objectives and needs

Indicators determined by the act of recording and monitoring key performance indicators are measurable indicators that help WSA/WUD to:

- To better understand water losses,
- Defining targets for improvement,



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- Measuring and comparing performance,
- Developing standards,
- To monitor and evaluate,
- Prioritizing investments.

Data is quantitative information on selected indicators or variables which can be collected from the source itself (e.g. through survey, monitoring, statistics of entities) or secondarily through pre-existing sources (studies, aggregated statistics, etc.). Qualitative information can also be gathered to provide context for the evaluation and can be collected primarily from various stakeholders (intervention managers, beneficiaries, etc.) while using various qualitative or mixed methods (surveys, case studies, focus groups, interviews etc.). Data and information represent the evidence for the evaluation.

Potential data sources for the identification of each administrative loss components are given table below.

Table 18 Potential Data Sources for AL Monitoring

Administrative (Apparent) Loss Component		Data Source
Illegal connections		Check GIS property number - actual property in DMA - billing database
Meter inaccuracy	age	Meter audit: test old meters (sample calibration) (on average meters under-read 5%)
	class	Meter audit: test class B or lower meters (sample calibration)
	size	Meter audit: check if meters are sized correctly
	installation	Meter audit: check if meters are installed correctly
	tampering	Analyze information from meter reading / meter replacement team
Billing errors-Accounting errors		Thorough process of billing data and database: - Check billing database against actual meter readings, - Check GIS property number - actual property in DMA - billing database
Data handling errors-Meter Reading Errors		Meter reading audit



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ANNEX A- LEGISLATIVE AND INSTITUTIONAL STATUS



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A. LEGISLATIVE AND INSTITUTIONAL STATUS

A.1 International Legal Framework

A.1.1 European Union (EU) Directives Related to Water Management

The EU Water Framework Directive (WFD) numbered 2000/60/EC is considered as the most important directives on the protection and management of water resources in the EU, which adopts basin-based management. Accordingly, it is aimed to protect and develop water resources in surface and underground waters and to reach a good condition in all water bodies by preventing the deterioration in quality.

The purpose of the directive (Article 1) is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:

- Prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly dependent on the aquatic ecosystems,
- Supports sustainable water use based on long-term protection of available resources,
- Establish a framework for the aquatic environment, aimed at gradually reducing and halting or phasing out discharges, emissions and losses of priority hazardous substances for the aquatic environment, enabling the gradual reduction of groundwater pollution and preventing further pollution.

The main objectives set under the EU WFD regarding integrated water management are:

- Development of an integrated policy on sustainable water use and implementation of this policy in accordance with the principle of subsidiarity (Articles 1 and 4),
- Developing a water management approach based on river basins, ensuring cooperation between member countries in the case of river basins or their transboundary effects and finally ensuring cooperation with non-member countries where river basins are only partially within their borders (Article 3),
- Conservation and improvement of the aquatic environment (Article 10 and Annex IX), primarily through collective control approaches on to quality as well as regulations on quantity to ensure greater integration,
- Defining environmental goals and measures to achieve these goals with the integration of all these issues and other plans.
- of all these issues and other plans.

Türkiye is in the EU accession process, to harmonize this process quickly and effectively to the relevant Turkish legislation with EU legislation and regulations and is obliged to reflect on the question of domestic law. Studies on *acquis* alignment continue intensively.



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A.1.2 World Bank Environmental and Social Framework

The World Bank (WB) Environmental and Social Framework (ESF) sets out a bank policy designed to end extreme poverty and promote the sharing of prosperity and support borrowers' projects, and a commitment to sustainable development through a set of environmental and social standards.

The World Bank's Environmental and Social Framework includes:

- Sustainable Development Vision, which sets out WB's demands for environmental and social sustainability,
- Environmental and Social Policy for WB Investment Project Financing, setting out the mandatory requirements applicable to WB,
- Environmental and Social Standards determining mandatory conditions for borrowers and projects.

The Environmental and Social Standards set out requirements for identifying and assessing environmental and social risks and impacts for WB-supported projects through Investment Project Financing. WB focuses on identifying and managing environmental and social risks. The application of these standards supports borrowers in their goals of reducing poverty and enhancing well-being in a sustainable way for the benefit of the environment and citizens. Standards:

- Supports loan recipients in achieving good international practices regarding environmental and social sustainability.
- Helps borrowers to fulfil their national and international environmental and social obligations.
- Improves non-discrimination, transparency, participation, accountability and governance.
- Improves the sustainable development results of projects with stakeholder participation.

A.2 National Legal Framework

The principal sources of law in the Republic of Türkiye are the constitution, laws, decrees, international conventions, statutes and regulations. There are many laws and decrees about the duties, responsibilities and authorities of the institutions in relation to water resources development and management. Numerous regulations, communiqués and circulars are regulating the implementation.

A.2.1 Legislation Related to Water Management

In our country, water management policies and legislation established by the Environment Law No. 2872 are developed and implemented by harmonizing them with the conditions of the country on an international scale.



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With the establishment of GDWM (General Directorate of Water Management) in 2011, necessary regulations are implemented in water-related issues within the scope of the EU Water Framework Directive (WFD) harmonization studies.

The Directive regulates the requirement to achieve “good ecological status” for all waters. The main principle of WFD is water management based on river basin regions. The Directive provides the planning and institutional framework that guides the implementation of the water sector directives.

Türkiye's EU accession and the need to fulfil one of the obligations in the process of harmonization is adaptation and implementation of WFD which targets “to protect and control of water resources not only quantitative, but also qualitative”

In addition to the preparation and enforcement of new regulations, the existing regulations and communiqués were revised within this scope.

Table Annex A-3 gives the list of laws and explanations, regulations and communiqués. All the legislation in the report is the legislation that are taken into account for the development of the NRW Management Guideline for WSA/WUDs (Water and Sanitation Authority/Water Utility Departments).

A.2.2 Legislation Related to NRW

Regarding NRW management, the “Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems”³⁵ was published on 8 May 2014. The regulation aims to regulate the procedures and principles regarding the control of water losses in drinking-potable water supply and distribution systems. With the amendment made in 2019, metropolitan and provincial municipalities are obliged to reduce water losses to a maximum of 30% until 2023 and to a maximum of 25% until 2028, pursuant to Article 9 of the Regulation.

In the same article, it is stated that the necessary activities in this regard will be carried out within the framework of the methods given in the Technical Procedures Communiqué to be issued in accordance with the Regulation.

A.2.2.1 Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems

A number of principles have been determined within the regulation for reduction of water losses in Article 5 of the Regulation. In this context, following principles in the management of drinking-utility water supply and distribution systems are determined:

- a) Continuous measurement of the volume and flow of water supplied from the water source to the water supply system with appropriate devices at each building connection.

³⁵ The regulation was published in the Official Gazette dated 8 May 2014 and numbered 28994. Amendments were made with the Official Gazette dated 31 August 2019 and numbered 30874.



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- b) Continuous measurement and monitoring of water pressure at critical points in the drinking water supply system.
- c) Digitizing the plans of water supply and distribution systems and establishing a GIS database.
- d) Establishment of appropriate monitoring systems (SCADA, etc.) by the WUDs,
- e) Establishment of PMAs and DMAs within the system.

The measures those have to be implemented primarily in order to reduce physical water losses in the operation, design, construction, improvement and modernization of existing drinking water systems, as well as the new systems are given in Article 7 of the Regulation as follows.

- a) Designing the drinking water supply and distribution systems in such a way that water losses are at the lowest economic level and its construction is carried out in accordance with the specifications and instructions determined by the authorized institutions.
- b) Establishment of a Geographical Information Systems (GIS) database by the Water Utility Departments (WUDs) of Metropolitan and Provincial Municipalities, digitizing the existing data, transferring them to the database and updating them continuously.
- c) Designing drinking water systems containing Pressure Management Areas (PMAs) and District Metering Areas (DMAs).
- d) Hydraulic modeling of the existing systems by the WUDs of Metropolitan and Provincial Municipalities, if necessary, the creation of PMAs and DMAs.
- e) Inspections and controls during the construction of drinking water systems.
- f) Considering the necessary operation and control elements (flow and pressure measurement elements, etc.) for the control of water losses during the design, construction and operation stages of drinking water supply systems.
- g) Pressure management of the whole system, continuous pressure measurement at critical points, establishing pressure reducing/regulating valves and connection lines where necessary.
- h) Use of suitable materials that will reduce water losses during the design, construction and operation phases of water supply systems.
- i) Minimizing water losses by control of existing systems.
- j) Water distribution networks being in coordination with other public institutions and organizations' construction, maintenance and repair works related to the infrastructure facilities.
- k) The positions of all infrastructure facility networks on the streets being in accordance with the related standards.



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- l) Conducting active leakage control with continuous monitoring, maintenance and repair works.

In Article 30 of the Regulation, it is stated that all subscribers must be fitted with a meter. In addition, mandatory information to be kept and followed in subscriber lists is given with the same article. Article 30 sub-clauses are given below:

ARTICLE 30 – (1) All real and legal persons, to whom the administrations are obliged to provide services, are obliged, together with the administration, to subscribe, have the meter installed and keep the meter in working condition.

(2) Administrations carry out the necessary works in order to prevent the use of unsubscribed and unmetered water.

*(3) (Amended: RG-23/9/2020-31253) Subscribers; ID, address, subscriber type (residential, commercial and similar), communication, meter number, meter brand, meter diameter, meter length, meter stamp date, meter measurement range, meter index, meter working principle and meter multiplier are all recorded, Existing records are updated. Address records are kept in accordance with the parameters in the national address database.

(4) While establishing the subscription, the subscriber types are determined according to the usage type and user of the water, and the system is entered.

It has been stated that the meter operations are mandatory as per the Regulation. In the 3rd paragraph of the 8th article titled Detection of Water Losses in Drinking Water Supply and Distribution Systems, the following issues are stated about the meters.

“It is ensured that all meters are regularly maintained, calibrated or renewed, and meters that have low measurement accuracy, lost their measurement accuracy and are older than 10 years, are replaced with meters with high measurement accuracy that are suitable for water quality, intended use and current technology.”

A.2.2.2 Communiqué on Technical Procedures Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems

Accordingly, “Communiqué on Technical Procedures Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems”³⁶ was published on 16 July 2015. It provides a road-map for utilities for the reduction of NRW, including:

- Measuring the volume and flow of drinking water supply,
- Establishment of a Geographical Information System (GIS) database,
- Establishment of monitoring systems,

³⁶ Published in the Official Gazette dated 16 July 2015 with issue number 29418 (Revised and published on 23 September 2020 with issue number 31253)



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- Performing hydraulic modelling and calibration of the network,
- Separation of networks into sub-zones in the field,
- Integration of software and data with the central database,
- Integrated management of drinking-potable water supply and distribution systems,
- Detection and reduction of physical losses with active leakage control.

In the article (Article 37) of the Communiqué it is stated that a unit should be created to prevent unauthorized consumption and the duties of this unit are explained as follows:

(1) A unit shall be established by the administrations to detect, investigate and prevent the causes of unauthorized consumption. This unit investigates all kinds of factors that cause water loss, makes the necessary proposals for taking the necessary measures and carries out the necessary studies. It collects data by detecting all kinds of unauthorized consumption originating from the source, transmission and distribution lines, subscribers and meters, and prepares recommendations for the prevention of unauthorized consumption. This unit constantly monitors and reports to prevent unauthorized consumption. A team consisting of personnel specialized in unauthorized consumption is established under this unit. Necessary equipment for these teams is provided by the administrations.

(2) Reports are made in subscriber and meter management. The points to be considered in the reports and in the follow-up of unauthorized consumption are as follows:

- a) Reading data is checked regularly.
- b) Abnormal readings are detected.
- c) The consumption of subscribers in different time intervals is analyzed.
- ç) The meters outside the minimum and maximum consumption thresholds are listed.
- d) Counters with zero consumption are listed.
- e) In order to increase the efficiency of the readers, the statistics of the meter readers are listed.
- f) Replaced meters are analyzed before and after the replacement, and their benefits and costs are evaluated.
- g) Consumption analyzes in sub-regions are made on a regional basis.
- ğ) Inefficient meters are detected and replaced.
- h) Consecutive same consumptions, negative consumptions and large consumers are listed.
- ı) The accuracy of the readings and invoices is confirmed by using these lists.



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(3) Suggestions are submitted together with the reports prepared by considering the above-mentioned issues.

A.2.2.3 Work Plan Circular for Reducing Water Losses in Drinking Water Systems

In order to achieve the water loss rates determined in the Regulation within the targeted periods, the “Work Plan Circular for Reducing Water Losses in Drinking Water Systems” was published by DGoWM on 04.10.2021. In this circular, it is specified that;

- a) In order to reduce the water loss rates to 25% and below (the lowest level that can be reduced technically and economically), which is the final target of the legislation, by the municipalities, the Work Term Plan in Annex-1 and Annex-3 for metropolitan municipalities. Work Plan Detail Report Format will be prepared.
- b) For each step of the works to be done, the Guide on Actions for Reducing Water Loss in Drinking Water Systems in Annex-4 will be taken into account.
- c) By the end of February 2022, the Work Plan committed by the Mayor will be submitted to the Ministry by all municipalities.
- d) Metropolitan and provincial municipalities, which are required to achieve the maximum 25% water loss level in 2028, which is the final target of the regulation, will submit the Work Plan Detail Report to the Ministry by the end of February 2023 and complete the necessary studies within the following 5 years.

The Guide on Actions for Reducing Water Loss in Drinking Water Systems in Annex-4 of the Circular is given in Table Annex A- 1 below.



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Table Annex A- 1 Actions for Reducing Water Loss in Drinking Water Systems

Suggested Actions with Annex-4 of the Circular
Improvement of Geographical Information System Infrastructure
Implementation of Supervisory Control and Data Acquisition (SCADA)
Institutional Experience and Capacity Building
Hydraulic Modelling
Establishment of District Measurement Areas
Establishment of Pressure Management Areas
Assessment of Infrastructure Rehabilitation Needs
Reducing Administrative Losses
Integrated Subscriber Counter Management
Unregistered Connection Control
Management of Leakages
Recognizing Leakages
Leak Detection and Repair
Call Center and Fault Management System
Performance Monitoring and Target Defining
Raising Public Awareness on Water Saving
Determination of Pricing and Tariffs for Water Services

Source: Work Plan Circular for Reducing Water Losses in Drinking Water Systems

A.2.2.4 Measuring and Measuring Instruments Inspection Regulation

According to the Measures and Adjustment Law No. 3516, “Measuring and Measuring Instruments Inspection Regulation” was published in the Official Gazette dated 24 July 1994 and numbered 22000. Amendments were made with the Official Gazette dated 15 December 2019 and numbered 30979.

A “Schedule of Error Margins” table is given in Article 29 "Inspections of Water Meters" which is in the Second Part-First Section of the Regulation for Meter Lines, and the margins of error must be in accordance with these values given in Table Annex A- 2.

The purpose of this Regulation is to determine the procedures and principles of the first, periodic and immediate inspections as well as the complaints and stock inspections, and to



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determine the duties and responsibilities of those who use them and the obligations they will be subject to as indicated in Article 9 of the "Measures and Adjustment Law" No. 3516.

Table Annex A- 2 Margin of Errors Schedule from the Regulation³⁷

Measurement Systems of the Meters	(1) Meters with rated flow rate up to 20 m ³ /h		(2) Meters with rated flow rate over 20 m ³ /h	
	<u>Flow Ratio</u>	<u>Margin of Error</u>	<u>Flow Ratio</u>	<u>Margin of Error</u>
Speed Meters	% 1,5 – 5 (Included)	± % 5	% 1 – 5 (Included)	± % 5
	% 5 – 100 (Included)	± % 2	% 5 - 100 (Included)	± % 2
Volumetric Meters	% 1 – 5 (Included)	± % 5	% 1 – 5 (Included)	± % 5
	% 5 - 100 (Included)	± % 2	% 5 - 100 (Included)	± % 2
Hot Water Meters (For water with a temperature higher than 20°C.)	% 3 - 5 (Included)	± % 5	% 2 - 5 (Included)	± % 5
	% 5 – 100 (Included)	± % 2	% 5 - 100 (Included)	± % 2
Reciprocating, jumping counters			Up until % 5	± % 10
			% 5 to 100	± % 5
Flanged (voltman) and combined meters	Within the flowrates of			± % 5
	Above the flowrates of			± % 2

A.2.3 Gap Analysis for National Legislative Status and Implementation Practices

Following the Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems³⁸, especially for the purpose of reducing water losses and taking control, as stated in Annex A.2.2; “Communiqué on Technical Procedures Regulation on the Control of Water Losses in Drinking Water Supply and Distribution Systems”³⁹ has been published.

³⁷ Measuring and Measuring Instruments Inspection Regulation.

³⁸ The regulation was published in the Official Gazette dated 8 May 2014 and numbered 28994. Amendments were made with the Official Gazette dated 31 August 2019 and numbered 30874.

³⁹ Technical Procedures Communiqué on Control of Water Losses in Drinking Water Supply and Distribution Systems published in the Official Gazette dated 16 July 2015 and numbered 29418



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As stated in Annex A.2.2 and explained in all actions given under Section 3, both the measures to be taken and the methods to be applied to achieve the sustainable water loss management objective are explained in detail.

The general bottleneck in the legislation in our country is not the absence of legislation, but its implementation. The main bottlenecks identified by the projects implemented in the world and by the experience of the Consultant are given below.

- Current Water Balance Forms do not reflect the actual situation. Many WSA/WUDs in Türkiye use the default percentages in the standard water balance form. Therefore, the NRW component, which is the real problem on a local basis, cannot be determined.
- The absence of national standard performance indicators is one of the main problems. The absence of performance indicators that are mandatory to be monitored nationally causes WSA/WUDs to accept data that are readily available or that can be easily prepared as indicators. This situation causes these non-indicative data to not be able to evaluate the performance. In addition, it is not possible to compare similar provinces on a national basis.
- Data supply, monitoring and control systems are not available in most Administrations to cover the entire system. This prevents the system from being monitored centrally.
- Since the integration of subscriber information with the Central Population Administration System (MERNIS) and the National Address Database (UAVT) has not been completed, unauthorized water theft is seen as the biggest obstacle to accruing with the previous reading in case the meter cannot be read.
- Local governments should be supported in integration with national systems on Management Information Systems, remote reading and control.
- It has been stated that there will be a responsible team for losses in WSA/WUDs. However, the team must be certified and undergo necessary field and office training. Centrally support teams should be established for small administrations that have difficulties in creating and managing teams.
- National water loss awareness studies should be carried out periodically, primarily by Administration's personnel and subscribers. Informative and educational publications should be made, especially on unauthorized use, water theft and malfunction reporting.
- Operation and maintenance books should be created for the entire drinking water supply system and its components. These operation maintenance books, which will be prepared on a national basis, should be prepared by the Administrations on a local basis in accordance with their own systems.



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A.2.4 Summary of National Laws, Regulations and Communiqué on Water Management Sector

Table Annex A- 3 National Laws, Regulations and Communiqué on Water Management Sector

Name of Law and Regulation	Explanation
Laws	
Law on Environment	The objective of this Law is to ensure the protection of the environment, the common asset of all living creatures, in line with sustainable environment and sustainable development principles. The Law aims at protection and improvement of the environment, protection and efficient utilization of natural resources, prevention of water, soil, and air pollution as well as protection of flora and fauna of Türkiye in addition to its historical assets
Ministry of Environment, Urbanization and Climate Change (MoEUCC)	Ministry's duties and responsibilities in the field of environment; to determine principles and policies for the protection and improvement of the environment and to prevent environmental pollution, to develop standards and criteria, to prepare programs, to create education, research, project design, action plans and pollution maps, to determine and monitor the implementation principles of these, related to climate change to carry out business and operations.
Ministry of Agriculture and Forestry (MoAF)	Roles and responsibilities in the field of water; "Creating policies for the protection and sustainable use of water resources is to coordinate national water management."
Law on the Establishment and Duties of the General Directorate of State Hydraulic Works	To establish protective facilities against floods; establishing irrigation facilities; rehabilitating wetlands, carrying out survey and planning works related to erosion and sediment control, carrying out afforestation activities aimed at protecting their own facilities, examining, approving and controlling drinking water and sewerage projects; to carry out studies and projects of all the mentioned works; to build the necessary facilities to recycle used water; to monitor surface and underground waters in terms of quality, to report the situation to MoAF in case of detection of pollution due to wastewater.
Law on Iller Bank Corporation (ILBANK)	The purpose of ILBANK is to meet the financing needs of the special provincial administrations, municipalities and affiliated organizations, and exclusively the local administration unions of which they are a member, to develop projects related to the local joint services of the people living within the borders of these administrations, to provide consultancy services to these administrations and to provide technical services with urban projects and to assist in the execution of superstructure works and to fulfill all kinds of development and investment banking functions.



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Name of Law and Regulation	Explanation
Municipal Law	Its purpose is to regulate the establishment, organs, management, duties, powers and responsibilities of the municipality, and working principles and procedures. Article 41 of the Municipal Law No. 5393 obliges the municipalities to prepare strategic plans and performance programs. When the Municipal Law is evaluated within the scope of the duties and powers of the municipal organization; It is charged with carrying out services such as water supply, sewerage and wastewater services, and stormwater removal within its jurisdiction. Besides, this scope seems to include the establishment of geographical and urban information systems. Therefore, within the scope of the Municipal Law, municipalities are assigned at the local level in the two most basic issues related to USBS (services related to water and keeping data related to them).
Metropolitan Municipality Law Establishment of Fourteen Metropolitan Municipalities and Twenty-Seven Districts and Amendments at Certain Law and Decree Laws	One of the most fundamental issues defined within the scope of the Metropolitan Municipality Law is the duty of "making master development plans in accordance with the environmental plan". In addition, definitions such as parceling plan and zoning plan implementation are made within the scope of this law. Similar to the Municipal Law, the duty of "establishing geographical and city information systems" is set for metropolitan municipalities. Another noteworthy provision in the law is that metropolitan municipalities are given the following authority within the scope of carrying out water and sewerage services: "to establish, establish and operate the necessary dams and other facilities; improvement of streams; to market spring water or water produced at the end of treatment".
Law on the Establishment and Duties of the General Directorate of Istanbul Water and Sewerage Administration (ISKI Law)	With an amendment made in 1984 in the Law, it was decided to establish an administration similar to ISKI in all metropolitan municipalities. The law defines broad powers and duties for the General Directorates of Water and Sewerage Administration among water service organizations at the local level.
Law on Waters	It regulates the supply and management of waters specific to meeting public needs in cities, towns and villages.
Law on Groundwater	The Law constitutes the basis of legal regulations related to groundwater. Groundwater is ensured and in the possession of the Government and all kinds of investigation, usage, protection and registration of these waters is subject to the provisions of this Law. With the Law No. 6427 (Article 10), the certificate of utilization license cannot be issued for wells, galleries, tunnels and the like without installing measurement systems. The usage purpose, amount, basin boundary and other issues are determined by the Council of Ministers upon the proposal



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Name of Law and Regulation	Explanation
	of the DSI General Directorate. In addition (Provisional Article 3), sanctions were determined in the event that the measurement system of those who received a certificate of utilization before the law's adoption date was not established within the period specified in the law.
Regulations	
Regulation on Control of Water Losses in Water Supply and Distribution Systems	
Regulation on the Procedures and Principles to be Followed in Setting the Tariffs for Wastewater Infrastructure and Municipal Solid Waste Disposal Facilities	
Regulation on Environmental Impact Assessment	
Regulation on Environmental Permit and License	
Regulation on Strategic Environmental Assessment	
Regulation on Procedures and Principles on Strategic Planning in Public Administrations	
Regulation on Establishment and Management of the National Geographic Information System	
Communiqué	
Communiqué on Technical Procedures Regulation on Control of Water Losses in Drinking Water Supply and Distribution Systems	

Source: <https://www.mevzuat.gov.tr>.



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A.2.5 Standard Water Balance Form Given in the Current Regulation

Table Annex A- 4 Standard Water Balance Form Given in the Current Regulation⁴⁰

(1) System Input Volume The amount of the effluent clean water obtained and treated (could be any kind of treatment from plants only carrying out disinfection to plants with advanced treatment processes) from surface or groundwater sources such as: dam lakes, natural lakes, wells, springs, etc. is written in this cell in m ³ /year. (100%)	(10) Authorized Consumption Value obtained from the addition of identified water consumption values from cells numbered (4) and (9).	(4) Billed Authorized Water Consumption Value obtained from the addition of identified water consumption values in cells numbered (2) and (3).	(2) Billed Metered Consumption The total amount of water obtained from the reading of periodic indices of all subscribers (household, commercial, public enterprise, etc.) registered in the subscriber database (having subscription contract) is written here in m ³ /year.* *The consumption of subscribers who only have wastewater subscription (who supply their own drinking-consumption water) will not be included in the calculation.	(5) Revenue Water Again obtained from the addition of identified water consumption values in cells numbered (2) and (3).
			(3) Billed Unmetered Consumption Expresses the bill arrangement identified by comparing the amount of water consumed by unmetered users with the consumption of subscribers similar in terms of usage. The sum of water consumption by these type of bills is written in this cell in m ³ /year.	
	(11) Water Losses Value obtained from the subtraction of the value in cell numbered (10) from the value in cell numbered (1)	(9) Unbilled Authorized Water Consumption Value obtained from the addition of identified water consumption values in cells numbered (7) and (8).	(7) Unbilled Metered Consumption Water consumption by users such as places of worship, fire department, public fountains, etc., even if they are not charged, must certainly be subscribed, measured with water meters and their indices recorded. Similar to billed subscribers, the water consumed by this type of subscribers is expressed by the records obtained from the database and are written in this cell in m ³ /year.	(6) Non-Revenue Water Obtained by subtracting cell numbered (5) from cell numbered (1).
			(8) Unbilled Unmetered Consumption The value in this cell is generally identified by the estimation based on the experience and records of the establishment, because: a) Water used by fire hydrants b) Water wasted due to any kind of malfunction from the moment the malfunction is realized and the valve closed, to the completion of the repair c) Water used in obligatory conditions such as during the maintenance of pipelines and armatures (valves, vacuum lifters, flowmeter, etc.) or the volume of water lost is expressed and the date, work time, pipe diameter, and other factors of these operations are recorded, accumulated at the end of every year and written in this cell in m³/year.	
		(14) Administrative Losses Value obtained from the addition of identified water consumption values in cells numbered (12) and (13).	(12) Unauthorized Consumption It is the cell in the table that needs to be determined most precisely. It can be determined using estimation and approximate calculation. GIS is used to analyze the accuracy of the estimation: based on the National Address Database, the number of all businesses and institutions/organizations in need of water, especially non-subscribed residences, is determined by research and analysis, effective field work by experienced personnel (dredging teams) and the office of technical staff. The determined consumers are compared with their peers in the subscriber database, and the total water volume they consume is written in this cell in m ³ /year.	
			(13) Meter Errors Expresses errors caused by subscriber meters; a) being assembled incorrectly b) exceeding the period of use (10 years) c) erroneous measurement tolerance range accepted by the manufacturer according to the type/grade d) not being noticed even though it is broken etc. caused by technical reasons. Since the occurrence of some of these conditions is inevitable, Administrations with meter repair stations are based on their general calibration experience and data records, whereas Administrations without repair stations determine the desired value in this cell by cooperating with the measurement and adjustment legislation, manufacturer information, Provincial Directorates of Industry and Commerce or experienced Administrations.	
		(15) Physical Losses Value obtained from the subtraction of the value in cell numbered (14) from the value in cell numbered (11).	(17) Loss-Leakages Occurring in Supply and Distribution Lines and Service Connections It is the value obtained by subtracting the value in cell number (16) from the value in cell number (15). Administrations calculate the loss in this section according to the minimum night flow rates, estimate the physical loss in the network, and this result, which is the result of the calculation, is decided by comparing the value of cell number (15) with the value difference of cell number (16).	
			(16) Leakage and Overflow in Water Storage Tanks It refers to the amount of wasted water caused by improper water management (the amount of water discharged from the floodgate due to the inability to adjust the water level) and invisible infiltrations due to the physical condition of the tank. The SCADA system is used to determine the value in this cell. With the continuous control of the flow meters to be installed at the entrance and exit of the warehouses, daily, weekly and monthly calculations are made and recorded and the year-end value is obtained and written in this cell.	

⁴⁰ The regulation was published in the Official Gazette dated 8 May 2014 and numbered 28994. Amendments were made with the Official Gazette dated 31 August 2019 and numbered 30874.



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A.3 Institutional Framework

There are many regional and local officials which is included in many national environmental management and infrastructure financing and management.

At the national level, MoAF (Ministry of Agriculture and Forestry) and MoEUCC (Ministry of Environment, Urbanization and Climate Change) are the main institutions dealing with urban water and sanitation services. While MoAF is responsible for the regulation, management and monitoring of water supply services; MoEUCC handles the same functions for sanitation services. The Presidency of Strategy and Budget (formerly Ministry of Development) is in the decision-making phase, responsible for the preparation of the water resources investment program.

Institutions responsible for water management and their areas of responsibility in our country are given in Table Annex A- 5.

Table Annex A- 5 Institutions Responsible for Water Management and Their Responsibilities

Institution Name	Protection of Water Resources	Allocation of Water Resources	Planning	Investment	Permission, Control and	Monitoring		
						Wastewater Discharges	Quality of Water Resources	Drinking Water
Ministry of Agriculture and Forestry	+	+	+	+	+	+	+	+
Ministry of Environment, Urbanization and Climate Change	+	+	+	+	+		+	
Ministry of Energy and Natural Resources		+			+			
Ministry of Health					+			+
Ministry of Culture and Tourism				+				
Metropolitan Municipalities - Water and Sewerage Administrations/Water Utility Departments	+	+	+	+	+	+		+
ILBANK			+	+	+			

Source: Consultant's assessment after examination of regulations and laws



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Each institution has priorities in the framework of their duties and authorities for water management in Türkiye.

The water sewage administrations of Metropolitan Municipalities (MMs) are the “service” institution which is responsible for protection of water resources, planning, allocation of water resources, monitoring, permit and inspection in water management. In the 3rd article of the Law No. 5216, “Metropolitan municipality is a public legal entity formed by the decision-making body electors. It is a structure that has provincial administrative borders and provides coordination between district municipalities within its borders. Has administrative and financial autonomy and fulfills the duties and responsibilities given by law”.

The Municipal Law No. 6360, not only increased the number of the MMs, but also changed the Turkish Metropolitan Municipality system considerably. Currently there are 30 Metropolitan municipalities in Türkiye. The map showing MMs is given below in Figure Annex A- 1.

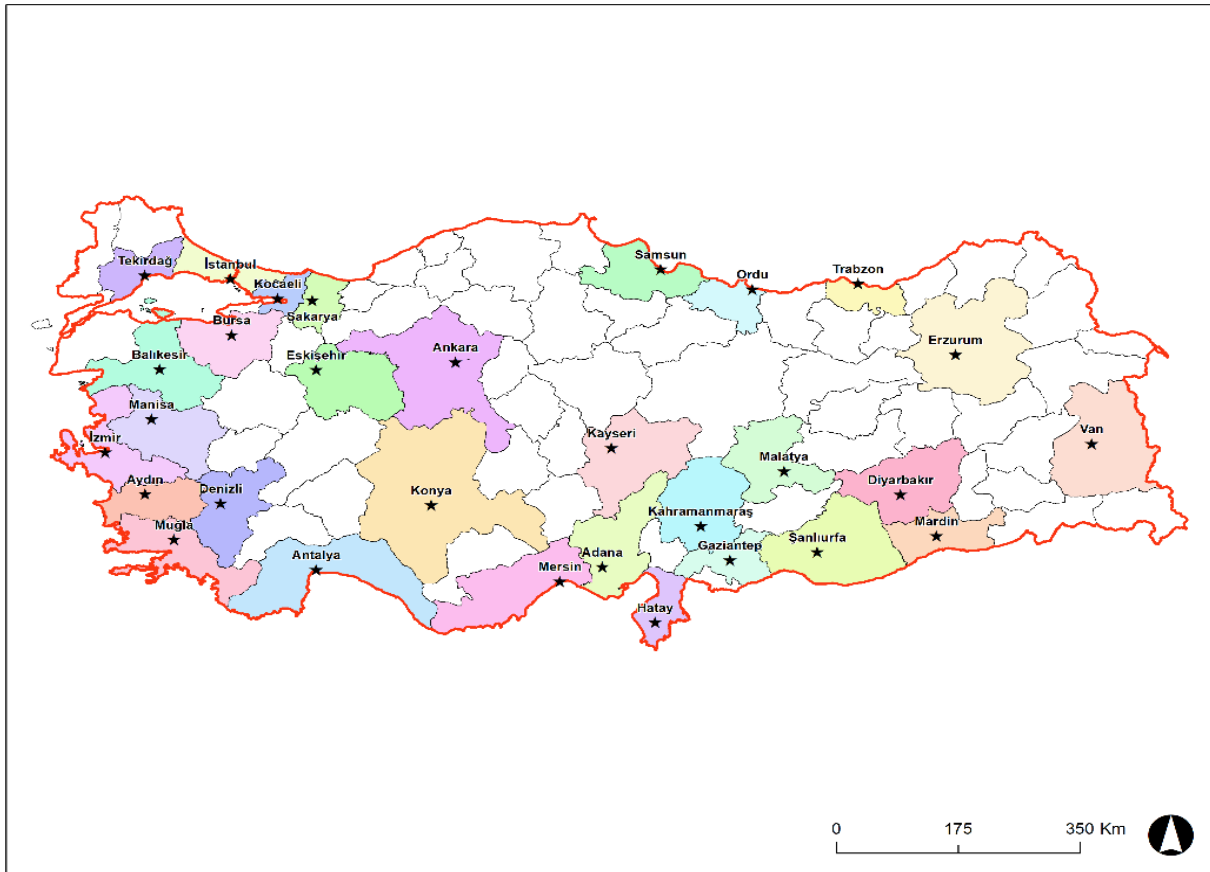


Figure Annex A- 1 Metropolitan Municipalities in Türkiye



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Together with the Law, the metropolitan municipality, as the sole local government, assumed the local government services in the entire province. Upon the conference of authorities and responsibilities beyond the urban boundaries to cover an entire province, MMs are now in charge of rural administration in addition to urban administration. This brought financial challenges to the MMs by giving them more expenditure responsibilities for the provision of municipal services in the vast areas outside of the core urban centers. Municipalities are legally responsible for the collection of solid waste, the establishment and operation of the water network, wastewater and storm water systems, gas and urban transport services, and the construction and repair of streets.

The Law 6360 aims to provide better services to the rural areas through the financially strengthened MMs as a result of abolished special provincial administrations.

The general reason for the enactment of the Law No. 6360 was “Today, with globalization, the management paradigm is changing and this change brings forth new values. An effective, citizen-oriented, accountable, participatory, transparent and local government approach has come to the fore as the basic principles and values for public administration reforms in many developed countries. These principles and values envisage, on the one hand, to increase citizen satisfaction by improving the service quality for citizens, on the other hand, to ensure more participation of citizens in public administration. In this new understanding, public administration has to meet the increasing service expectations of the citizens, efficiency and productivity.”⁴¹

In the justification of the law, the emphasis is placed on economies of scale, and the need to overlap the provincial civil boundaries with the boundaries of the metropolitan municipality in efficient provision of services. Here, it has emerged that it is beneficial to increase the scale in providing large-scale and general quality services, especially infrastructure and development services.

MMs were authorized by the ‘Metropolitan Municipality Law’ to formulate, specify and apply the legislation required for the most efficient management of water and wastewater facilities within their boundaries.

⁴¹ Grand National Assembly of Türkiye, 2012, p. 6



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A.4 Policy Documents and Strategy Papers for Combating Climate Change

In parallel with the international efforts to combat climate change mentioned in Section 2.1.2, the strategies have been formed and the action plans have been developed in Türkiye. The main documents are given in the table below.

Table Annex A- 6 Fundamental Policy Documents, Strategies and Action Plans Related to Climate Change

Policy Document	Explanation
Environment and Climate Action Operational Program, 2019 and 2018 revision	The general objective of the program is to improve the quality of environmental protection and life of citizens by addressing the fight against climate change better and by harmonizing the EU with the environmental and climatic action. The program in general contains 3 separate actions within this context. Action 1 - Water: The objective of this action is to improve the quality of water in Türkiye and to harmonize it with EU acquis and policies by providing integrated water management. Capacity building projects and infrastructure works are activities under this action. A budget of EUR 7 million has been allocated to the European Investment Bank under this component. Action 2 – Waste Action 3 – Environmental Management for Sustainable Development
Strategical Paper	Explanation
National Climate Change Strategy Paper, 2010-2023	The strategy paper has been prepared by Ministry of Environment, Urbanization and Climate Change (MoEUCC) in order to contribute to global efforts to reduce the impacts of climate change. With this strategy document, Türkiye is contributing to the fight against climate change as a goal within the framework of "common but differentiated responsibilities", which is one of the basic principles of the United Nations Framework Convention on Climate Change. Strategies have been determined that can be updated when needed in line with national or international developments. These: • To actively participate in the negotiations for the establishment of a comprehensive and functional international cooperation mechanism in efforts to combat and adapt to global climate change. • To prepare the National Climate Change Action Plan in a dynamic understanding. • To initiate structuring regarding climate change in relevant institutions. • To establish the necessary infrastructure for preparation of the emission inventory. • To develop climate change policies in cooperation with all stakeholders.



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Policy Document	Explanation
	Climate change National Focal Point is the MoEUCC. The Ministry carries out the task of national coordination for all issues related to climate change. However, Türkiye has to go before the UNFCCC parties and corporate restructuring Prime Ministerial Circular No. 2001/2 on Climate Change Coordination Committee (CCCC). CCCC was restructured in 2013 and renamed the Climate Change and Air Management Coordination Board (CCAMCB). Project proposals developed in line with these strategies and will serve as a basis for the action plan to be prepared are evaluated and prioritized by the Board.
Action Plans	Explanation
National Climate Change Action Plan (2014 – 2023) (IDEP)	The National Climate Change Action Plan (IDEP) has been prepared by the MoEUCC in order to reduce greenhouse gas emissions in combating climate change, adaptation to climate change and minimizing its effects. Climate Change Action Plan, has been prepared in the scope of "Developing Türkiye's National Climate Change Action Plan Project". Within the scope of the Action Plan, objectives and targets have been determined under the main headings of energy, industry, transportation, buildings, waste, agriculture, land use and forestry, cross-sectoral common issues. In CCAP, there are 541 actions to achieve 107 goals with 49 goals.
National Climate Change Adaptation Strategy and Action Plan (2011-2023)	The National Climate Change Adaptation Strategy and Action Plan prepared by the MoEUCC includes adaptation to the effects of climate change. It has been prepared in order to make people's livelihoods, economies and natural systems less affected by changes due to climate and in some cases to benefit from adaptation. Priority target areas have been determined supported by the technical and scientific work processes and adopted by the participants focused following five key areas; • Water Resources Management • Agriculture and Food Security • Ecosystem Services, Biodiversity and Forestry • Natural Disaster Risk Management • Human health
National Communication Strategy and Action Plan of Climate Change (2020)	The Strategy and Action Plan has been prepared by the MoEUCC to raise public awareness about climate change throughout the country, using a language that can be understood by everyone in line with the perception of the target audiences, and to convey the message to the final beneficiaries that combating climate change is a part of daily life. This is the first study developed in the communication sector in the fight against climate change in Türkiye.



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ANNEX B- DEFINITIONS



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B. DEFINITIONS

B.1 Definitions of Water Balance Components

Since Standard Water Balance Form given in the current Regulation was prepared based on the IWA Standard Water Balance Table 2000 version, most of the definitions are very similar. Abbreviated definitions of principal components of two approaches are described as follows with comparatively.

- Definition given in Standard Water Balance Form given in the current Regulation are abbreviated as TR in relevant places. In the following definitions SWBF abbreviation is used for the Standard Water Balance Form given in the current Regulation.
- Definition in given in IWA Standard Water Balance Table are abbreviated as IWA in relevant places. In the following definitions IWA SWB abbreviation is used for in the IWA Standard Water Balance given in Table 2.

System Input Volume

Although the definitions in the Regulation and IWA differ on a word-by-word basis, they are identical in definition; represents the clean water supplied to the water supply system for which the water balance is calculated.

- TR: The expression of the amount of clean water obtained from surface or underground water sources like dam, lake, natural lake, wells, spring, etc. (all treatments in the range from only disinfection facilities to facilities with advanced treatment processes) measured at the plant outlet, in m³/year is written in related cell in the water balance table. It is numbered as (1) in SWBF.
- IWA: The system input volume is the volume of treated water, be that produced by the utility themselves or imported into the area from another utility, input to the section of the water supply system to which the water balance calculation relates.

Authorized Consumption

Authorized consumption represents the total volume of metered and/or non-metered water that is used by registered customers.

- TR: The total volume of billed and unbilled authorized consumption which includes volume of metered and/or unmetered water. It is numbered as (10) SWBF and it equals to sum of components Billed Authorized Consumption (4) and Unbilled Authorized Consumption (9).
- IWA: The volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier, for residential, commercial, municipal and industrial purposes. This also



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includes water used by the military, government and other users, even if these are provided free of charge. It also includes water exported across the utility's boundaries.

Authorized consumption may include items such as water taken for firefighting, fire training exercises, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains and frost protection, amongst others. These may be billed or unbilled, metered or unmetered.

Revenue Water

Revenue water represents total amount of authorized water consumption that brings revenue which means billed to the end-users.

- TR: The total volume of billed authorized metered and unmetered water consumption. This component is numbered as (5) in SWBF and it equals to sum of components Billed Metered Consumption (2) and Billed Unmetered Consumption (3).
- IWA: The volume of water for which income is obtained. It is the sum of billed authorized consumption including water exported across the utility's boundaries for which income is received.

Billed Authorized Consumption

- TR: The total volume of billed authorized consumption which includes volume of metered and/or unmetered water. It is numbered as (4) in SWBF and it equals to sum of components Billed Metered Consumption (2) and Billed Unmetered Consumption (3).
- IWA: Those components of authorized consumption which are billed and produce revenue. It is equal to billed metered consumption plus billed unmetered consumption and also known as revenue water.

Billed Metered Consumption

- TR: The total amount of water obtained by reading the indexes of any subscriber (residential, commercial, official institution, etc.) registered in the subscriber database (with a subscription agreement) at certain periods, in m³/year of is written in related cell in the water balance table. Consumption of subscribers who only have a wastewater subscription (providing drinking water from their own well) will not be included in the calculation. It is numbered as (2) in SWBF.
- IWA: All metered consumption which is also billed. This encompasses all groups of customers such as domestic, commercial, industrial or institutional and includes water exported across the utility's boundaries which is metered and billed.



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Billed Unmetered Consumption

- TR: It refers to the issuance of invoices by determining the water consumed by users who consume water without being measured, by comparing their consumption with peer subscribers in terms of consumption. The expression of the total water consumption of such bills in m³/year is written in related cell in the water balance table. It is numbered as (3) in SWBF.
- IWA: All billed consumption which is calculated based on estimates or norms but is not metered. This may be a very small component within fully metered systems, for example, billing based on estimates for the period a customer meter is out of order but can be the key consumption component in systems without universal metering. This component may also include water exported across the utility's boundaries which is unmetered but billed.

Unbilled Authorized Consumption

- TR: The total volume of unbilled authorized metered and unmetered water consumption. This component is numbered as (9) in SWBF and it equals to sum of components Unbilled Metered Consumption (7) and Unbilled Unmetered Consumption (8).
- IWA: Unbilled authorized consumption are those components of authorized consumption which comprise legitimate usage, but which are not billed and therefore do not produce revenue. Unbilled authorized consumption is equal to unbilled metered consumption plus unbilled unmetered consumption.

Unbilled Metered Consumption

- TR: Even if the water consumed in such as places of worship, firefighting, public fountains, etc. is not charged, it must be measured by means of a meter, and its indexes must be recorded. Unbilled meter consumption expresses the water consumption amount obtained from the records in the database of the water consumed by such subscribers and at such places, just like the billed subscribers, and the expression in m³/year is written in related cell in the water balance table. This component is numbered as (7) in the SWBF.
- IWA: Unbilled metered consumption is metered consumption which is, for any reason, unbilled. This may, for example, include metered consumption by the utility itself or water provided to institutions free of charge, including any water exported across the utility's boundaries which is metered but unbilled.

Unbilled Unmetered Consumption

- TR: This component is usually based on the organization's estimation based on experience and records. Because it describes the total of the following;



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- a) The amount of water used for firefighting from fire hydrants,
- b) Due to all kinds of pipe malfunctions, the amount of water running out from the moment the malfunction is noticed and the valve is closed until the repair is completed,
- c) The amount of water used or lost in compulsory cases such as water discharged during the maintenance of pipelines or armatures (valves, suction cups, flow meters, etc.).

The expression in m³/year is written in related cell in the water balance table. This component is numbered as (8) in SWBF.

- IWA: Unbilled unmetered consumption is any kind of authorized consumption, including any water exported across the utility's boundaries, which is neither billed nor metered. This component typically includes items such as firefighting, flushing of mains and sewers, street cleaning or frost protection, amongst others. In a well-run utility, it is a small component of total authorized consumption.

Non-Revenue Water (NRW)

- TR: Non-revenue water is the difference between the system input volume and revenue water. This component is numbered as (6) in SWBF and it equals to the difference between components System Input Volume (1) and Revenue Water (5).
- IWA: Non-revenue water are those components of system input volume which are not billed and do not produce revenue, i.e., not revenue water. It is equal to unbilled authorized consumption plus physical (real) losses and administrative (apparent-commercial) losses.

Water Losses

- TR: The difference between system input volume and authorized consumption. This component is numbered as (11) in SWBF and it equals to the difference between components System Input Volume (1) and (10).
- IWA: The difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, for partial systems such as transmission or distribution schemes, or individual zones. Water losses consist of physical (real) losses and administrative (apparent-commercial) losses.

Apparent Losses (AL)

In our country apparent losses are commonly referred as 'administrative losses' in the regulatory system therefore apparent losses are described as 'administrative losses' in this Guideline.

- TR: The total volume of unauthorized consumption and inaccurate measurements and/or reading errors caused by meters. This component is numbered as (14) in SWBF



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and it equals to sum of components Unauthorized Consumption (12) and Customer Metering Inaccuracies (13).

- IWA: Apparent losses include all types of inaccuracies associated with customer metering as well as data handling errors, such as meter reading and billing, plus unauthorized consumption from theft or illegal use. It is a component of water losses in IWA SWB.

Unauthorized Consumption

- TR: This is the component that needs to be determined most precisely in any water balance table. It can be determined using estimation and approximate calculation. The following is used to analyze the accuracy of the estimation:
 - GIS is used when determining the numbers of all businesses and institutions/organizations in need of water, especially non-subscribed residences based on the National Address Database,
 - Effective field work by experienced personnel (dredging teams) and
 - The work of technical staff.

The determined consumers are compared with their peers in the subscriber database, and the total water volume they consume m³/year is written in related cell in the water balance table. This component is numbered as (12) in SWBF.

- IWA: Unauthorized consumption is any unauthorized use of water. This may include water illegally withdrawn from hydrants, for example, for unauthorized construction purposes, illegal connections, bypasses to consumption meters or meter tampering. It is a component of apparent losses in the IWA SWB.

Customer Metering Inaccuracies

- TR (Measurement Errors in Meters): Measurement errors in meters are mainly caused by the following technical reasons/problems in subscriber counters/meters;
 - a) incorrect assembly,
 - b) exceeding the period of use (>10 years),
 - c) erroneous measurement tolerance range accepted by the manufacturer according to the type and kind,
 - d) not being noticed even though it is broken etc.

Since the occurrence of some of these conditions is inevitable the volume of water is determined based on either general calibration experience and data records for those administrations with meter repair stations, or measurement and adjustment legislation, manufacturer information and cooperating with Provincial Directorates of Industry and Commerce for administrations without repair stations. This component is numbered as (13) in the SWBF.



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- IWA: The volume by which meters under-record the true volume consumed by customers. The level of customer metering inaccuracy depends on meter type, meter class, meter sizing (in relation to the flow), meter age, installation details (e.g., close to bends, near pumps etc.) and the size of roof tanks, if the meter feeds roof tanks. The actual in-situ performance is assessed as meter under registration. It is a component of apparent losses in the IWA SWB.

Data Handling and Billing Errors

- TR: This component is not measured or calculated in the SWBF. In this Guideline, this component is assessed in Financial Management section (Section 3.4).
- IWA: The volume of true consumption which is not recorded on the billing system due to billing or data handling errors. These could include transcription errors, consumption on premises that have not been registered on the billing system due to internal procedural errors, premises incorrectly flagged on the billing system (e.g., flagged as demolished but still live), etc. It is a component of apparent losses in the IWA SWB .

Underestimation of Unmeasured Consumption

- TR: As described below, this will be a particular problem where unmeasured consumption is high, for example domestic premises are not metered, that's why in Türkiye's application this component is not taken into account.
- IWA: The volume by which the true consumption of unmeasured customers is underestimated. This may be household or non-household use. This will be a particular problem where unmeasured consumption is high, for example in countries where domestic premises are not metered, or where there are unmeasured communal water supplies in improvised housing areas. In practice true consumption may be overestimated in which case administrative losses (and possibly physical losses) could be understated.

Real Losses (RL)

- TR: This component equals to the difference between water losses and administrative (apparent) losses. It is the total water losses caused by leakage on transmission and/or distribution mains and leakage and overflows from utility storage tanks. It is numbered as (15) in the SWBF and it equals to the difference between components (11) and (14).
- IWA: Real Losses from the pressurized system (transmission mains, mains and service pipes) and the utility's service reservoirs, from the distribution input meters up to the point of supply. It is a component of water losses in the IWA SWB.

Leakage on Transmission and/or Distribution Mains

- TR: This is named as "Loss-Leakages Occurring in Supply and Distribution Lines and Service Connections" in SWBF. It is the difference between real losses and the amount



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of water lost due to leakage and overflows from utility storage tanks. Administrations estimate/calculate the physical (real) loss in the network according to the minimum night flow rates (See Annex B.4). Based on the result of this calculation, Administrations then decide by comparing this estimated value with the difference of physical (real) losses and leakage and overflows from utility storage tanks. This component is numbered as (17) in the SWBF and it equals to the difference between components Physical Losses (15) and Leakage and Overflows from Utility Storage Tanks (16).

- IWA: Water lost from leaks and breaks on transmission and distribution pipelines and appurtenances. These may either be small leaks which are still unreported, such as leaking joints, or large bursts which were reported and repaired but obviously leaked for a certain period before that. It is a component of real losses in the IWA SWB.

Leakage and Overflows from Utility Storage Tanks

- TR: It refers to the amount of wasted water caused by incorrect water management (the amount of water discharged from the floodgate due to the inability to adjust the water level) and invisible infiltrations due to the physical condition of the tank. The SCADA system is used to determine this component. With the continuous control of the flow meters to be installed at the entrance and exit of the storage tanks, daily, weekly and monthly calculations are made and recorded and the year-end value is obtained and written in related cell in the water balance table. This component is numbered as (16) in SWBF.
- IWA: Water lost from leaking storage tank structures (service reservoirs) or overflows from such tanks caused by operational or technical problems, for example, a failed level control mechanism or leaking tank joints. It is a component of real losses in the IWA SWB.

Leakage on Service Connections up to the Point of Customer Metering

- TR: This component is not separately measured or calculated in the Standard Water Balance Form given in the current Regulation. This is evaluated in ““Loss-Leakages Occurring in Supply and Distribution Lines and Service Connections” numbered as (17) in SWBF.
- IWA: Water lost from leaks and breaks of service pipes from and including the tapping point up to the point of supply. Leakage on service pipes may be reported breaks but will predominately be small unreported leaks which may run for long periods, often years. They may be leaks that are below the level of detection and therefore contribute to background leakage. It is a component of real losses in the IWA SWB.



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B.2 Definitions Related to Asset Management

The definitions of the system components together with actions are given in this section. Although some of the definitions are well known by WSA/WUD, these definitions are also given in order to adequately understand each action suggested in the Guideline and to avoid a gray area.

Supply

Supply is the provision of potable water into the water distribution network for consumption by customers.

Consumption

Consumption is all water taken into premises, whether domestic, commercial, industrial or institutional among others, be that for use or because of plumbing losses. When considering the water balance for a whole system, then consumption will include all consumption on premises together with water directly taken off the system, whether recorded, billed, unbilled, authorized or unauthorized, namely being the equivalent to authorized consumption plus apparent losses.

Water Supply Coverage

Water supply coverage delineates the area and properties that are connected to the water supply system. In an area where only part of the population is served this refers to the ratio between the supplied population and total population in the administrative area of the utility.

Water Supply Network

A water supply network is a collection of assets, such as impounding reservoirs, boreholes, treatment works, aqueducts and any necessary associated pumps and pumping station delivering raw water to the treatment works.

Water Distribution Network/System (WDS)

A water distribution network is a collection of assets, primarily mains and service pipes but may include booster pumping stations, which deliver water from a water supply network to customer premises.

Transmission Main

A transmission main is used for the transfer of potable water between treatment works and service reservoirs or between service reservoirs. It is normal practice for utilities to avoid supplying water to customers from transmission mains unless there are particular circumstances or reasons for doing so.



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Service Reservoir (SR)

A service reservoir is a structure that holds water and defines the start of the water distribution network. A service reservoir is fed by a transmission main and will feed distribution mains or possibly a transmission main to another service reservoir. The main functions of a service reservoir are to provide the necessary head so that water can be supplied to customers within the supply area by gravity, to even out the diurnal demand pattern in order to minimize the maximum capacity needed at treatment works and transmission mains and also to provide emergency capacity to improve security of supply to the distribution network in the case of failure at the treatment works or a burst on the transmission main.

Main

A water main or distribution main is a pipe used for the “general” supply of water, usually supplying several properties and being within the reticulation of the network.

Attributes

Attributes are the physical parameters of a particular area. Typical attributes are length of mains, diameters, installation year and material, number of properties, number of connections, etc.

Connection

A connection is where a service pipe is connected to a main by a tapping point. A connection can be either legal or illegal.

- Legal Connection: A connection which has been installed onto a main or another service pipe by or with the permission and authority of the utility.
- Illegal Connection: A connection which has been installed onto a main or another service pipe without the permission or authority of the utility.

Connection Density

The ratio of the number of connections per unit length of main, i.e., no/km. Utilities do not generally know the number of connections on their system and therefore it is more common for them to express connection density in the form of connected properties or customers per unit length of main. This can however distort the value depending on the connection ratio and it is best to make it clear whether connection or property density is being used.

Service Pipe

A service pipe is the section of pipe which connects a water main with a building. It includes both the service connection and private service pipe.

Service Connection



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That part of the service pipe that runs from the main to the edge of street. There will usually be an external stop tap, and possibly a revenue meter, at the demarcation between the service connection and the private service pipe.

The service connection may run up to the building wall itself if this is at the edge of the street. In this case the external stop tap, and possible revenue meter, may be above or below ground or may be just inside the building itself.

A service connection may supply one or more than one property. This generally applies in organized systems or developed countries and is the ideal arrangement, but may however be less well defined in some other countries.

The service connection is owned by the utility and the maintenance of it is their responsibility.

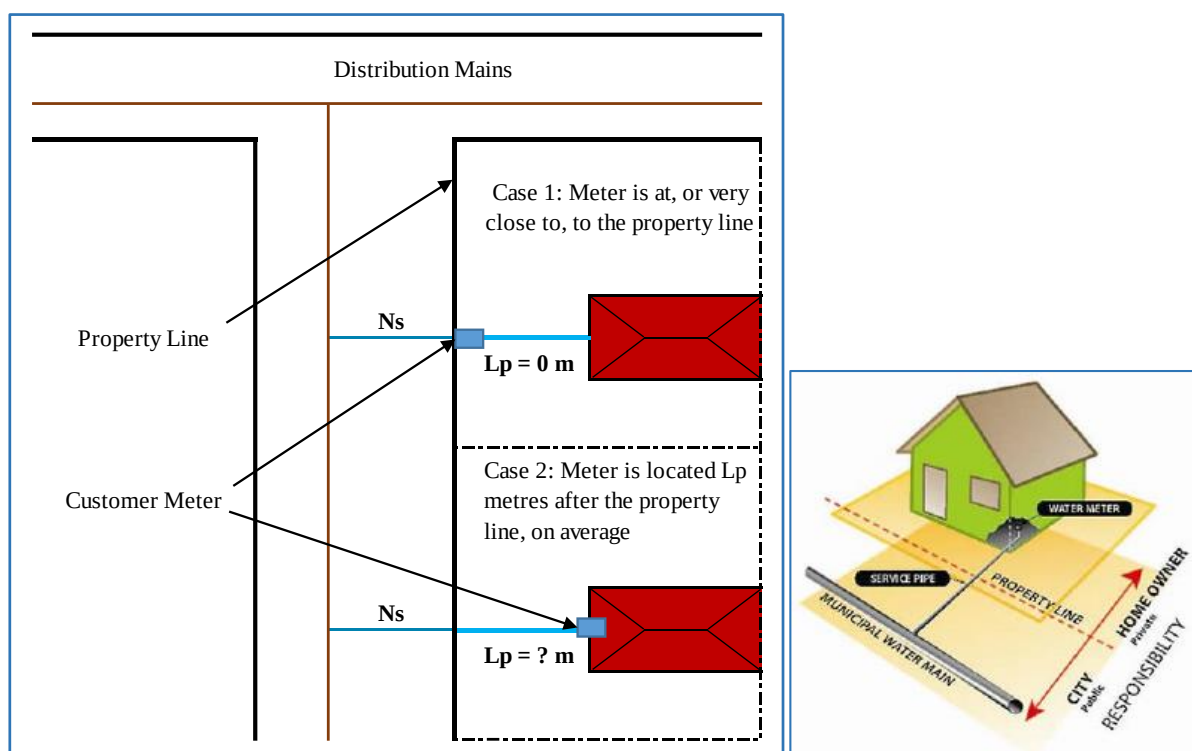


Figure Annex B- 1 Service Connection and Private Pipe Cases

Source: Pearson, D. (2019). Standard Definitions for Water Losses. (A. Donnelly) London: IWA Publishing. doi:10.2166/9781789060881

Private Service Pipe

The private service pipe is the pipe that runs from the street boundary where the main is laid, to the internal stop tap in a property or supply location. This pipe may often be laid underground and referred to as the underground private service pipe, but can also be above



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ground, such as in a block of flats. The supply pipe is owned by the owner of the property and maintenance is their responsibility.

The length, in a utility or zone, of the private service pipes between the external stop tap and the point of supply is used in the calculation of UARL and UBL. Care has to be taken in the estimation of private service pipe length when the properties are internally or externally metered and in the case of flats or multiple properties.

The service connection is owned by the utility and the maintenance of it is their responsibility. A service connection may supply more than one private service pipe.

Common Private Service Pipe

A private service pipe that feeds more than one customer.

Flow

Flow is the rate at which water passes a particular point in the network. Units of flow are typically L/s, m³/h.

Net Flow

The net flow is the flow into an area taking into account the additions and subtraction of flows measured at the inlet and outlet meters of the area. It is equivalent to the demand on the area.

Appurtenances

A generic term to describe apparatus that is attached to mains. This includes sluice valves, hydrants, air valves and PRVs.

Fittings

A generic term to describe tees, bends and couplings etc. on mains.

Valve

All types of valves definitions are given in Annex 4.

Flow Meter

A flow meter is a device for measuring the flow of water at a point in a system. It may be a meter installed to aid management of a water supply network or water distribution network or it may be a revenue meter. All types of flow meters are given in Annex B.4.

Fire Hydrant

A fire hydrant, sometimes called a fireplug, is a hydrant by which firefighters can gain access to a supply of water. It may be paid for by the fire brigade and is normally also maintained by them.



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Hydrant

A hydrant is a fitting positioned on a main or on a short branch to the side of the main from which water can be discharged. There are two prime purposes for a hydrant, namely, firefighting and mains flushing.

Per Capita Consumption (PCC)

Per capita consumption is the average daily consumption per person in an area. If all the properties are metered then this value can be obtained from the billing system using the following equation:

$$PCC_{est} = \frac{\text{Measured Consumption on metered domestic properties}}{\text{Number of metered domestic properties} \times \text{Occupancy}}$$

When domestic properties are not metered it is necessary to estimate PCC (or Per Household Consumption (PHC)) in order to provide an estimate of the unmeasured household consumption, which will be a significant component of billed unmetered consumption, to be used in the SWBF. Estimation of PCC is usually carried out using a small area monitor or individual household monitor studies. It is critical that consumption does not include non-household consumption nor any leakage on the mains or service connections. Typical units of PCC are l/c/d.

Per Household Consumption (PHC)

Per household consumption is the average daily consumption per domestic property in an area. If all the properties are metered then this value can be obtained from the billing system using the following equation:

$$PHC_{est} = \frac{\text{Measured Consumption on metered domestic properties}}{\text{Number of domestic properties}}$$

PHC is more reliable than PCC where occupancy rates are not known. Estimation of PHC is usually carried out using a small area monitor or individual household monitor studies. It is critical that consumption does not include non-household consumption nor any leakage on the mains or service connections. Typical units of PHC are l/prop/d.

District Metered Area (DMA)

A DMA is a section of the distribution network, commonly where sluice valves have been shut off, usually permanently, so that demand in the area can be monitored by the flow through one or more meters for the purpose of leakage management. There may be more than one DMA meter measuring the flows into and out of the DMA. All unmetered connections along the boundary of the DMA must be valved off (closed). There is no fixed rule on the size of DMAs.



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If they are too small then there is a higher cost for monitoring (meters, pulse units, flow loggers) and analysis. If they are too large then the resolution for discerning when leakage is accumulating is reduced. It is generally recommended that DMAs are between 6–10 km and 500–2500 properties. DMA boundaries should be chosen to take advantage of natural hydraulic boundaries in order to minimize the number of meters. They should be chosen to separate domestic and industrial/commercial areas where possible. They should also be designed along the contours of the area in order to minimize the difference in elevation across the DMA to aid pressure management.

Zone

Zone is a term that is often used for larger sections of a network, which may comprise several DMAs or which may not have any DMAs at all, but which is too large to be considered as a DMA.

Sub-DMA

A sub-DMA is an area within a DMA that is monitored in order to localize the area where a leak may have broken out within the DMA. The valving and/or recording of the flows of a sub-DMA may be temporary or permanent. The metering of a sub-DMA may be temporary, using a meter installed on a trailer and an overland bypass between hydrants.

Infrastructure Condition Factor (ICF)

The infrastructure condition factor (ICF) is the ratio of the actual background leakage to unavoidable background leakage that may be expected on the same area (zone, DMA or sub-DMA). The ICF can provide a reflection of asset condition. New fully welded PE systems could be expected to have an ICF close to 0, whereas the ICF for an older system in poor condition may be about 3. ICFs of greater than 3 can indicate that there are active leaks running in the DMA. Where ICF on a DMA is estimated to be greater than 3, there should be rigorous checks to ensure that the attributes are correct and that the boundary valves are closed.

Unfortunately, without carrying out detailed measurements, it is impossible to know the ICF. In such cases working with the default values of 1 will mean that there is a good chance that the background losses are underestimated and consequently the recoverable losses are overestimated. Using a higher ICF (of say 5) might easily lead to an overestimation of the background losses which will cause an underestimation of the true excess loss reduction potential. Thus, it is recommended to work with the ICF=1 background leakage values unless better data is available.

B.3 Definitions Related to Pressure Management

The definitions of the system components together with actions are given in this section. Although some of the definitions are well known by WSA/WUD, these definitions are also given in order to adequately understand each action suggested in the Guideline and to avoid a gray area.



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Pressure

Pressure is the force exerted by the water within a pipe. It is equivalent to how high the water would rise in an open tube if this was connected to the side of the pipe at the point of interest. Pressure is measured on the network using a pressure gauge. The units of pressure are typically m.

Pressure Gauge

A gauge connected to a water main or service pipe for measuring pressure in the main or service pipe. The pressure can be read manually or recorded on a pressure logger.

Pressure Logger

An electronic device that can store the readings from a pressure transducer, for later interrogation or uploading to a central computer system or cloud-based application, such as a leakage management system. The pressure that is recorded will be the instantaneous pressure registered on the pressure transducer at the relevant time.

Transients

Transients are very high frequency pressure surges within the distribution network created by operational changes, pump starts or stops or draw-off from the network.

Pressure Management Index (PMI)

The PMI has been suggested as a way of measuring network performance in respect to pressure management. In this case, the average zone pressure is expressed as a ratio of the Standard of Service on pressure, be that statutory, regulatory or simply a guidance level.

Discrete Pressure Area (DPA)

A DPA is a discrete area within the network where pressure is subject to the same pressure regime, either natural or managed through a PRV. Many water utilities may refer to these as hydraulic zones.

Pressure Managed Area (PMA)

A PMA is a DPA where the pressure regime is controlled by one or more PRVs.

Critical Point (CP)

A CP is the point of lowest available head within a DPA. Monitoring the pressure at the CP is useful in establishing whether the Standard of Service for pressure is being delivered to all customers. It is also useful for setting the controls of a PRV if the DPA is pressure managed.



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Average Zone Point (AZP)

The AZP is the point in a DPA which is representative of the average pressure experienced by all properties in the DPA. The average height of properties in a DPA can be calculated using GIS, if this contains the height of each property, or manually by counting the properties between contours on a map.

Average Zone Pressure

The average pressure measured at the average zone point over a day.

Average Zone Night Pressure (AZNP)

The AZNP is the average pressure across a DPA during the period when the leakage is assessed for leakage monitoring purposes using the minimum night flow method. This will normally be during the night but not necessarily. The pressure will also normally be at its maximum at the time of minimum flow, but not necessarily, depending on the type of pressure management. The AZNP should be measured at the Average Zone Point.

The AZNP of an area such as a zone or a DMA with several DPAs, should be calculated by property weighting the AZNPs of all the individual DPAs that make up the area.

Average Operating Pressure (AOP)

In the case of a system with continuous supply, the AOP is the average pressure experienced by all the properties in a DPA over an entire day.

$$\text{Average Operating Pressure} = \text{Average Zone Night Pressure} \times \text{Hour to Day Factor} / 24$$

$$AOP = AZNP \times HDF / 24$$

The AOP for areas such as a zone or a DMA with several DPAs should be calculated by property weighting the AOPs of all the individual DPAs that make up the area.

In the case of systems with intermittent water supplies, the AOP should only be evaluated for the period when the system is pressurized.

B.4 Definitions Related to Active Leakage Control

The definitions of the system components together with actions are given in this section. Although some of the definitions are well known by WSA/WUD, these definitions are also given in order to adequately understand each action suggested in the Guideline and to avoid a gray area.

Leak

A leak is a failure of the water supply network such that there is an unplanned loss of water from the water supply network. It is a generic term that can be used on any size or type of asset, from a service pipe to a trunk main or service reservoir or any fitting from a gate valve



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to a customer meter. In some utilities, the word “burst” may have a specific connotation in relation to a leak that is large enough to cause a supply disruption or severe impact on customers or general public. From the leakage management perspective there is no difference between leak, burst or break.

Leak on Main

A leak that has occurred on a water main by either a pipe break or failure at this point – this includes joints, pipe breakage or at the tapping point connection.

Leak on Service Connection

A leak that has been located on a service connection, namely a leak that is after the connection to the main. This includes leaks at the tapping point itself and anywhere on the service connection up to the stop tap/meter at the customer boundary.

Leak on Private Service Pipe

A leak that has been located on the private service pipe which runs from the customer boundary or meter to the internal stop tap of the property. This is considered to be on private property and the repair is, thus, usually the responsibility of the owner.

Leak on Appurtenances

This the generic term for leaks on assets such as external stop taps, customer meters, DMA meters, PRVs, gate valves and hydrants. A work management system will usually identify which asset is leaking, although the allocation may have to be corrected following excavation.

Daily Leakage

The daily volume of leakage, usually calculated at DMA level but can be evaluated at zone level, assessed either using the Total Integrated Flow Method (TIF Method), or from the night leakage multiplied by the hour to day factor (HDF). The most commonly used units would be m^3/d .

Night Leakage

Night leakage is the leakage during 1 h at the time of the minimum flow, which usually occurs in the middle of the night. It is assessed using the minimum flow method, usually at a DMA level but can be evaluated at zone level. The most commonly used units would be m^3/h .

Minimum Night Flow (MNF)

The minimum night flow is the minimum 1 h flow rate recorded during the night period, normally defined as being between midnight and 6am. The minimum night flow in urban situations normally occurs during the early morning period, commonly between 2 and 4am. The term minimum night flow is therefore common parlance for the minimum flow because of this. The minimum night flow is the most meaningful piece of data as far as estimating night leakage is concerned. The term night line is also often used for Minimum Night Flow.



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Tracking the minimum night flow over a period of time can show whether unreported leakage is accumulating on the area (DMA, sub-DMA or Zone) and is therefore a key activity in leakage management.

Minimum Flow (MF)

The minimum flow is the minimum 1 hour flow rate recorded during a 24-h period. The minimum flow in urban situations normally occurs during the early morning period, commonly between 2 and 4am and is referred to as the minimum night flow. However, in some locations the minimum flow may occur outside of this night period due to other water use demands, such as agriculture or the use of night time electricity, and therefore the more generic title of minimum flow is more suitable. In the case of systems with intermittent water supply, the minimum flow has to be taken during periods when the system is pressurized, although even then customer tanks may still be filling and therefore this flow has to be interpreted with care.

Total Integrated Flow Method (TIF Method)

The total integrated flows are the daily volumes of the water balance components, such as the average daily net flow and measured consumption. Leakage in an area, such as a DMA or zone, can be estimated by carrying out a water balance using the TIF components and comparing this to the estimate derived from the using the minimum night flow method.

Minimum Night Flow Method (MNF Method)

The minimum night flow method is used to estimate night leakage in a DMA or zone using the minimum night flow, provided there is no service reservoir in the zone which could be filling or emptying during this period. During the minimum night flow period, consumption is at a minimum and therefore leakage is at a maximum proportion of the total flow. Estimation of the leakage component of the minimum night flow is undertaken by subtracting from the minimum night flow, an assessment, estimated or logged during the period of minimum flow, of night consumption for all the customers connected in the DMA or zone being studied.

The minimum night flow method cannot generally be used with systems with intermittent water supplies, as the system may be shut off or depressurized during the period of minimum night flow and therefore there will be little or no leakage at that time. Even if the system is pressurized during the night, the consumption pattern can be unreliable as customers cisterns may be filling or customers may be storing water ready for the next period without supply.

Continuous Logged User (CLU)

When a particular non-household customer's use during the minimum night flow period is significant and variable then it may be necessary to log the user on a continuous basis so that their consumption can be subtracted from the minimum night flow. The general availability and deployment of smart meters is making this aspect of leakage management easier.



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Operability Test

The operability test is a technique used to give confidence as to whether a DMA is correctly isolated, verify that there are no meter scaling errors and that the DMA attributes are reasonably correct. In the test, leakage assessed using the minimum night flow method is compared to that derived using the total integrated flow method components on the same area. Either the leakage from the two methods is compared or the implied household consumption from equating the leakage is compared to the expected household consumption as the pass/fail criteria for the operability test. It is usually assessed on an individual DMA basis but can then be accumulated to higher levels in the network hierarchy.

Top Down Leakage Assessment (TD)

The assessment of leakage in a zone by carrying out a water balance on that zone as a whole, namely water in minus water out. SWBF should be used for this assessment.

Bottom Up Leakage Assessment (BU)

The assessment of leakage in a zone by adding up the leakage assessed on the individual components, such as DMAs, service reservoirs and trunk mains. Allowance must be made for leakage in areas that are not monitored and also for leakage in areas where data is believed to be inaccurate.

Minimum Achieved Night Flow

The minimum achieved night flow is the minimum night flow that has been achieved in a DMA over a long period, usually greater than four years, provided that the DMA boundary, pressure regime and water use regime have not changed significantly within this period.

Minimum Achievable Night Flow (MABL)

The minimum achievable night flow is an assessment of the minimum night flow that may be expected in a DMA, considering a realistic estimate of the infrastructure condition factor, average zone night pressure and assessed night consumption.

Valves

Step Valve

A sluice valve used to shut off a step in a step test.

Circulating Valve

A sluice valve used to isolate sections of a DMA in order to create steps for a step test.

Boundary Valve

A sluice valve which is shut in order to create the boundary of a zone, PMA or DMA.



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Air Valve (AV)

An air valve is a valve designed to allow air, that may have accumulated at high points in a water main, to be expelled or allow air into the main when these are drained for maintenance or repair. They may also be installed at other strategic points, other than at the highest point on a main.

Sluice Valve (SV)

A sluice or gate valve is a valve which opens by lifting an internal gate or wedge allowing water to pass through and when in the closed position prevents water from passing. They are located on the network by the utility for the purposes of isolating or separating lengths of pipe for maintenance or repair of leaks, other interventions such as step tests or for the creation of district metered areas or waste areas. Large diameter (~350 mm) sluice valves can be fitted with a small bypass valve to equalize pressures across the valve before attempts are made to open the principal valve. Also referred to as a gate valve.

Butterfly Valve

A butterfly valve is a valve that is operated with a disc turning through 90 degrees to allow or to stop the flow of water. It is generally fitted on larger diameter mains where a sluice valve would be too large such that it might be close to or above ground level. Butterfly valves can be fitted with a small bypass valve to equalize pressures across the valve before attempts are made to open the principal valve.

Pressure Control Valve

The generic family of control valves that operate on the basis of pressure within the water supply or water distribution network. These include pressure reducing valves, pressure sustaining valves, pressure relief valves and altitude control valves.

Altitude Control Valve

A type of pressure control valve that is controlled by the absolute pressure at a location on the network. They are used to control the filling of service reservoirs.

Pressure Sustaining Valve (PSV)

A type of pressure control valve that is used to ensure that the pressure at a point in the network is sustained.

Pressure Reducing Valve (PRV)

A pressure reducing valve is a control valve that reduces the pressure of water to a desired value at its outlet as it passes through. They are sometimes referred to as pressure management valves. Pressure reducing valves are a specific application within the more generic family of pressure control valves.



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Pressure Relief Valve

A pressure relief valve is a control valve that relieves the pressure of water to a desired value by allowing the water to be discharged from the network.

Wash Out (WO)

A wash out is either a sluice valve or a hydrant which has been provided by the utility, usually but not necessarily at dead ends, for the purpose of flushing or emptying the network.

Flow Meters

Abstraction Meter

A meter that measures the volume of raw water abstracted from a source, such as a borehole, river intake or sea water intake.

Production Meter

A meter that measures the volume of potable water put into supply at a treatment works or desalination plant.

Distribution Input Meter

A meter that measures the flow that defines the input into the water supply network of a utility. It will normally be a production meter but may be a meter measuring any imports to or exports from the utility.

Bulk Meter

A bulk meter is any meter on the water supply network or water distribution network that is not a revenue meter.

Non-revenue Meter

Any meter that is not a revenue meter, for example a DMA meter, bulk meter, or production meter.

Revenue Meter

A revenue meter is a meter that is used for the purpose of billing consumption to properties, be that for domestic, commercial, municipal or industrial purposes. It will invariably be a full-bore meter on a service pipe.

DMA Meter

A meter that measures the flow into or out of a DMA.



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Meter Box

The piece of furniture located at the property boundary that usually contains a revenue meter and external stop tap. Sometimes referred to as a boundary box.

Volumetric Meter

A volumetric meter is an instrument which measures either directly or indirectly, the volume, as opposed to the mass, of water passing through the instrument. Many volumetric meters actually measure the velocity of flow rather than directly measuring the volumetric flow rate. A positive displacement meter is an example of a direct volumetric meter and a turbine meter is an example of an indirect volumetric meter.

Positive Displacement Meter

A positive displacement meter uses a fixed volume chamber, or chambers, which is filled with water when it passes through the meter. The meter estimates the flow by counting the number of chambers that are filled in a given time period. It is a type of volumetric meter that directly measures the volumetric flow rate.

Turbine Meter

A turbine meter uses a turbine to measure the speed of water flowing through the meter. The meter can have single or multiple jets driving the turbine. The volume is estimated from the velocity using the cross section of the meter. It is a type of volumetric meter that indirectly measures the flow rate.

Electromagnetic Meter (EM)

An electromagnetic meter is a meter that uses the principle of Faraday's Law to estimate the velocity of water passing through the meter. A current is generated as the water flows through an electromagnetic field with the current being proportional to the velocity of the water. The volume is estimated from the velocity using the cross section of the meter.

Ultrasonic Meter

An ultrasonic meter uses the principle of the Doppler effect or transit time to estimate the velocity of water flowing through the meter. The meter has transmitters that emit ultrasound both with and against the direction of flow. For a Doppler ultrasonic meter, the velocity of flow is proportional to the difference in the amplitude of the sound received by sensors after passing through the water. For a transit time ultrasonic meter, the velocity of flow is proportional to the difference in travel time between the two signals. Ultrasonic meters are available as either a fixed full-bore meter inserted into the pipeline or as a meter strapped on or bolted around the outside of the existing pipe. This could be a permanent or temporary arrangement.



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Full-bore Meter

A full-bore meter is a meter where the full flow passes through the meter. The installation therefore involves replacing a whole section of the pipe by the meter. They can be used on mains and service pipes. Installation costs can be high on existing large diameter mains.

Insertion Meter

An insertion meter is a meter that can be inserted into an existing pipe through a tapping on the top of the pipe. It is used on larger diameter mains and not service pipes. The tapping and meter insertion can be made under pressure and therefore there is no disruption to supply to customers and costs are minimized. This type of meter can therefore cost significantly less than a full-bore meter for the same diameter main. On very large diameter mains, a multi-point insertion probe with more than one velocity sensor can be used. The velocity sensor, which is located on the insertion probe, may be a turbine meter, an electro-magnetic or an ultrasonic meter. The accuracy of an insertion meter is less than that of a full-bore meter because it is necessary to allow for the velocity profile across the main either by sampling at different depths, using a standard depth, or by integrating the velocities from multiple sensors.

Flow Logger

An electronic device that can store the readings from a flow meter, for later interrogation or uploading to a central computer system or cloud based application, such as a leakage management system. The flow that is recorded will be the average flow registered on the flow meter over the relevant time period, often 15 minutes but can be some other time period.

Pulse Unit

An electronic device that is attached to a flow meter and converts the output of the meter into an electronic output that can be recorded on a flow logger.

Stop Tap and Tapping

Stop Tap Chamber

The piece of furniture located at the property boundary that provides access to the external stop tap, in countries where the external stop tap is located below ground and where the property is not externally metered. It is often constructed of concrete segments or plastic ducting. Alternatively, it may be an integral part of the stop tap that brings a telescopic spindle up to the surface thereby avoiding the risk of the chamber filling with water and debris. Sometimes referred to as a stop tap box.

External Stop Tap

A stop tap that is at or close to the street boundary. This stop tap is owned by the water utility and maintenance is their responsibility. In some countries the water utility meter and associated stop tap must be within 1 meter of the first draw off from a service, hence their location inside the property. Additionally, in some countries, a separate water utility stop tap is



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not used, with the cock on the tapping point being used to isolate the main. Sometimes referred to as a stop cock. In the United States, this is referred to as a curb stop.

Internal Stop Tap

A stop tap that is adjacent to the outside wall of a property or immediately inside the property. This is owned by the owner of the property and maintenance is their responsibility.

Stop Tap

A stop tap or stop valve is used to regulate or control the flow of water from a main into and within both residential and commercial buildings. Sometimes referred to as a stop valve.

Tapping

Tapping is the process of drilling through the pipe wall of a water main to provide a means of connection to the main. This could be a small diameter tapping (~20 mm) for a service connection (tapping point) or it may be a larger diameter (~60 mm) for the purpose of installing an insertion meter.

Tapping Point

Tapping Point is the generic name for the connection from the main to the service connection. It can be either a ferrule or a tapping tee.

Tapping Tee

A tapping tee is the name for the connection from the main to the service connection in the case of PVC or PE mains. It is normal to have some form of saddle which is either fixed mechanically or welded to the main in order to provide support to the connection. The fitting usually contains its own cutter (self-tapper) which is wound down to drill through the plastic pipe to make the connection. The fitting may well contain a ferrule so that the supply can be turned on or off once the main has been tapped.

Ferrule

A ferrule is the connection from the main to the service pipe in the case of a metallic pipe. They are usually made from brass and are tapered. The main is drilled and the ferrule is then tapped into the main. Some ferrules may include a valve so that the supply can be shut off at the main. In such cases, they are referred to as ferrule cocks or corporation stop cocks.

B.5 Definitions Related to Speed and Quality of Repairs

The definitions of the system components together with actions are given in this section. Although some of the definitions are well known by WSA/WUD, these definitions are also given in order to adequately understand each action suggested in the Guideline and to avoid a gray area.



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Reported Bursts are those events that are brought to the attention of the water utility by the general public or the water utility's own staff. A burst or a leak that, under urban conditions, manifests itself at the surface is normally reported to the water utility.

Unreported Bursts are those that are located by leak detection teams as part of their normal everyday active leakage control duties.

Table Annex B- 1 Flow Rates for Reported and Unreported Bursts

Location of Burst	Flow Rate for Reported Bursts	Flow Rate for Unreported Bursts
	l/hour/m pressure	l/hour/m pressure
Mains	240	120
Service Connection	32	32

Source: IWA Water Loss Task Force

Burst Frequency

In order to provide a statistically robust estimate it is better if this frequency is the average over several years (~4 years). It is essential that the pressure regime and network boundary is consistent over this period.

- **Mains Burst Frequency:** The average frequency (i.e. number per year) of bursts that occur on the mains in a network or part of a network, e.g. DMA.
- **Service Pipe Burst Frequency:** The average frequency (i.e. number per year) of bursts that occur on the service pipes in a network or part of a network, e.g. DMA. It is often useful to split the frequency of bursts between those occurring on service connections and those occurring on private service pipes.
- **Service Connection Burst Frequency:** The average frequency (i.e. number per year) of bursts that occur on the service connections in a network or part of a network.
- **Private Service Pipe Burst Frequency:** The average frequency (i.e. number per year) of bursts that occur on the private service pipes in a network or part of a network.

B.6 Definitions Related to Administrative (Apparent) Loss Management System

The definitions of the system components together with actions are given in this section. Although some of the definitions are well known by WSA/WUD, these definitions are also given in order to adequately understand each action suggested in the Guideline and to avoid a gray area.

Administrative (Apparent) Loss (See Annex B.1)

Authorized Consumption (AC) (See Annex B.1)



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Meter Under-Registration (MUR)

Meter under-registration (MUR) is the amount that any flow meter under-records or over-records the true volume of water that passes through the meter.

MUR is defined, in ISO 4064, as:

$$MUR = (Volume_{Actual} - Volume_{Measured}) / Volume_{Actual}$$

Thus, MUR is between –100 and +100% and the actual volume that should be recorded is:

$$Volume_{Actual} = (Volume_{Measured}) / (1 - MUR)$$

Meter Calibration

Over time, meter performance can drift away from the manufacturer's original calibration. Meter calibration is the process of checking that a meter's calibration coefficients are as defined by the manufacturer when the meter was supplied. A good earth connection is also critical for all electronic meters and therefore should be checked during the calibration process.

Meter Verification

Even though a meter may be calibrated correctly, it may not measure flows accurately because of the installation arrangement. Meter accuracy is very susceptible to poor installation, for example, incorrect orientation, or being located too close to bends, pumps or other installations which may affect the water flow. Meter performance should therefore be verified on a regular (say ~1–3 years) basis. This could simply be by comparing the measured flow to flows measured at other meters either upstream or downstream. Where this verification indicates that there may be problems, then more sophisticated verification should be undertaken. This could involve installation of multiple insertion probes near the meter, using a temporary external strap-on ultrasonic meter.

Meter Reading Lag

Manual revenue meters are often read on a regular cycle. Reading cycles may be monthly or may be read at much less frequent intervals. For example, in the UK, domestic customer meters are only read once every six months. This means that the water supplied and water consumed figures can be out of phase, a phenomenon referred to as meter lag. The longer the meter reading cycle the higher will be the potential impact of the meter reading lag. The impact of meter reading lag is more significant during periods of fluctuations in demand such as short-term weather-related demand or when drought restrictions are introduced. The use of



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rolling 12-month average rather than spot monthly top down leakage will reduce, but may not entirely remove, the impact of meter lag.

Automatic Meter Reading (AMR)

Automatic meter reading is the technology of automatically collecting consumption, diagnostic and status data from revenue meters and transferring that data to a customer billing system for billing, troubleshooting and analysis. In general, AMR is used to describe the process where revenue meter data is downloaded automatically replicating the normal billing cycle, possibly on a more frequently basis, for example, volumes every day, week, month or quarter.

Advanced Metering Infrastructure (AMI)

Advanced metering infrastructure is the collective term to describe the whole infrastructure from true smart meters to two-way communication networks to control center equipment and all the applications that enable the gathering and transfer of water usage information in near real-time.

Smart Meter

In strict terms, a meter is considered to be smart if it can be controlled by a network operator, allowing for example, consumption to be controlled in periods of high demand. In practice the word smart is commonly used for meters without this control function, but where 15-minute (or more frequent) data can be remotely collected. Because of the immediacy and frequency of data collection, Smart meters are more useful to support leakage management than AMR meters.



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ANNEX C- IWA PERFORMANCE INDICATORS



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C. IWA PERFORMANCE INDICATORS

Table Annex C- 1 Performance Indicators for Water Supply Services

Categories		Code	Indicators
Water Resources		WR1	Inefficiency of use of water resources
		WR2	Water resources availability
		WR3	Own water resources availability
		WR4	Reused supplied water
Personnel	Total Personnel	Pe1	Employees per connection
		Pe2	Employees per water produced
	Personnel per main function	Pe3	General management personnel
		Pe4	Human resources management personnel
		Pe5	Financial and commercial personnel
		Pe6	Customer service personnel
		Pe7	Technical services personnel
		Pe8	Planning and construction personnel
		Pe9	Operations and maintenance personnel
	Technical services personnel per activity	Pe10	Water resources and catchment management personnel
		Pe11	Abstraction and treatment personnel
		Pe12	Transmission, storage and distribution personnel
		Pe13	Water quality monitoring personnel
		Pe14	Meter management personnel
		Pe15	Support services personnel
	Personnel qualification	Pe16	University degree personnel
		Pe17	Basic education personnel
		Pe18	Other qualification personnel
	Personnel training	Pe19	Total training
		Pe20	Internal training
		Pe21	External training
	Personnel health & safety	Pe22	Working accidents
		Pe23	Absenteeism
		Pe24	Absenteeism due to working accidents or illness at work
		Pe25	Absenteeism due to other reasons
	Overtime work	Pe26	Overtime work
Physical	Treatment	Ph1	Treatment plant utilization
	Storage	Ph2	Raw water storage capacity
		Ph3	Transmission and distribution storage capacity
	Pumping	Ph4	Pumping utilization
		Ph5	Standardized energy consumption
		Ph6	Reactive energy consumption
		Ph7	Energy recovery
	Transmission & distribution	Ph8	Valve density
		Ph9	Hydrant density
	Meters	Ph10	District meter density
		Ph11	Customer meter density
		Ph12	Metered customers
		Ph13	Metered residential customers



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Categories		Code	Indicators
Operational	Automation & Control	Ph14	Automation degree
		Ph15	Remote control degree
	Inspection and maintenance of physical assets	Op1	Pump inspection
		Op2	Storage tank cleaning
		Op3	Network inspection
		Op4	Leakage control
		Op5	Active leakage control repairs
		Op6	Hydrant inspection
	Instrumentation calibration	Op7	System flow meters calibration
		Op8	Meter replacement
		Op9	Pressure meters calibration
		Op10	Water level meters calibration
		Op11	On-line water quality monitoring equipment calibration
	Electrical & signal transmission equipment inspection	Op12	Emergency power system inspection
		Op13	Signal transmission equipment inspection
		Op14	Electrical switchgear equipment inspection
	Vehicle availability	Op15	Vehicle availability
	Mains, valves and service connection rehabilitation – pumps rehabilitation	Op16	Mains rehabilitation
		Op17	Mains renovation
		Op18	Mains replacement
		Op19	Replaced valves
		Op20	Service connection rehabilitation
		Op21	Pump refurbishment
		Op22	Pump replacement
	Operational water losses	Op23	Water losses per connection
		Op24	Water losses per mains length
		Op25	Apparent losses
		Op26	Apparent losses per system input volume
		Op27	Real losses per connection
		Op28	Real losses per mains length
		Op29	Infrastructure Leakage Index (ILI)
	Failure	Op30	Pump failures
		Op31	Mains failures
		Op32	Service connection failures
		Op33	Hydrant failures
		Op34	Power failures
		Op35	Water-point failures
	Water metering	Op36	Customer reading efficiency
		Op37	Residential customer reading efficiency
		Op38	Operational meters
		Op39	Unmetered water
	Water quality monitoring	Op40	Tests carried out
		Op41	Aesthetic tests carried out
		Op42	Microbiological tests carried out
		Op43	Physical-chemical tests carried out
		Op44	Radioactivity tests carried out
		QS1	Households and businesses supply coverage



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Categories		Code	Indicators
Quality of service	Service coverage	QS2	Buildings supply coverage
		QS3	Population coverage
		QS4	Population coverage with service connections
		QS5	Population coverage with public taps or standpipes
	Public taps and standpipes	QS6	Operational water points
		QS7	Average distance from waterpoints to households
		QS8	Per capita water consumed in public taps and standpipes
		QS9	Population per public tap or standpipe
	Pressure & continuity of supply	QS10	Pressure of supply adequacy
		QS11	Bulk supply adequacy
		QS12	Continuity of supply
		QS13	Water interruptions
		QS14	Interruptions per connection
		QS15	Bulk supply interruptions
		QS16	Population experiencing restrictions to water service
		QS17	Days with restrictions to water service
	Quality of supplied water	QS18	Quality of supplied water
		QS19	Aesthetic tests compliance
		QS20	Microbiological tests compliance
		QS21	Physical-chemical tests compliance
		QS22	Radioactivity tests compliance
		QS23	New connection efficiency
	Service connection and meter installation & repair	QS24	Time to install a customer meter
		QS25	Connection repair time
		QS26	Service complaints per connection
	Customer complaints	QS27	Service complaints per customer
		QS28	Pressure complaints
		QS29	Continuity complaints
		QS30	Water quality complaints
		QS31	Interruption complaints
		QS32	Billing complaints and queries
		QS33	Other complaints and queries
		QS34	Response to written complaints
Economic and financial	Revenues	Fi1	Unit revenue
		Fi2	Sales revenues
		Fi3	Other revenues
	Costs	Fi4	Unit total costs
		Fi5	Unit running costs
		Fi6	Unit capital costs
	Composition of running costs per type of costs	Fi7	Internal manpower costs
		Fi8	External services costs
		Fi9	Imported (raw and treated) water costs
		Fi10	Electrical energy costs
		Fi11	Other costs
	Composition of running costs per main function of the water utility	Fi12	General management functions costs
		Fi13	Human resources management functions costs
		Fi14	Financial and commercial functions costs
		Fi15	Customer service functions costs



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Categories	Code	Indicators
	Fi16	Technical services functions costs
	Fi17	Water resources and catchment management costs
	Fi18	Abstraction and treatment costs
	Fi19	Transmission, storage and distribution costs
	Fi20	Water quality monitoring costs
	Fi21	Meter management costs
	Fi22	Support services costs
	Fi23	Depreciation costs
	Fi24	Net interest costs
	Fi25	Unit investment
	Fi26	Investments for new assets and reinforcement of existing assets
	Fi27	Investments for asset replacement and renovation
	Fi28	Average water charges for direct consumption
	Fi29	Average water charges for exported water
	Fi30	Total cost coverage ratio
	Fi31	Operating cost coverage ratio
	Fi32	Delay in accounts receivable
	Fi33	Investment ratio
	Fi34	Contribution of internal sources to investment
	Fi35	Average age of tangible assets
	Fi36	Average depreciation ratio
	Fi37	Late payments ratio
	Fi38	Inventory value
	Fi39	Debt service coverage ratio
	Fi40	Debt equity ratio
	Fi41	Current ratio
	Fi42	Return on net fixed assets
	Fi43	Return on equity
	Fi44	Return on capital employed
	Fi45	Asset turnover ratio
	Fi46	Non-revenue water by volume
	Fi47	Non-revenue water by cost

Source: Performance Indicators for Water Supply Services, Third Edition, IWA, 2016



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ANNEX D- CASE STUDIES, BEST PRACTICES AND WORKSOP RESULTS



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D. CASE STUDIES, BEST PRACTICES AND WORKSOP RESULTS

D.1 Case Studies and Best Practices

Many WSAs/WUDs particularly in the developing countries continue to operate inefficient water distribution systems (WDSs) with significant amount of water and revenue losses. As mentioned previously, there are various factors that contribute to water losses such as ageing infrastructure, high pressures, external and internal pipeline corrosion, poorly designed and constructed WDSs, metering errors, illegal use, and poor operation and maintenance practices.

The amount of water lost from WDSs is astounding. According to the World Bank study completed in 2006, NRW from WDSs worldwide was estimated at a staggering 48 billion m³ per year (enough to serve nearly 200 million people) costing water utilities about US\$14 billion every year (Kingdom, Liemberger, & Marin, 2006)⁴². The same report indicates that about 55% of the global NRW by volume occurs in the developing countries. According to a recent study completed in 2019 on the same topic, the global volume of NRW has been estimated as 346 million m³ per day or 126 billion m³ per year. Conservatively valued at only US\$0.31 per cubic meter, the cost/value of water lost amounts to US\$39 billion per year (Liemberger & Wyatt, 2019)⁴³. These numbers prove the seriousness of the problem that WSA/WUDs are facing financially. However, not only is this an enormous financial concern, but elevated NRW also detracts from water utilities, in a time of increasing scarcity and climate change, from reaching their goals of full service coverage, at a reliable level of service at an affordable price.

The quantity of water lost is considered as one of the measures of the operational efficiency of a WDS. NRW is also a measure of systems efficiency and high levels of water losses which result in high NRW values may be indicative of poor governance and poor physical condition of the WDS and the costs of system inefficiency are usually transferred to customers via high water tariffs (Mutikanga, 2012)⁴⁴.

Tracking water distribution input is further complicated by the fact that most components of the WDS are located underground. Urban WDSs are often “buried and forgotten” until when they manifest into leaks and bursts causing significant economic, environmental and social costs. Water lost in WUDs is already treated to drinking water standards and energized to provide adequate pressure to reach the consumers. Leakage, often leads to service interruption, is costly in terms of energy losses and may cause water quality contamination via pathogen intrusion. The American Water Works Association (AWWA) estimates that 5-10 billion kWh of electricity generated annually in the USA is wasted in energizing NRW that is either lost as

⁴² Kingdom, B., Liemberger, R., & Marin, P. (2006). The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries. The World Bank Group, Water Supply and Sanitation Sector Board, Publica Private Infrastructure Advisory Facility. Washington, DC: The International Bank for Reconstruction and Development/The World Bank.

⁴³ Liemberger, R., & Wyatt, A. (2019). Quantifying the global non-revenue water problem. *Water Supply*(19.3), 831-837. doi:10.2166/ws.2018.129

⁴⁴ Mutikanga, H. . (2012). Water Loss Management: Tools and Methods for Developing Countries. Doctoral Dissertation, Delft University of Technology, Delft, The Netherlands.



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leakage or used but not paid for (American Water Works Association (AWWA) Water Loss Control Committee, 2003)⁴⁵. Due to the water-energy nexus, a WDS which is water-inefficient is also energy-inefficient. Water loss also increases the carbon footprint of WSA/WUDs with adverse effect on climate change.

The stark reality is that the World's water resources are finite and limited and can no longer sustain the current rate of growth unless used wisely. Since water loss is inevitable, many tools and methods for minimizing water loss in the distribution system have been developed and applied over the years. According to research completed in 2012, water losses that result revenue losses continue to be elusive to manage and control and are considerably high in most water utilities worldwide and they vary from 3% of system input volume (SIV) in the developed countries to 70% in the developing countries (Mutikanga, 2012).

In this section of the Guideline, a couple of NRW management case studies from different countries with different NRW values and backgrounds will be explained in detail to draw a picture of what is happening around the World and what are some of the best practices applied by the WSA/WUDs.

D.1.1 The Netherlands

There are ten private drinking water companies in the Netherlands which are responsible for the quality and quantity of continuous drinking water supplies to more than 17 million people.

⁴⁵ American Water Works Association (AWWA) Water Loss Control Committee. (2003, August). Applying Worldwide Best Management Practices in Water Loss Control. AWWA Journal.



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Figure Annex D- 1 The Private Water Companies in The Netherlands

The WDSs in the Netherlands are known as probably the most efficient in the World. Although IWA Task Forces recommendation is that percentages are not suitable for comparing operational performance in management of Real (Physical) Losses, because of differences and changes in consumption; in the Netherlands, low leakage levels in the range 3-7% of distribution input have been reported since 2000s. Additionally, it is known that when calculating Real Losses the Netherlands' Utilities didn't make any deduction for Unbilled Authorized Consumption (e.g. water from fire hydrants or for flushing) and Apparent (Administrative) Losses (illegal connections, theft of water and customer metering inaccuracy) until recently. Which means that NRW and water losses are almost wholly Real (Physical) Losses in the Netherlands (Lambert & Merks, The LEAKSSuite Library, 2019)⁴⁶.

These low leakage/NRW values got international attention when OFWAT presented the report 'Comparing the performance of the Water Enterprises in England and Wales in 1998 – 1999 with water Enterprises in other Industrialized Countries' (Beuken, Lavooij, Bosch, & Schaap, 2008)⁴⁷. After this attention a research project has been completed where experiences from British and Dutch water companies have been exchanged and the leakage has been

⁴⁶ Lambert, A., & Merks, C. (2019, May 20). The LEAKSSuite Library. The Leakssuite website: <https://www.leakssuitelibrary.com/netherlands-ilis/>

⁴⁷ Beuken, R., Lavooij, C. S., Bosch, A., & Schaap, P. G. (2008). Low Leakage in the Netherlands Confirmed. Eighth Annual Water Distribution Systems Analysis Symposium (WDSA). Amsterdam. doi:10.1061/40941(247)174



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measured in a pilot area in the Netherlands using UK leakage measuring methods to confirm low leakage percentages (Beuken, Lavooij, Bosch, & Schaap, 2008).

Leakage is determined using two different methods for the Netherlands and the UK and the study included application of both methods with data collected from pilot areas. In the Netherlands top-down method is used which involves water balance and calculating leakages as the difference of the system input and revenue water hence; the NRW. In the UK bottom-up method is used in case data of water consumption are lacking due to non-metered connections and leakage levels are usually estimated by night flow analysis.

Noise loggers, leak noise correlators and ground microphones (*Please see Section 3.2.4: Active Leakage Control for details*) were used to obtain global information about the presence of leaks in chosen pilot sites which were in control of two different water companies in the Netherlands. First site was Benthuisen, a village with approximately 3500 inhabitants and 24 km long distribution network managed by Oasen. Second site was Diemen-Noord with 11 km long distribution network managed by Waternet. The measurements in the distribution networks in Benthuisen and Diemen-Noord resulted in leakage levels less than 2%. The top-down method in Benthuisen even resulted in a leakage level of 0.4 %. Additionally, three teams from British water companies visited three different sites in the Netherlands to do leak detection. In total about 45 km of mains were investigated by experienced leak detection crews which resulted in the detection of 3 leaks with a total volume of approximately 1 m³/h. The results given for the leakage measurements and the leak detection prove that the leakage levels in the Netherlands are in fact low as presented in the OFWAT report.

After these results, reasons behind low leakage values in the Netherlands were determined as follows:

- A majority of mains are in the footpath with loose block paving on the surface, therefore leaks become readily visible.
- System has a higher percentage of plastic mains,
- Most service pipes are made of polyethylene or copper. All lead services have been replaced. The service pipes contain fewer joints than in the UK.
- System has a relatively low maximum operating pressure (the range of 2.50 bar to 5.0 bar) due to the fact that the Netherlands' topography is pretty flat,
- Most areas have 100% metering of customers,
- A majority of mains are in the footpath with loose block paving on the surface, therefore leaks become readily visible

It was also concluded that in the Netherlands active leak detection will not be useful in most cases, as the levels of leakage are very low (between 0.06– 1.50 m³/km/day). Leak detection is also less appropriate as most of the mains are made of PVC and experiences have shown that the most common leak detection equipment is not suitable for these mains. Active leak detection could only be useful in case of high local leakage levels in non-plastic mains, caused by a limited number of relatively large leaks. This shows that the appropriate method changes based on the assets the WSA/WUD has on site.



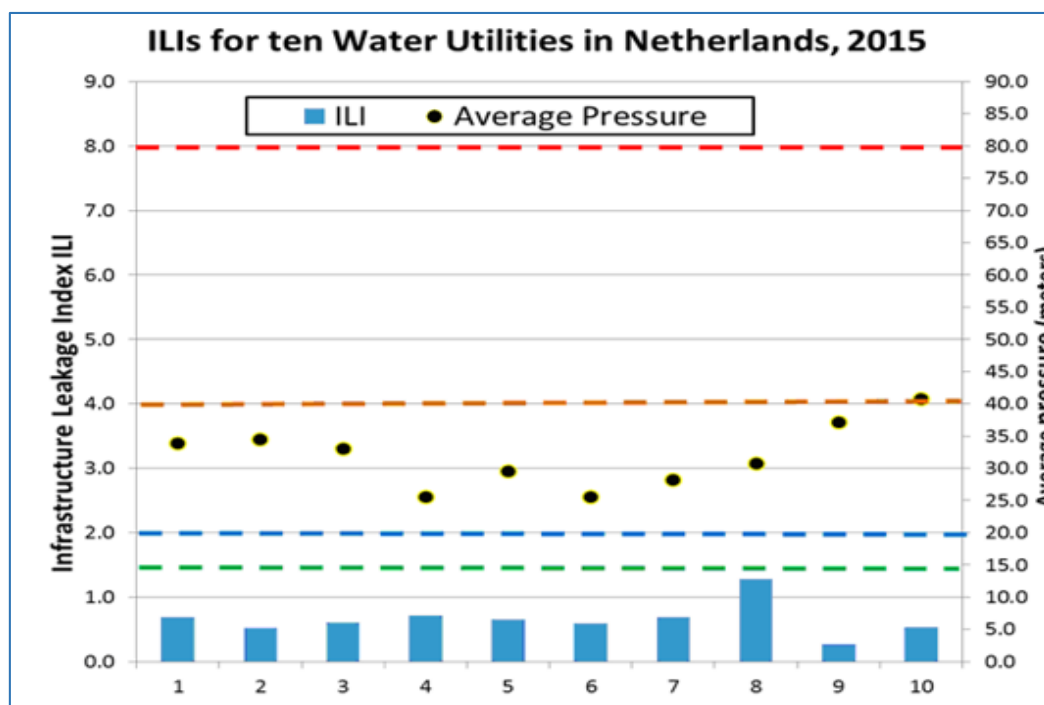
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As indicated previously, percentage of losses is not a recommended and comparable operational efficiency indicator. For this reason using publicly quoted information in the report Prestatievergelijking drinkwaterbedrijven 2015 – available in Dutch language only – the ILIs of Netherlands' Utilities are given in this section. Table Annex D- 1 below shows the range of infrastructure, pressure and Real Losses KPIs assessed from available published data.

Table Annex D- 1 KPIs Calculated for the Netherlands' Water Utilities with 2015 Data (Lambert & Merks, The LEAKSSuite Library, 2019)

2015	Mains	Service Connections, main to meters				Average Pressure	KPIs for Real Losses		
		Number Nc	Service Conns /	Length /conn	Length		ILI	lit/conn/day	m3/km mains/day
	km	Thousands	km of mains	m/conn	km	meters			
Maximum	47,196	2,564,517	159	4.0	10,258	40.8	1.3	41	3.2
Median	6,925	577,710	70	4.0	2,311	31.9	0.6	21	1.5
Minimum	3,120	201,504	40	4.0	806	25.5	0.3	11	0.7
Country	119,338	7,987,181	67	0.0	31,949	32.3	0.6	22	1.5

As the connection densities for all ten utilities significantly exceed 20 per km of mains, it is probable that, with usual IWA assumptions, more than half of the Real (Physical) Losses annual volume will be occurring on service connections rather than mains. If this is the reality, liters/connection/day is likely to be preferable to m³/km mains/day for target-setting and tracking progress in Real (Physical) Losses, because of the wide range of connection densities. The ILIs and average pressure for each of the Netherlands' Utilities are shown in Figure Annex D- 2 below.





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Figure Annex D- 2 ILIs for 10 Water Utilities in the Netherlands with 2015 Data

When these ILI values are compared with the World Bank grouping system given in Section 3.2.1 and Table 5 of the Guideline all ten Netherlands' Utilities have ILIs within Category A ($ILI < 2$); and nine Utilities have ILIs less than 1.0, meaning they are achieving lower Real (Physical) Losses than calculated using the 1999 standard international equation for Unavoidable Annual Real Losses (UARL) given in Section 2.3 of the Guideline which is also recommended in the EU Reference Document “*Good Practices on Leakage Management*” published in 2015⁴⁸.

Possible reasons for the low ILI values in the Netherlands besides the ones determined as a result of the pilot studies explained previously are:

- all leaks are identified and repaired very quickly due to very small DMAs and impermeable ground conditions,
- well-thought design of infrastructure,
- detailed monitoring of water distribution,
- the laying of mains in cycle tracks (rather than in roads).

In addition to these reasons, pressure management has been actively promoted in the Netherlands Utilities' strategies. The average operating pressures range from 25.5 to 40.8 meters, with five Water Utilities in the ‘Low’ category and four in the ‘Very Low’ category. Netherlands' Utilities certainly understand that, for effective pressure management of leakage, ‘every meter counts’. At ‘Low’ and ‘Very Low’ average operating pressures, with flexible pipe materials, the calculated Unavoidable Background Leakage component of the UARL equation (used in the calculation of ILI – please see *Infrastructure leakage index (ILI)* needs to be reduced by more than the usual simple assumption of a linear pressure: leakage relationship (Lambert & Merks, The LEAKSSuite Library, 2019). Burst rates also reduce at lower pressures and based on the study completed in 2008, burst frequencies of mains had values ranging from 0.05 to 0.15 bursts per km per year, including bursts caused by third parties (Beuken, Lavooij, Bosch, & Schaap, 2008)⁴⁹.

Also, as mentioned in the EU Reference Document, after it was determined that 15% of all water losses in the Netherlands arise from digging damage, a Dutch Law ‘WION’ came into force in July 1, 2018 to reduce damage by digging by enforcing digital exchange of location of the data for underground cables and pipes between stakeholders. After the law came into force, some investments were made towards data digitalization and introduction of “carefully digging” concept by the KLO (cable and pipe consultation) which was founded for this purpose. The situation for the water utilities in the Netherlands in terms of digging damage is slightly brighter than other operators: only 10% of all damages are on water mains and pipes. However,

⁴⁸ EU Reference document “*Good Practices on Leakage Management*”, 2015

⁴⁹ Beuken, R., Lavooij, C. S., Bosch, A., & Schaap, P. G. (2008). Low Leakage in the Netherlands Confirmed. Eighth Annual Water Distribution Systems Analysis Symposium (WDSA). Amsterdam. doi:10.1061/40941(247)174



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this 10% counts for the 15% of all water losses and in 2013 this value was estimated as 10 Mm³/year. The target set by the KLO was reducing digging damage between 2014-2018 by 40% which will also affect the amount of real water losses that is lost as a result of digging damage. The reduction was estimated to be 4 Mm³/year in the Netherlands in 2018.

Benchmarking is also considered as a management tool for the utilities which is already adopted by some countries aiming to reduce the amount of non-revenue water. The Netherlands is actually seen as the pioneers in the use of benchmarking in this area worldwide. Its first application was carried out in the eighties, as internal comparison of practices of different companies. In 2012, a federal law made the practice of benchmarking by service providers mandatory. Until present days, 35% of improvement in efficiency of the water companies was observed, thus justifying the importance given by the public sector to related practices. In the Netherlands, the benchmarking applied to supply water is published by the Association of Dutch Water Companies (Vereniging van drinkwaterbedrijven in Nedeland - VEWIN) in the form of reports of federal coverage each two or three years (Marques, Carvalho, Sa, & Malheiros, 2021)⁵⁰.

In addition to cooperating for benchmarking efforts, all of the ten water utility companies are shareholders of the water research institute KWR. These water companies and KWR work closely together to co-create the so-called Joined Research Programme and its outcomes. The emphasis of the Programme is on translating scientific knowledge into applicable, practical solutions for end-users. They have been doing research on asset management since 1997 (Beuken, Eijkman, Savic, Hummelen, & Blokker, 2020). The research began with focusing on defining concepts of asset management and condition assessment of the current system. After that phase, the water authorities started application of asset management methods and the focus was condition assessment, risk analysis and performance measurement. In addition to the application of the concepts of asset management to water distribution networks, the Dutch water companies wanted research to be expanded to developing and applying those concepts to the areas of water abstraction and treatment between 2013-2017. The drinking water companies became aware that asset managers should not try to rebuild existing assets but focus on redesigning them according to a set of future states.

One of the water utilities, Oasen decided to increase the percentage of annual replacement up to 1% (i.e. replacing the complete network in 100 years' time) in 2014 in light of this conclusion. To select the pipes that contributed most to leakages and NRW, Oasen chose a data driven approach. It was decided that at least 50% of the replacement decisions would be made based on these calculations, and less than 50% for third parties or for other reasons.

The figure below shows the preliminary estimation of the NRW percentage as reported in the annual report of Oasen (green line) and the final estimation for the period 1998 up to 2017 (blue line). As seen in Figure Annex D- 3 from 2014 the NRW drops rapidly from 5.5% down to a

⁵⁰ Marques, L. O., Carvalho, R. S., Sa, M. O., & Malheiros, T. F. (2021). Benchmarking as a management tool to reduce non-revenue water. Sustentare and International Workshop on Sustainability Indicators (WIPIS)(24). doi:10.1590/1809-4422asoc20200025vu2021L4DE



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historically low 4%. This remarkable result is a great example of the power of how strategic objectives can be turned into measurable results in an accountable and transparent way with data driven asset management.

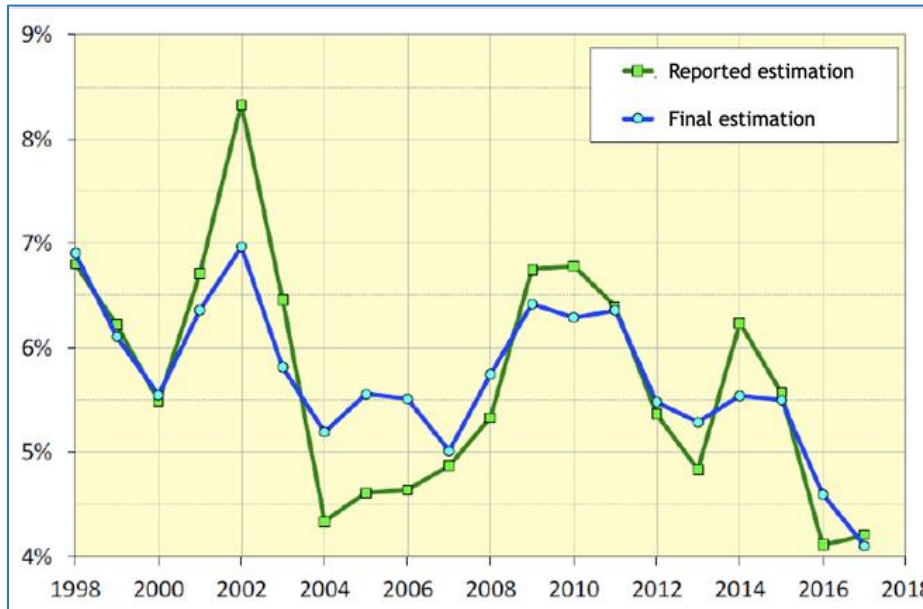


Figure Annex D- 3 Development of the Estimation of NRW at Oasen (Baggelaar, 2020)

Currently the water companies have been focusing on integrated asset management that transcends disciplinary themes and focusses on integrated decision making. Currently, three research projects are under way focusing on: (1) integrated decision making, (2) linking customer expectations to asset management decisions, and (3) the impact of future trends reported in earlier research on asset management.

In conclusion, the Netherlands drinking water companies have been taking the right approach towards NRW management for a long time hence, they lead the way in many areas such as pressure management, asset management, leakage control, benchmarking, institutional and legal approaches. And numbers show that all of their efforts have been returned in numbers such as low ILI values as 0.7 which puts them on top of the countries when it comes to NRW management.

D.1.2 Croatia

Ever since ancient times, the city of Split has never gone short of water thanks to the source of the river Jadro which now produces between 4.54 and 9.34 m³/s, depending on the season. During the 4th century the Emperor Diocletian had extensive hydraulic installations built to collect water from the source and transport part of it by aqueduct to the neighboring city of Salona and to the imperial palace which today still forms the historical center of the city of Split. Since that time, the water systems have been continuously maintained, renovated, modernized and developed, in order to meet the challenges of development and particularly, the development of industry and tourism in the region.



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In terms of the design of these installations, priority has always been given to the quality and safety of the supply of water to major population centers and, it is no doubt thanks to this strategy that today, Split and its neighboring towns are able to cope with the severe peaks in summer consumption due to the development of tourism and seaside resorts, without any major difficulties.

On the other hand, the enormous production capacity of the river Jadro and the low cost of the treatment and pumping of the water collected have never encouraged successive operators to optimize the resource. Therefore, losses from the water distribution systems have currently reached 60% of the volumes imported. Under such conditions, the city of Split and the neighboring communities are likely to exceed their quota for the use of water from the Jadro River and may no longer be capable of meeting the future requirements of the region without having to find new water resources, the channeling and transportation of which will require extensive investment.

In this context, the water and sanitation service VIK SPLIT, which also manages the water distribution networks of the neighboring communities, 4 cities and 9 municipalities, has decided to launch a project to optimize the management of installations in order to reduce the level of losses. This project was carried out in two stages: (i) carrying out an audit intended to quantify the loss components and determine the causes and (ii) drawing up a plan of action for the gradual reduction of losses and setting up long term management methods.

The NRW audit was carried out in two phases. The preliminary audit, based on information available within the company (VIK SPLIT), enabled us to understand the operation of the company and to make an initial estimate of real and apparent losses. The detailed audit was based on studies in the field and the laboratory for a more accurate assessment of real and apparent loss components (component analysis).

VIK SPLIT manages the water distribution and sewage networks serving the cities of Split, Solin, Trogir, Kaštela and 9 other population centers, with a population of approximately 250.000 inhabitants, which corresponds to some 60.000 connections, whether these are active or not. The system include conveyance from the Jadro, 4 km from the center of Split, a supply and distribution network of 1.129 km, 56 reservoirs and 47 pumping stations. In 2011, 50.5 million cubic meters (94.25% coming from the Jadro) were injected into the network and the sales of water concerned were of 20.5 Million cubic meters, namely 30 million cubic meters of non-revenue water (60% of the volumes distributed).

The initial analyses concerning routine company documents revealed different causes of such a loss, the three most important of which are as follows:

- Excessive service pressure (more than 60 m) on most of the network, which increases the leakage rate, whatever the causes.
- Customers' meters which tend to be oversized; such oversizing may sometimes be justified by the development of seasonal activities but results in extensive under-metering for most of the year;



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- Large numbers of unregistered connections in areas where housing has developed illegally; that is, without prior authorization for land use.

In so far as the management of the company is concerned, the main findings of the audit are as follows:

- An organization and responsibilities not always clearly defined,
- The absence of written procedures in a wide range of fields of activities,
- Modern management tools available (system for managing recent subscribers, geographical information system, SCADA system, etc.). However, the use of such tools is not optimized,
- Recent improvements in terms of organizational and financial management with, particular, the creation of a fixed monthly tax on the size of the connection. Whilst this tax, which is perfectly justified, ensured that the accounts were balanced in 2011, it had no impact on the high rate of losses from the system and therefore, the sustainability of financial equilibrium achieved by its creation.

As part of the detailed audit, VIK SPLIT conducted surveys in the field and in the laboratory intended to quantify in more detail the different loss components and test procedures in order to reduce such losses:

- Measurement of flow rates at night and detection of leaks in 3 pilot sectors: Mravince, Firule and Gomilica, which correspond to various types of housing: these studies enabled us to assess the real level of losses in these sectors and the extent of invisible leaks.
- Census and audit of approximately one thousand subscribers living in these 3 pilot sectors: few anomalies (less than 2%) were found in terms of the management of customers but it would appear that the management of meters leads to significant losses, since 80% of the meters are class A and the rest class B.
- Plotting the consumption profiles of subscribers: these tests concerned some 60 connections of different sizes, from 15 to 80 mm. The existing meters were replaced by class C reference meters and flow rates and pressure were recorded every 2 seconds over a week. Figure Annex D- 4 shows the average user consumption profile. The study came to the conclusion that almost all the meters tested are oversized.



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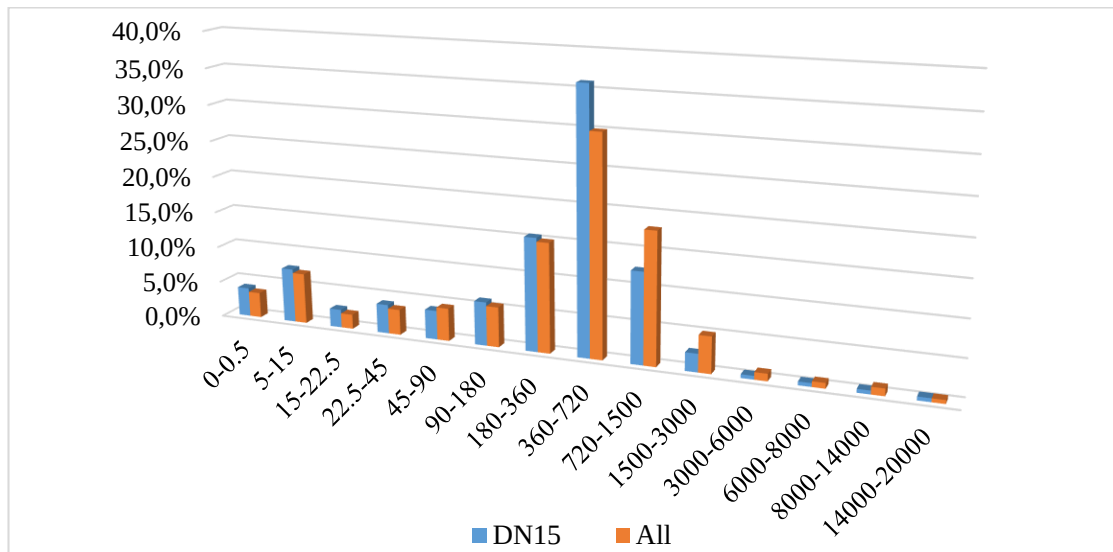


Figure Annex D- 4 Average Consumption Profile of Users in Split (15 mm and others)

- Plotting error curves for meters in service, for a sample of approx. one hundred meters of different sizes: In accordance with the regulations in force VIK SPLIT services and recalibrates all meters in service every 5 years. Repairs are carried out using spare parts. The tests showed that even if the repairs are well done, they will probably not last since the results of the precision tests of the meters in service are relatively random. The plan of action recommends the gradual replacement of all meters by correctly sized class C meters.
- Hydraulic model of the network and pressure measurement campaign: since VIK SPLIT does not have a hydraulic model of its network, a model was created for the audit as a basic tool for drawing up and monitoring the action plan. In order to calibrate the model, data provided by the SCADA system was supplemented by a pressure measurement campaign on almost 60 critical points of the network. The hydraulic model obtained confirms the very high pressure measured on the network, even at peak times and was very useful for drawing up the action plan to be implemented.

The results of the audit enabled to draw up the water balance of the system with an acceptable margin of error as shown in Table Annex D- 2.

The table and graph below (Table Annex D- 2 and Figure Annex D- 5) reveal two fundamental points: approximately 75% of losses are real (physical) losses (leakage) and 25% apparent (administrative) losses. But if these losses are valued at the marginal cost of production for real losses (approximately 0.37 Kn/m³) and at the average rate for apparent losses (approximately 4.62 Kn/m³), we note that it is the reduction of commercial losses that will have a significant impact on the financial situation of VIK SPLIT.

Nevertheless, the fight against real losses remains essential for limiting the volume of water taken from the Jadro, thereby delaying the new investments that will be needed to mobilize new resources and the future economic impact of taxes on withdrawals applicable as from 2015.



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For VIK, the reduction of 50% in real and apparent losses would result in an additional resource of 22 million Kuna a year, namely 23% of operational turnover (which was approximately 95 million Kuna in 2011, 1 EURO = 7.5586 Kuna).

Table Annex D- 2 Preliminary Water Balance of the System (Split, 2011)

System Input Volume 50,575,046 m³ Error Margin [+/-] 1,1%	Authorized Consumption 20,550,937 m³ Error Margin [+/-] 0.0%	Billed Authorized Consumption 20,539,998 m³	Billed Metered Consumption 20,539,998 m³	Revenue Water (%56) 20,539,998 m³
			Billed Unmetered Consumption 0 m³	
	Water Losses 30,024,109 m³ Error Margin [+/-] 1.8%	Unbilled Authorized Consumption 10,939 m³ Error Margin [+/-] 0.0%	Unbilled Metered Consumption 10,939 m³	Non-Revenue Water (NRW) (% 44) 30,035,048 m³ Error Margin [+/-] 1.8%
			Unbilled Unmetered Consumption 0 m³ Error Margin [+/-] 0.0%	
		Administrative Losses 7,531,961 m³ Error Margin [+/-] 15.5%	Unauthorized Consumption 3,650,000 m³ Error Margin [+/-] 25.0%	
			Customer Meter Inaccuracies and Data Handling Errors 3,881,961 m³ Error Margin [+/-] 18.9%	
	Physical Losses 22,492,148 m³ Error Margin [+/-] 5.7%			



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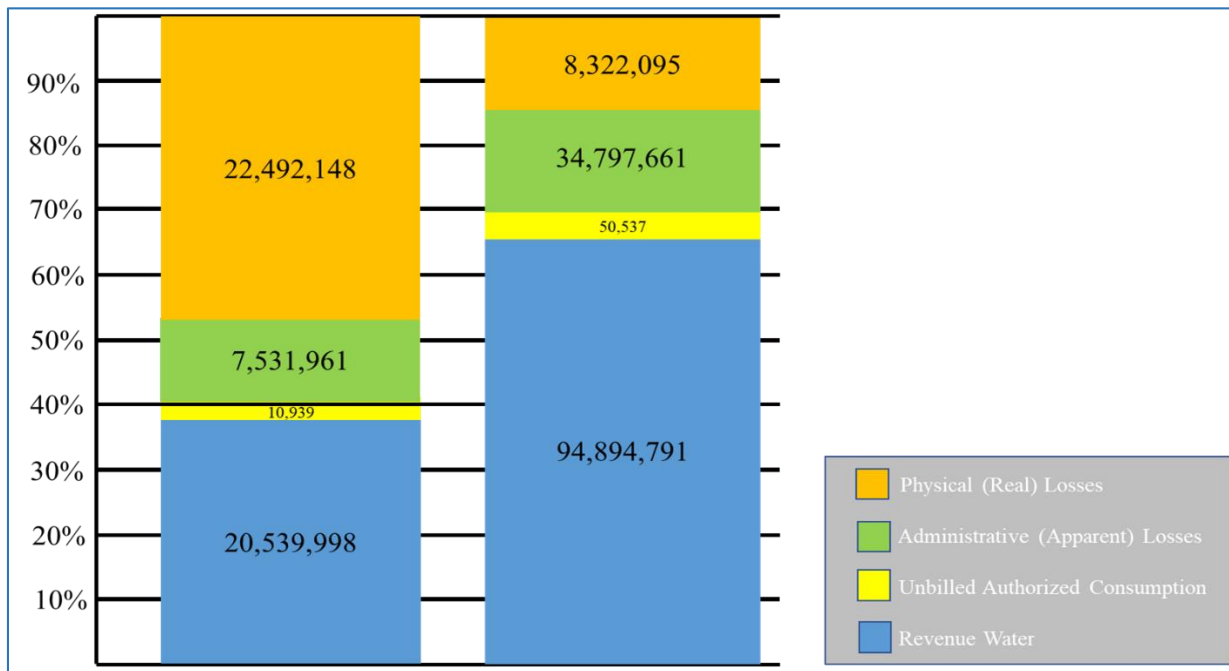


Figure Annex D- 5 Economical Water Balance of the System (Split, 2011)

The audit enabled to define and assess the main reasons for losses and to establish guidelines for the action plan to be drawn up in order to reduce such losses. The audit also revealed the organizational inadequacies responsible for the continuous increase in these losses since at least 2008 as shown in Figure Annex D- 6.

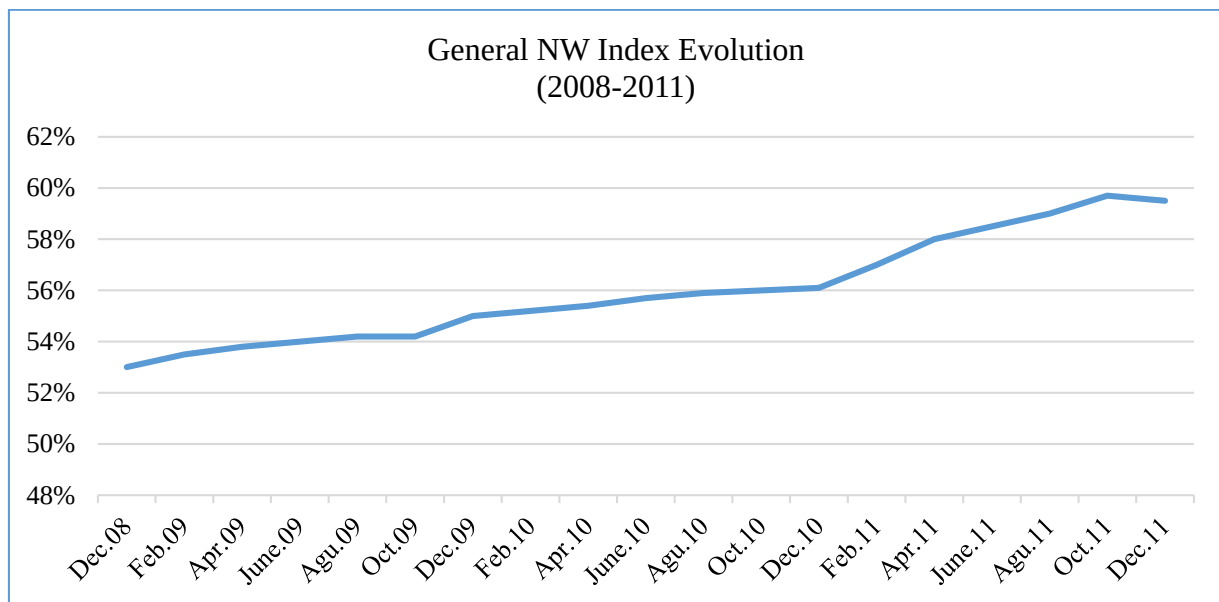


Figure Annex D- 6 Increase in Water Losses in Split Since 2008

In Figure Annex D- 7, the oval represents losses, illustrates the dynamics of losses and the philosophy behind the drafting of the plan of action, shown below. Each action on the



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components (real or apparent) is symbolized a two-way arrow. An action only affects the loss if its impact (centripetal) is greater than that of natural degradation (centrifugal). In other words, it leads to an increase in overall losses when no corrective action is taken (centrifugal arrows) and a reduction to the contrary (centripetal arrows). All components must also be taken into account since, if they are not, the impact of a given action could be cancelled out by the natural increase in loss in another field not taken into account. This shows that a complete plan of action must be based on a holistic approach.

The diagram also explains the increases in losses between 2008 and 2012, the period during which VIK SPLIT merely repaired those leaks reported without taking any significant corrective action in other fields.

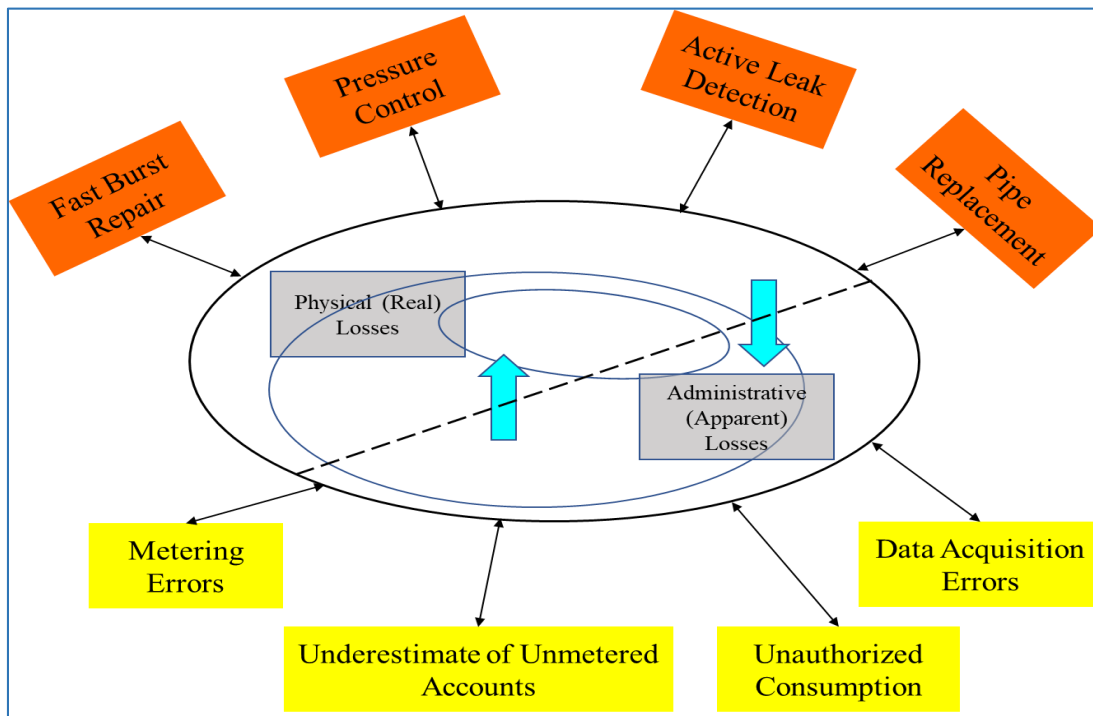


Figure Annex D- 7 The Dynamics of Water Losses

A plan of action to reduce water losses must set two main objectives: an economic target to reduce losses and the sustainability of the results obtained. For this, the plan of action may be classified into three main categories: the Operational Dimension, Project Management and Change Management.

The project to plan of action for the loss reduction is designed for 10 years. It is estimated that losses could be reduced from 59% (value of the index at the end of December 2011) to 43% after 5 years and to 36% after 10 years, by implementing the plan of action described below.

During the following years (after year 5), it is supposed that VIK SPLIT will go on with the NRW Reduction Plan in a sustainable way, by incorporating in its operation policy all the



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procedures developed by the project as well as by executing the investment plan that the project defines for the period 6 to 10 years.

The details of the objectives are indicated in the following table (Table Annex D- 3).

Table Annex D- 3 Objectives of the NRW Reduction Plan

NRW Reduction Plan Goals		Split Istok	Split Zapad	Solin	Kastela	Trogir	Zagora	VIK SPLIT
NRW Index	2011	59.4%	49.9%	68.7%	31.8%	63.1%	59.2%	59.4%
	2016	44.9%	35.5%	49.1%	45.9%	43.7%	36.0%	43.1%
	2021	37.4%	32.3%	42.8%	35.1%	36.4%	29.3%	36.3%

The plan of action is divided up into 28 sub-projects described briefly below.

The Operational Dimension

This category includes those essential actions intended to reduce and monitor real and apparent losses and also certain preliminary actions essential to the success of this program. The sub-projects concerned are as follows:

Additional surveys and preliminary action:

- Finalization of the macro-metering system of production and water transfer: the 0.2% of production still estimated must be fitted with meters, macro-metering must be completed on certain transfer lines, water levels in some tanks must be surveyed and, above all, a system for the general calibration of large meters, which is at present non-existent, must be installed.
- Updating the cadastre: the creation of the hydraulic model enabled us to measure the reliability of the GIS. The cadastre needs to be updated in order to complete any missing or incomplete information, diameters, materials, etc... With that updated information, it will be possible to improve the confidence of the hydraulic model.
- Carrying out additional hydraulic studies to refine the pressure studies and define the hydraulic sectors and DMA (District Metered Areas) in order to monitor service pressure.
- Complete the existing SCADA system by extending the area covered by the current SCADA system, including new macro-metering points, as well as a network of pressure measuring points at critical points of the network to monitor pressure.
- Assessment of unbilled authorized consumption, such as industrial water or fire hydrants: this does not concern the volumes billed or losses themselves; rather these volumes must be correctly assessed to be optimized by the operator and included in the water balance.
- Improvement of the recovery rate on bills issued: the reduction of apparent losses entails the billing of difficult customers (fraudsters and low-income families); these measures will not have the expected financial impact unless these new customers pay their bills



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regularly: it is therefore essential to find the most appropriate means to improve the recovery rate: otherwise, this would have a negative effect on the plan's success.

Reduction of Apparent Losses

- Program for the extensive replacement of the meters of small consumers: this concerns subscribers generally equipped with 15 and 20 mm meters. The existing meters must be replaced with class C 15 mm meters.
- Program for the selective replacement and resizing of the meters of major consumers, which are almost always oversized, in some cases, a preliminary survey plotting consumption profiles using data loggers may be necessary.
- Campaign for the detection and regularization of illegal connections, particularly in illegally occupied areas; the recent legislation (2011) should facilitate such regularization operations.
- Campaigns for the detection and regularization of fraud amongst registered customers.
- Project for the safeguarding of fire hydrants to minimize the risk of the theft of water and the resulting health risks for the population: this sub-project has technical and institutional components.

Reduction of Real Losses

- Active campaigns for the systematic search for leaks to detect and repair existing leaks, whether invisible or unreported; this project includes hardware acquisition and training components.
- Sectorization and active pressure monitoring: the completion of the hydraulic model will enable us to define a more or less detailed sectorization strategy for the distribution networks and make the first pressure management and control installations for each sector or DMA, within approximately two years.
- Campaigns for the selective search for leaks in each sector or DMA shall be drawn up on the basis of sub-projects and VIK statistics.
- Programs for the renovation of connections on the basis of pre-determined criteria
- Programs for the renovation of the distribution networks on the basis of pre-determined criteria

The Project Management

The management of an integrated project for the reduction of losses in a water utility company, such as VIK SPLIT, requires close coordination between all of the different entities of the company. Furthermore, it is essential to define progress and performance indicators so as to assess the project on an ongoing basis. The project therefore provides for the following:

- The creation of the NRW Steering Committee bringing together the main internal players,
- The creation of a NRW Unit responsible for the coordination of the project and certain specific tasks,



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- The establishment of a reporting system encompassing the different data processing systems within the company.
- The establishment of function and inspection procedure sheets. Each sub-project has progress and performance indicators.

The Sustainability of the Project and the Change Management

The Change Management is essential for the preservation and sustainability of the plan of action. The Change Management will bring about the reorganization of VIK SPLIT and result in well-defined projects:

- Improved customer management: customer management is currently the responsibility of the company's financial department. The creation of an independent customer services department is proposed.
- Accountability of Business Units (BU): the 6 existing BU only manage the technical aspects of the networks and maintenance of the fleet of meters. This project would give them increased responsibility as becoming the local player for the NRW Reduction Plan and aiming not only an efficient management of networks but also requiring being involved in the customer management.
- Development of the entity responsible for legal aspects and investigations into illegal consumption: this unit which was created by VIK SPLIT in 2011 will play a major role in the fight to reduce and control apparent losses due to the unauthorized use of water.
- Development of a complete communication program that will include internal communication in order to involve all the staff in the project, institutional communication with the main stakeholders of VIK SPLIT and user satisfaction surveys.
- Drawing up any missing or incomplete procedures, including the following in particular: customer contract, sizing of customers' meters, data processing and reporting, purchasing procedures, supervision of work, monitoring of pressures, surveillance of reservoirs, repair of leaks, DMA management, etc.
- Definition of the human resources required and implementation of the corresponding training programs; notably, the training and technical support of the NRW Unit staff and its contacts inside the Business Units for the implementation of modern loss reduction techniques.
- Technical assistance and coaching: in a project of this size, it is essential to have the benefit of the assistance of recognized experts and refer to international benchmarks: the Technical Assistance will include a coaching of the different levels of VIK SPLIT staff in the way to implement a sustainable Change Management.

Budget, Time Chart and Project Profitability

This project follows a diverse approach and complies with the specific characteristics of the general system and particularly the 6 Business Units managed by VIK SPLIT: for each one of them, a specific financial analysis has been done to evaluate the local impact of the project and/or to adjust the local strategy according to the results obtained.



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The overall cost of the project is estimated to be 319 Million Kuna (43 million Euros) over the period of 10 years. The rate of NRW shall go from 59% to 36%. The return-on-investment period is estimated to be less than 5 years.

Like many projects that aim to reduce and control losses, the VIK SPLIT loss reduction project has an excellent internal rate of return; but its implementation and success will require on-going effort in terms of management change and adapting to new and recently-developed, international methods.

D.1.3 Azerbaijan

Greater Baku and the Absheron peninsula are served by AzerSu, which manages all SuKanal (that manage water supply and sewerage services) and joint stock companies (JSCs) for provincial towns and other residential areas. A project was completed in the design of a leakage reduction program throughout the city of Baku to assist the water utility company AzerSu which was funded by FASED French fund in 2017.

The proposed methodology was designed by activities and steps:

Activity 1: Definition of the DMA and desk review

- Data collection and field surveys (population, inventory of network, connectivity, existing valves, etc...),
- Understanding of the network functioning and selection of a DMA,
- Mapping, if required,
- Preliminary design and installation of necessary hydraulic equipment (Valves, flowmeter(s), pressure probes).

Activity 2: Water balance and NRW strategy

- Bulk metering, flow and pressure measurement
- Campaign of consumption measurement on a representative sample of customers to both assess the consumption along the day, and estimate the water meters' inaccuracies,
- Determination of detailed water balance in accordance with IWA standards: assessment of physical & commercial losses,
- Leak detection and location surveys (Minimum Night Flow analysis, gas tracing),
- Leak detection and leak location trainings,
- Definition of NRW reduction program for the pilot zone.

Activity 3: NRW reduction program and beyond

- Identify the lessons learnt from the pilot DMA,
- Proposal for a more global NRW program, policy of replacement for water meters, leak detection and repair, pipe replacement.



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At the end of activity 1, Azersu decided that they would experiment the activities 2 and 3, on a subzone of Keshla zone called NZS, part of Nizami district as well.

For the first step, main actions under the FASEP consisted in:

- Investigation to locate all possible inlets/outlets;
- Trial trenches to check material, diameter and depth of existing pipes in the area;
- Pipe tracing of all pipes found in trial trenches;
- Update of network drawings (detection of pipe route from trial trench).

A special effort has been realized in order to complete the very weak mapping information on that zone. Once the investigations completed, the following actions (activity 2) have been carried out to monitor the flow supplying the pilot zone:

- Installation of flowmeters and valves at every known inlet of the zone (9 inlets equipped in the first stage);
- Construction of 2 inlet chambers (Green Space and Yavar Safarov);
- Installation of 4 permanent pressure measurements;
- Installation of GSM/GPRS data logger and configuration of an online platform to access data online;
- Pressure Zero Test to confirm DMA isolation;
- Flow and pressure monitoring of inlets for several weeks and data analysis;

Finally, to get better knowledge of the consumption within the pilot area, the third step consisted in the following actions:

- House to house survey of customers within the area;
- Reading of meter indexes whenever possible;
- Billing data collection and analysis (domestic and commercial) since January 2017;
- Flow and pressure monitoring of a sample of customers with portable test benches, including customers without meter, public fountain, etc.;
- Calculation of monthly and daily values per category of customer.

All the actions listed above allowed us to establish an initial NRW assessment of NZS (the pilot zone) as well as to estimate the breakdown between real and apparent losses.

The result of 76% NRW (in March 2018) called for immediate implementation of a water loss reduction action plan. Further, the analysis shows a majority of real losses (60% of the inlet volume) which can be leaks on distribution mains, service connections (including illegal connections), or overflow of tanks installed upstream the meters.



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The action plan proposed to reduce the NRW level, as explained previously, had focused mostly on the reduction on the physical losses. The following actions, after discussion with Azersu, have been implemented at the level of the pilot zone:

- Implementation of a sectorization by installing some new valves on the network (to create DMA, District Metered Area);
- Step testing in order to define which are the most leaking sectors;
- Leak location by acoustic method;
- Leak location by gas tracer;
- Leak repair by the teams of Nizami's district team;
- Pressure management, Azersu has reduced the inlet pressure into the pilot zone (4 bars in February 2018 to 2 bars in June 2018) but in July and the following months the pressure increased again.

The main lesson learned from the “experiment” carried out in NZS is that it is possible to quickly reduce NRW by implementing simple actions.

From March to June 2018, the average daily savings represent 566 m³/d. Extrapolated to one year, this represents more than 200,000 m³. The reduction of NRW water shows a decrease from 830 m³/d (March) to 270 m³/d (June) so a reduction of 70 % as seen in Figure Annex D-8.

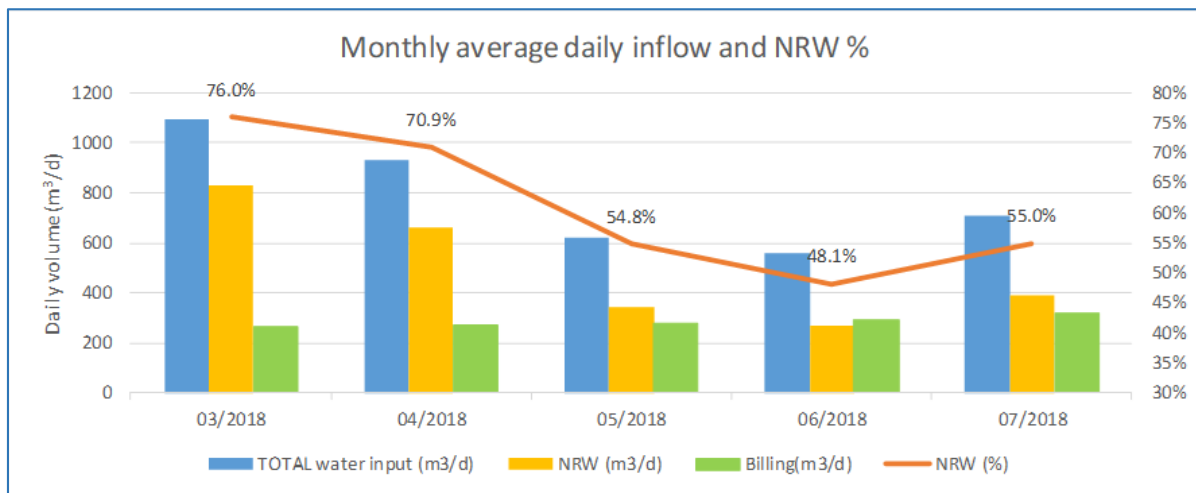


Figure Annex D- 8 NRW Ratio Change March 2018 – July 2018

Of course, the NRW ratio calculated on the pilot zone cannot be extrapolated to the whole Nizami District, let alone whole city of Baku.

The pilot zone shows some real positive results:

- Strong and immediate visible impact of leak repair and correction works at the railway (connections removed) mostly from April to May;



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- Additional reduction allowed by pressure reduction at the inlet;
- Spectacular result up to 70 % reduction in NRW in only few months by implementing simple actions.
- But the results, to be sustainable should be also accompany by:
- An active leak location (currently, only visible leaks are repaired);
- An improvement of speed and quality of repair must be optimized by using modern technics and equipment;
- The pressure variations must be controlled and are too important with an old network;
- The service connections are too long and often in poor conditions (PVC at low depth) and should be replaced.

As a synthesis for the short-term action plan (Quick wins), we suggested to Azersu in order to replicate that strategy to other Baku districts to:

- Improve the assets knowledge (location, condition, ...);
- Have Sustainable repairs (change methods and forbid repair by customers);
- Implement the pressure management with a constant pressure (or reduction at night to start);
- Realize leak location with gas tracer and/or acoustic correlation;
- Resize of large consumers' flowmeters.

And for a more long-term action plan, we propose to Azersu to:

- Implement a leak detection policy (for visible AND invisible leakages);
- Address apparent losses;
- Improve the meter accuracy by resizing or change of technology the domestic and industrial water meters when not appropriate;
- Locate the illegal connections;
- Take into account the dynamic of losses;
- To have a dedicated team for leak location in each district.

For all the activities, a training has also been performed with Azersu in order to achieve a good knowledge transfer.

D.1.4 Colombo

In scope of System rehabilitation for NRW Reduction in North of the Colombo City project, initiated by the NWSDB and financed by ADB, followed the Western Province Metropolitan Area Water Supply Master Plan Update and the aim was to achieve reduction of NRW level in Colombo down to 18%.





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For the execution of the Project, the Municipal Area of Colombo was divided into 4 areas called “packages”.

The Project was divided in 3 main components:

- 1) Pre-construction works;
- 2) Construction works;
- 3) Testing, commissioning of DMAs, and NRW Management.

Pre-construction works consisted mainly in investigations, hydraulic modelling and DMA Design and carried out within the first year of the Project in 2015. DMA boundaries and pipe sizing were optimized for better operation and energy savings. Each DMA was modelled separately and then a global model was assembled at the end of the Design period.

The first DMA meter was installed in November 2015 at the inlet of DMA 3 (Crow Island). This DMA can be considered as the pilot zone for the Project as it was the first permanently isolated DMA in CMC (Colombo Municipality Council) area.

Monthly NRW assessments were carried out in this DMA throughout 2016, which allowed to follow the impact of pipe replacement. Initial levels of NRW were indeed very high, from 50 to 60 %, and dropped to 22% in January 2017.

However, construction works continued in this DMA for most of 2016 (and also in 2017 with service connection replacement) and the “initial assessment” was only contractually accepted by NWSDB in January 2017, after completion of all additional construction works requested by PIU after completion of the Design phase.

NRW monthly assessments also started in DMA 1 in April 2017 and in DMA 4A in July 2017. Again, due to pending works, the contractual initial assessments are respectively June 2017 and January 2018. NRW assessments in DMAs 2A and 2B were expected to start shortly.

Flow and pressure measurements were also performed on a regular basis since the end of 2015 for domestic, commercial and large customers. Assessment of night usage and meter inaccuracies allowed to establish a preliminary water balance, giving a breakdown between real and apparent losses and supporting the actions proposed.

During this period, water utility company’s engineers and assistant engineers were trained to the use of many new equipment: metal detector, pipe tracer, loggable meters, data logger, insertion flowmeter, acoustic methods for leak location, gas tracer etc. Furthermore, DMA and NRW concepts were also introduced to Sierra’s team during this period.

Throughout 2016 and 2017, several Pressure Zero Tests and Step Tests were carried out, mostly in DMAs 1 and 3. However, NWSDB regularly requested additions to the construction works, which constantly delayed the date of completion and handing over of DMA for NRW management.

Leak location and repair activities started in 2016 with some acoustic location (some of it on new pipes which failed pressure testing) but most of it was carried out in 2017, with the



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use of gas tracer from February 2017 onwards. Use of gas tracer showed its efficiency, allowing to detect many small leaks which would have been undetectable by acoustic methods.

Two overseas training took place, in France and Cambodia. 14 NWSDB Officials participated in these overseas training. In addition, around 110 NWSDB staff received theoretical training (workshops in Colombo in 2015 and 2017) and more than 30 received on-the-job training to the use of equipment in Sri Lanka.

It is essential that NWSDB's O&M staff continued NRW management activities and properly maintains all new equipment installed under the Project as it is the only way for the NRW reduction to be sustainable.

All recommendations done throughout the Project can be found in our monthly reports. In this summary, we stress a few critical issues on:

- Pipe Replacement Approach;
- GIS Update;
- DMA commissioning, NRW assessment and reduction;

Pipe Replacement Approach

As repeated since the Project started, the initial contract only imposed systematic replacement of CI pipes due to their age and proven bad conditions. For PVC pipes however, decision should be jointly taken during NRW Management stage, based on proper justification. The second condition was not taken into consideration and large quantities of additional PVC were replaced in DMAs, before the DMAs were established and monitored (except for DMA 3 which was monitored by a flowmeter). Therefore, it is impossible to know if these pipes' replacement were justified since no baseline was established before their replacement. Total length of pipe to be laid according to DMA design was 106,8 km. Given the uncertainties, an increase of 5 to 10% would have been acceptable and understandable.

Out of the designed length, 95.6 km was PE. Since the progress of PE pipe laying was 88 km at the end of January 2018, it means that progress of pipe laying would be 92% if the quantities had remained the same. With this figure, pipe laying could be completed in 15 DMAs out of 16. But it is completed in only 5 DMAs.

Instead, planned length of PE pipe is 141 km (at the end of January 2018) and will still probably increase again as construction will start in new DMAs. Hence real progress of pipe laying is less than 62%, less than 6 months before the end of initial contract period.

To our knowledge, NWSDB has not provided the evidence that additional PVC to be replaced was presenting excessive leakage. No leak detection activities took place in these DMAs. Roads with bundle lines are minimal and, in most cases, only a few houses had bundle lines in parallel to main line (so they could be easily reconnected without complete replacement).



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In several occasions, when disconnecting replaced PVC pipes while monitoring the flow, we observed no impact, which means these pipes were not leaking. Pipe replacement should always be technically justified.

The main issue with the approach defended by NWSDB is that since most of the pipes are replaced, NRW levels after construction reach low levels and no further actions are requested. Then, no one at NWSDB learns how to react when faced with rising NRW and normal resources, in which case systematic pipe replacement is not an option anymore. We understand the NWSDB policy to have a fully renewed water networks; however, in our view, the main challenge of this NRW Project cannot be met by solely replacing 100% of existing pipes. Without proper training, when faced with rising NRW in a near future, O&M will not have the necessary capacities and skills to reduce it and maintain it at a low level. NRW section of RSC WC has more knowledge and capacities but extremely limited resources.

For remaining DMAs, it is essential to stop replacing all pipes before isolating the DMA and monitoring NRW levels in it. Of course, initial NRW levels will probably be higher but it is a necessary step to train O&M staff on how to further reduce it without only resorting to pipe replacement (it is not financially viable). Following the present approach will provide short term results but will lead to failure on the long term.

We see this project as a way, not only to reduce, but to teach how to reduce NRW and maintain it at a low level. Placing all efforts in pipe replacement without learning how to operate and maintain the network is in contradiction with the long-term operation of a water utility. More efforts should be put on installation of valves, GIS update, measurements, leak detection and training of O&M staff. It is the key of the success as already proved in many countries.

GIS Update

Proper GIS update is fundamental to the proper execution of the project. To make proper planning of pipe decommissioning requires updated drawings of existing and new assets. Several presentations were done on the importance of investigating existing pipes before disconnected them, to identify their connectivity and make sure that no old pipe stays charged (and therefore leaking).

All attributes should be properly included in the update, including technical information, date of laying/installing,

For service connections, account number (rather than address) should be systematically included as it allows to make a link with the billing database.

Proper GIS update starts with proper data collection on site. If any team does not properly collect and transfer information to the GIS team, the update cannot be done.

GIS team has reported that several works (including installation of valves, pipe connection or disconnection, service connection transfer...) were not properly recorded on site and transmitted to them. While the GIS team has sufficient knowledge to do all these updates, there seems to be mostly an issue of quality of data received from site and also understaffing of the team to make all the updates on a timely manner.



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DMA Commissioning, NRW Assessment And Reduction

It was recommended to isolate and monitor DMAs as soon as possible, even before completion of pipe laying. All DMA inflow meters which are on existing pipes could be installed in advance. Establishing a baseline is the keystone of a properly executed NRW project.

When the majority of NRW is reduced before the DMA is monitored, one can only speculate on which actions were the most efficient. By commissioning the DMA at early stages and closely monitoring it while actions are being implemented, it is easier to know which actions have been the most successful.

This of course requires the installation of several valves on the existing network after verification of existing valves. The experience obtained in the first DMAs shows that there are only a few existing valves but most the ones known to O&M are working properly once exposed (most of them are not equipped with surface boxes).

Several reports and presentations were done regarding the installation of valves on existing network. Latest issue faced in DMA 2B after installation of the flowmeter confirms the importance of this task.

After installation of DMA 2B flowmeter, analysis of flow measurements showed that the measured flow was partly (but not fully) supplying DMAs 1 and 4A. This is due to unknown connections within DMA 2B. In the absence of valves on existing network, and without tracing major pipes (several DI and CI pipes in parallel in Ferguson road), it will be very hard to find these connections.

In DMAs 1, 3 and 4A, good results were reached by replacing approximately 50 to 65% of the pipes. And no one knows what percentage was really necessary. Maybe, similar results could have been achieved by starting with DMA isolation and replacing only 10% of the pipes but wisely chosen. In this context, it seems unjustified to replace almost 100 % in DMAs 2A and 2B before being able to do any assessment of their present condition.

Even if NRW in future DMAs is less than 18% after initial assessment, training of NWSDB staff to maintain it and/or reduce it further is of utmost importance. A lot was done during these 3 years but to change habits in the long term requires continuous efforts.

In the near future, NWSDB staff will be faced with NRW increase and will have to react quickly with available tools and limited financial capacity.

Therefore, O&M and NRW section should be familiar with all the ranges of actions at their disposal, and not only pipe replacement.



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D.2 Pilot Study

D.2.1 General

In order to determine the steps recommended in the guideline and the measures to be implemented, a pilot field study was carried out in the TOKİ DB2 DMA area in Balıkesir city, Kepsut District center to diagnose the current situation within the scope of Task 1.

In order to determine the current situation, studies were carried out in this selected area in April 2022. Prior to these studies, the current water balance status of the selected area was revealed. In the field studies carried out afterwards, physical losses were eliminated and a new water balance was created.

D.2.2 General Assessment of Water Supply System Management

During the construction of the Kepsut district network, which was completed about 20 years ago, many sub-isolated areas were created and valves were placed. However, in the last period, the majority of the valves have been covered with asphalt and have become unusable. Although the reservoir levels are measured with SCADA, it has been determined that the reservoirs feed each other's boundaries due to the fact that the limit valves are open and the measurements made to date have been incorrect.

As in many parts of our country, the majority of physical losses in the selected region of Kepsut district were realized in service line connections. It was seen that 18 of the 20 physical losses found in the findings were in the service connections. In the determination of anti-leakage actions with the study, the importance of service connection controls that are more financially advantageous for WSA/WUD and will get fast results before the renewal of the whole network was revealed.

In general terms, when the studies carried out by BASKİ for the relevant region are evaluated, it is seen that the Administrative Losses have been significantly controlled. However, the continuation of the measures taken is especially important to prevent the increase of irregular connections.

In this process, the interest of the personnel belonging to the relevant Administration to the project was at a high level and they gave all the support to the project institutionally. They have participated with great interest in the training on the technique and use of leak detection equipment. The personnel, who had difficulty in finding the physical losses before the field study, became aware of the fact that the works carried out afterward are applicable, can be applied by themselves, and in this way, the economic return of reducing the losses.

D.2.3 Assessment of Water Balance Table

The stages of work carried out within the scope of Task 1 in the water balance determination studies are explained in detail in the above sections. The water balance component values determined by the study are given below with Table Annex D- 4. The stages of creating a Water Balance are given below in summary.



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- **Phase 1:** An isolated area was selected, the amount of water entering the system was determined and a water balance table was created using the available accrual data.
 - TOKİ DB2 reservoir feed area has been selected as the working area. TOKİ DB2 reservoir feed area was accepted as DMA because the service area was isolated and SCADA data were used.
 - The amount of water entering the system was determined by using the measurement values taken with SCADA for January 2022 at the TOKİ DB2 reservoir exit. As a result of the examination of the measurement values, it was determined that the average monthly flow rate of 11.42 l/h was given to the system. Water is not transmitted from TOKİ DB2 to any reservoir or pumping center. It distributes water from the reservoir to the network. Therefore, this use is a direct use of the service area. Monthly "**System Input**" is entered in the "**Water Balance**" table as 30,587.33 m³.
 - Detailed accrual data were used while performing the consumption analysis of the TOKİ DB2 line. February accrual data, the time of reading of the accruals and the days they belonged were taken into consideration and the first reading and last reading days were re-evaluated in order to use the raw accrual data for "**Water Balance**". As a result of the data study, it was determined that there were 1,477 subscribers in the selected DMA and the total consumption was 13,092.71 m³ per month ("**Authorized Consumption**").
 - Among these subscribers, there are 14 subscribers whose meter measurement is made but no invoice is accrued. The January 2022 consumption of these subscribers is calculated as 934.48 m³ ("**Unbilled Authorized Consumption**").
 - With the two data determined above, "**Billed Metered Consumption**" was determined as 12,158.23 m³ per month.
 - With the Phase 1 water balance studies, "**Non-Revenue Water (NRW)**" was determined as 18,429.10 m³ per month and "**Water Losses**" was determined as 17,494.62 m³ per month.
 - In the "**Authorized Consumption**" section, it was seen that BASKI did not make a comparison according to the reading reports and therefore "**Billed Unmetered Consumption**" did not exist. Calculations were made by assuming that this part was "zero" (0) in the "**Water Balance**" table and "**Billed Authorized Consumption**" was determined as 12,158.23 m³ per month.
- **Phase 2:** Subscribers who could not be read for various reasons at the time of reading and whose invoices could not be accrued were evaluated by the comparison method and entered into the water balance table.
 - When the accruals were examined, some meters could not be read at the time of reading for various reasons and therefore could not be invoiced. In order to make a detailed analysis of this situation, meter reading conditions were evaluated for each consumer type, and the unread meters were given a value over the average subscriber and the estimated "**Unbilled Unmetered Consumption**" was calculated. As a result of the evaluation, it was calculated that the estimated monthly



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- consumption of 1,748.14 m³ was "**Unbilled Unmetered Consumption**". This value has been updated by entering it in the "**Water Balance**" table.
- With the monthly detection of 1,748.81 m³ of "**Unbilled Authorized Consumption**", the "**Unbilled Authorized Consumption**" component in the "**Water Balance**" table has been revised to 2,671.62 m³ per month.
 - With the above findings, the "**Water Balance**" table has been revised to "**Authorized Consumption**" component to 14,841.52 m³/month and the "**Water Losses**" component to 15,745.81 m³/month.
 - With this study phase, while the physical loss in the "**Water Balance**" table was 17,494.62 m³ (57%), this value decreased to 15,745.81 m³ (51.5%) in the updated table.
- **Phase 3:** Administrative loss components were identified through determinations and data evaluation, and the water balance table was revised.
 - During the interviews, it was informed that BASKI carried out meter changes and controls in the field in 2021. Therefore, no additional field study has been carried out for meter losses. However, due to the nature of mechanical meters, it is generally accepted that there is a reading error of 2.5% (327.32 m³).
 - In the evaluation made within the scope of the study, it was determined that there was one irregular connection. It was determined that the leakage connection, which was detected on site, was used for garden irrigation and even wasted in the existing one. In the study, it was determined that approximately 0.25 l/s of water was used as illegal water. Considering this, it is calculated that there will be a monthly consumption of 669.60 m³ per month. In this context, it has been seen that BASKI has eliminated irregular links as much as possible with a comprehensive study. However, there is always the possibility that there are other connections that have not been identified but exist.
 - With these two components, the "**Administrative Losses**" were determined as a total monthly area of 996.92 m³.
 - With this study stage, the "**Physical Losses**" component was determined as 14,841.52 m³/month and entered into the "**Water Balance**" table.
 - Final Stage before Physical Loss Prevention: The final water balance table was created by recalculating the physical losses whose sub-components were determined.
 - After the Physical Loss Prevention Studies: After the study, it was calculated that 8,000 m³ leakage per month was eliminated. In this case, while the current calculated NRW is at the level of 60%, it is calculated that this value is reduced to approximately 44% and the water losses is reduced to 32% after the study.

Flow rate changes before and after physical leaks are eliminated can be seen from SCADA data in Figure Annex D- 9.



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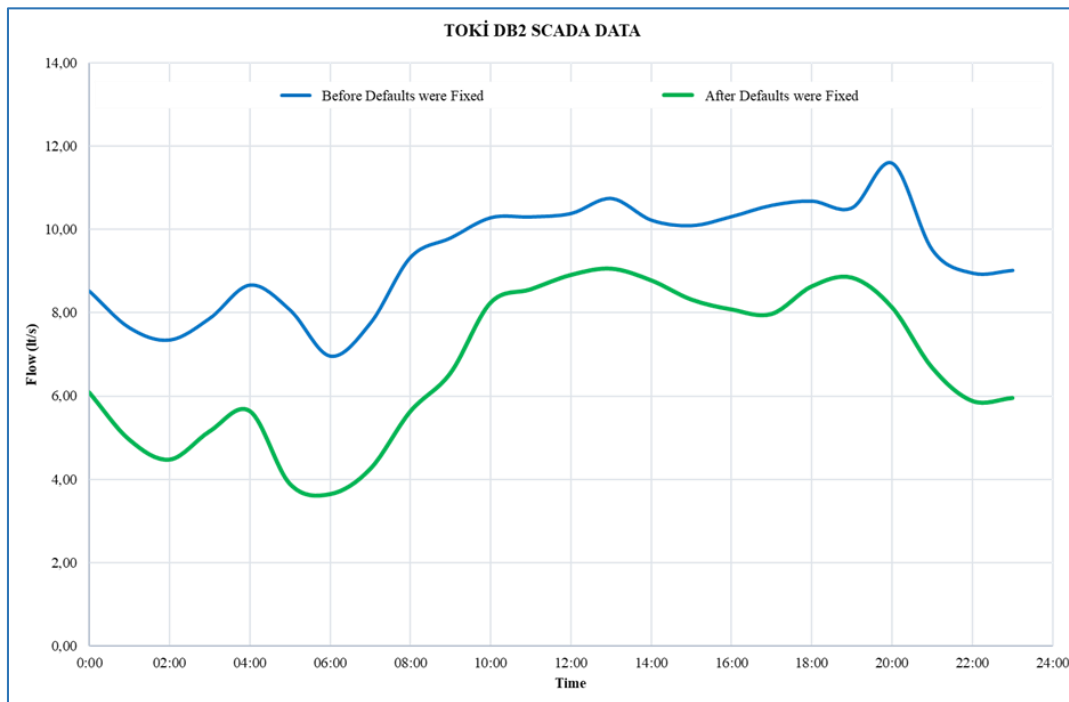


Figure Annex D- 9 SCADA Data Before and After Repair of Faults (l/s)

Table Annex D- 4 Water Balance Components Before and After Field Study (m³/month)

Water Balance Components	Before Physical Losses Control Studies					After Field Study	
	1st Phase)	2nd Phase	3rd Phase	Final		Final Balance	
	m ³ / month	m ³ / month	m ³ / month	m ³ / month	%	m ³ /month	%
System Input	30,587.33	30,587.33	30,587.33	30,587.33	-	21,748.61	-
Water Losses	17,494.62	15,745.81	15,745.81	15,745.81	51.5	6,918.76	31.8
Authorized Consumption	13,092.71	14,841.52	14,841.52	14,841.52	48.5	14,841.52	68.2
NRW	18,429.10	18,429.10	18,429.10	18,429.10	60.3	9,590.38	44.1
Authorized Consumption	12,158.23	12,158.23	12,158.23	12,158.23	39.7	12,158.23	55.9
Billed Authorized Consumption	12,158.23	12,158.23	12,158.23	12,158.23	39.7	12,158.23	56.0
Billed Metered Consumption		12,158.23	12,158.23	12,158.23	39.7	12,158.23	56.0
Billed Unmetered Consumption	0	0	0	0	-	0	-
Unbilled Authorized Consumption	934.48	2,683.29	2,683.29	2,683.29	8.8	2,683.29	12.3
Unbilled Metered Consumption	934.48	934.48	934.48	934.48	2.9	934.48	4.3
Unbilled Unmetered Consumption		1,748.81	1,748.81	1,748.81	5.7	1,748.81	8.0
Water Losses	17,494.62	15,745.81	15,745.81	15,745.81	51.5	6,907.09	31.8
Administrative Losses			996.92	996.92	3.3	996.92	4.6



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Water Balance Components	Before Physical Losses Control Studies					After Field Study	
	1st Phase)	2nd Phase	3rd Phase	Final		Final Balance	
	m ³ / month	m ³ / month	m ³ / month	m ³ / month	%	m ³ /month	%
Unauthorized Consumption			669.60	669.60	2.2	669.60	3.0
Meter Errors			327.32	327.32	1.1	327.32	1.6
Physical Losses			14,748.89	14,748.89	48.2	5,910.17	27.2
Loss-Leakages Occurring in Supply and Distribution Lines and Service Connections				14,748.89	48.2	5,910.17	27.2
Leakage and Overflows in Water Storage Tanks				0	-	0	-

D.2.3.1 Performance Indicators for Project Area

In order to calculate the ILI indicator proposed by IWA, the "**Unavoidable Annual Physical Loss**" must first be known. The water supply system specifications in the TOKİ DB2 DMA area and the calculated "**Unavoidable Annual Real Losses**" value are given in the Table Annex D- 5 below.

Table Annex D- 5 Field Study Data

Field Study Data and UARL Calculation		
Lm: Length of mains including all pipeline, except service pipes (km)		15,475
Nc: Number of service connections (number)		1,447
Lp: Length of private service pie between property boundary and customer revenue meter (km)		5.79
P: Average operating Pressure (AZP) (m)		38.00
UARL*: Unavoidable Annual Real Losses	l/day	60,072.30
	m ³ /month	1,802.17

$$* UARL \left(\frac{L}{day} \right) = (18 * L_m + 0.8 * N_c + 25 * L_p) * P$$

The physical losses present in the DMA area before the study and the ILI indicators of the physical losses after the study are given in the table below. The results of the EU Reference Document "*Good Practices on Leakage Management*" performance indicator of water losses per network length and water losses per connection are also shared with Table Annex D- 6 below.



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Table Annex D- 6 ILI Calculation Before and After Leakage Control Study

Stage of Field Study	CARL (m ³ /month)	ILI	World Bank Grouping	Loss Per Unit Length	Physical (real) losses per connection	Difference %
Before Field Study	14,748.89	8.19	C	953.08	10.20	59.88
After Field Study	5,910.17	3.27	A	382.36	4.09	

As can be seen in Table Annex D- 6, Kepsut district center was in the C group according to World Bank Grouping (Table 5) for physical losses in the TOKİ DB2 DMA area before the field studies, but after the field studies, it was increased to the A group.

When the amount of water losses per network length and water losses per connection is examined, 59.88% physical loss compensation has been realized and the amount of water withdrawn from the system has been reduced from 30,587.33 m³ to 21,748.61 m³ per month. With this study, an important step has been taken in the protection of water resources.

The effect of physical leak elimination completed during field studies on energy consumption was also examined. The monthly total energy consumption amounts of the periods before, during and after the fieldwork that are provided by BASKİ are given in Figure Annex D- 10. While the total energy consumption was 13,243.95 kWh before the studies, it was seen that this value was 12,041.09 kWh in the period after the field studies, as a result of the decrease in the amount of water entering the system and physical leak elimination. As a result, it was determined that there was a 10% decrease in monthly energy consumption with the studies carried out for only one month period, and this revealed that the studies carried out also have a high potential in terms of energy efficiency and are of great importance.

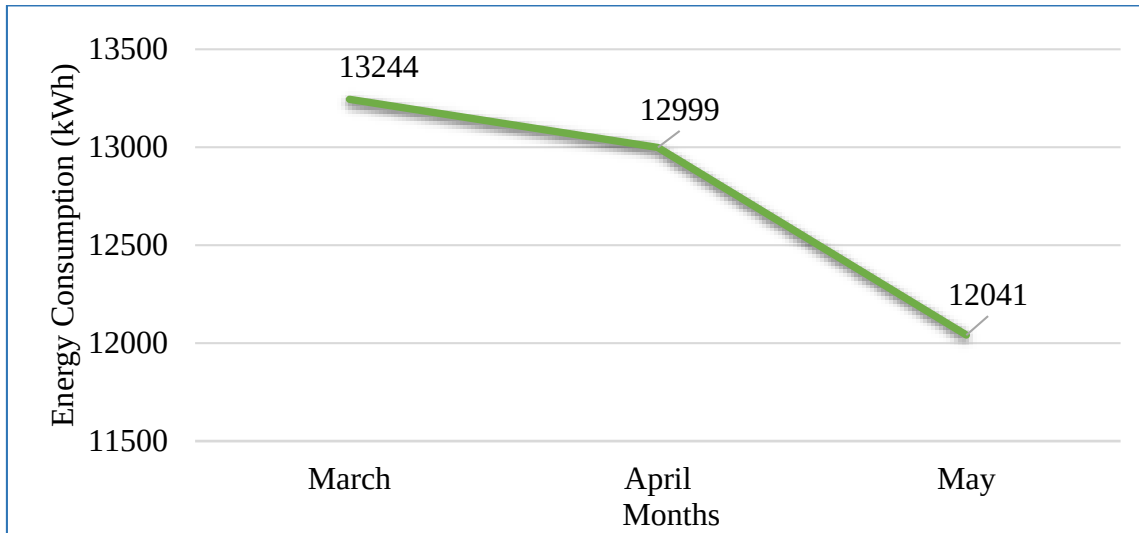


Figure Annex D- 10 Energy Consumption Change Before and After Leakage Elimination



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D.3 Workshops

D.3.1 First Workshop – Inception Phase

Within the scope of the NRW Management Guideline preparation project, the first workshop was held on the World Water Day on March 22, 2022 at Ankara ILBANK Macunköy Facilities.

The invitation for this first workshop was sent to the WSAs of the 30 MMs in Türkiye. A total of 23 MM's WSA representatives participated in this workshop, out of 30 MMs who were invited.



Figure Annex D- 11 Participants at the First Workshop

The workshop began with the opening speeches of ILBANK and World Bank representatives. The main objectives and outputs of the SCP Project were mentioned and the importance of the NRW Management Guideline was explained with a presentation. Afterwards, preparation of the NRW Management Guideline Project's scope, main objectives and outputs were explained to the participants with a presentation made by the Project Manager, Ms. Şule Mansur.

In the workshop, presentations were made on both national and international NRW management practices/projects and technologies used worldwide. The Izmit NRW management project, which was recently completed in Türkiye, was presented at the workshop. The approach of the project and the equipment used were explained. After the success of the project was explained to the attendees a question and answer session was held at the end of the presentation. New technologies used in NRW management practices in the world including satellite based technologies and radars were also presented at the workshop.

With this workshop, a questionnaire was distributed to the participants to see the current situation of the WSAs and to emphasize the importance of NRW management by showing the



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results. In the second half of the workshop, the current situation of NRW management was evaluated according to the feedback received, by going through the questionnaire distributed to the participants. Primary evaluation of the results showed that some of the municipalities needed more time and data to fill out the questionnaire. So, it was decided that distributing the questionnaire after the workshop to the WSAs would result in healthier results.

The workshop ended with the closing speech of ILBANK representative Ms. Zübeyde Gönül Ejderoğlu.

D.3.2 Second Workshop – Current Status Analysis Phase

The second workshop completed within the scope of the Task 1 – Analysis of the Current Situation and Field Studies, was held in Antalya between 15-16 June 2022. The second workshop was combined with the ILBANK's training program about the *Best Practice Examples*, which included 3 different projects carried out by ILBANK within the scope of SCP. Same as in the first workshop, 30 MM WSA representatives were invited to this training and workshop for the NRW Management Guideline Project.



Figure Annex D- 12 Participants at the Second Workshop and Best Practice Examples Training

The agenda created for the first day, 15 June 2022 within the scope of *Best Practice Examples* training was as follows:

- Keynote Speeches
- Project Description, Purpose and Features
- Introducing the NRW Management Guideline
- Field Study Presentation
- Best Practices Panel (Presentation)



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- Best Practices Panel (Discussion and Q&A)
- Information on the Method and Scope of the Second Workshop (Day 2)
- Closing Speech

The first day started with the opening speech of ILBANK on 15th of June. In order to inform the WSA representatives who could not attend the first workshop, the definition, purpose and scope of the project were explained by the Project Manager Ms. Şule Mansur with a short presentation. Then the structure and content of the NRW Management Guideline were shared with all the participants.



Figure Annex D- 13 Ms. Şule Mansur Presenting the NRW Guideline Preparation

Afterwards, the field studies completed within the scope of Task 1 to analyze the current status in a pilot area selected within SCP Component A cities were presented. The presentation included the selection methodology developed to identify the municipality that needs the most urgent NRW management response among the SCP Component A cities, and the outputs of the field studies. The outputs of the field studies were presented in order to show the WSA representatives that the Guideline is going to be based on the actual data and facts collected from the field works and that the approach the Guideline suggests to manage NRW is applicable on site.

In accordance with the main theme of the *Good Practice Examples* training program, two NRW management projects in Colombo and Baku were presented by the Infrastructure Specialist of the Project, Mr. Christian Moncet, who participated from France.

In the second half of the day, there was a panel where questions collected online during the presentations from the participants were answered. Under the moderatorship of Prof. Dr. Erdem Görgün, questions from participating WSA representatives were conveyed to Ms. Şule Mansur and Mr. Christian Moncet.



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After the panel where the questions were answered, a short presentation was made on what will be done within the scope of the Second Workshop, which will take place on the second day of the event on June 16th.

In the last day of the *Best Practice Examples* training program on 16 June 2022 was reserved for the Second Workshop of the NRW management guideline project. In this workshop, a group study was carried out aiming the active participation of WSA representatives.

The second workshop started with a presentation by Ms. Şule Mansur about the group study. In the group study, the aim was to receive direct feedback from the participants on four different streamlines created to be included in the Guideline to analyze the current status and take actions. These streamlines included current status analysis for the following:

1. Estimation of Meter Errors,
2. Estimation of Water Theft (Administrated Loss - Unauthorized Consumption),
3. Estimation of Leak Detection.

The fourth streamline was an action streamline on Increase the Speed of Malfunction Identification and Repair Quality. After the presentation, 4 teams were randomly formed by using an online system and the participants were scattered around the tables and were assigned one streamline.

Then all participants in these teams reviewed the draft streamlines and brainstormed on them to create a final version of these streamlines which meets their needs at the end of the study. When the was concluded, 1 (one) representative selected from each team shared their comments on the streamlines with all the other participants. This activity allowed every participant to share their knowledge and experience on the topic and resulted in very successful results.

D.3.3 Third Workshop – The Guideline Presentation

Within the scope of the GGS Guideline Preparation Project, the 3rd Workshop was held on 17 August 2022 at Ankara İLBANK Macunköy Social Facilities.

A total of 20 MM WSA representatives participated in this workshop, to which participants from the Water and Sewerage Units of 30 Metropolitan Municipalities were invited.

The agenda of the workshop is as follows:

- Opening Speeches
- Guidelinee Introduction: Guideline Purpose, Content, Action Areas Introduction, Current Situation Detection, Performance Indicators and Actions
- Sharing the Results of Survey 1 and Survey 2

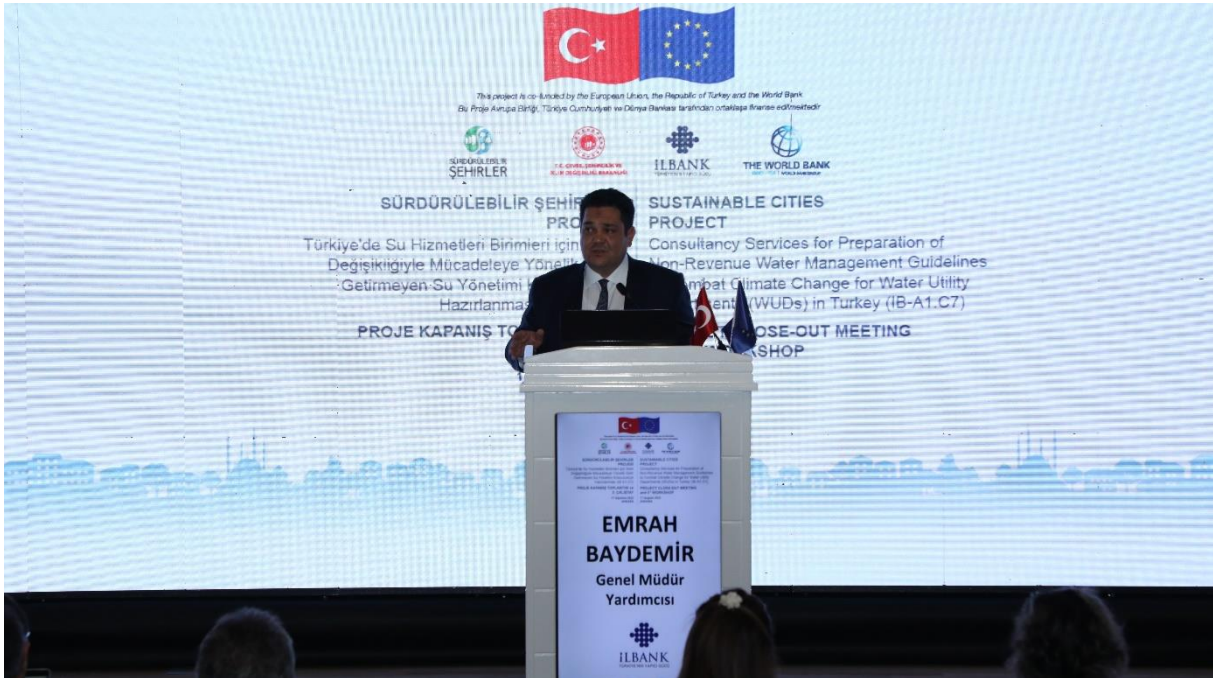


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- Panel for Introduction of Current and Potential Financing Instruments for NRW Management Projects
- Evaluation of Financing Instruments by Panelists
- Panel Q&A
- Closing Remarks



Figure Annex D- 14 Participants at the Third Workshop





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Figure Annex D- 15 Opening Speech by Mr. Emrah Baydemir, Deputy General Manager of ILBANK

In the second half of the day, a panel discussion was held during the presentations where the questions received from the participants online were answered. Under the moderation of Prof. Dr. Erdem Görgün, Potential Financing Instruments were discussed with the participants listed below.

- İLBANK – Mr. Emrah Baydemir (Deputy General Manager)
- Strategy and Budget Directorate – Ms. Feyza Eldeniz (Head of Department)
- EU Delegation to Turkey – Ms. Elif Ceyda Torcu Özden (Environment and Sustainable Development Sector Manager)
- World Bank – Ms. Canan Yıldız Uz (Senior Water and Wastewater Specialist)



Figure Annex D- 16 GGS Management Projects Existing and Potential Financing Tools Presentation Panel



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ANNEX E- NRW MANAGEMENT QUESTIONNAIRES



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E. NRW MANAGEMENT QUESTIONNAIRES

E.1 Questionnaire 1

Questionnaire 1



Anket_1_GGS
Projesi_BB_GGS Deđer

E.2 Questionnaire 2

Questionnaire 2



Anket_2_BB_Performa
ns Deđerlendirmesi.xl

