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Guidelines for water loss reduction | Summary

A focus on pressure management



On behalf of
Federal Ministry
for Economic Cooperation
and Development



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Pressure management is a best practice instrument for reducing water losses. In 2009, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and VAG-Armaturen GmbH formed a development partnership to introduce, promote and support pressure management in selected developing and emerging countries. Internationally accepted guidelines for reducing water losses from water distribution networks were developed to share knowledge with interested stakeholders worldwide.

The need for water loss reduction (WLR)

Water losses – A global problem

The sustainable and integrated management of water resources is one of the most challenging global issues. Fresh water is a limited, sometimes even scarce, resource and rapid global changes such as population growth, economic development, migration and urbanisation are placing new strains on water resources and on the infrastructure that supplies drinking water to citizens, businesses, industries and institutions. [1] Ensuring **safe, sufficient and affordable water supply** is becoming an ever more **pressing issue** for politicians and water professionals.

An aggravating factor in developing and transition countries, in particular, **is the huge amount of water being lost** through leaks in water distribution networks, referred to as physical or real water losses, and the volumes of

water distributed without being invoiced, referred to as apparent water losses. The sum of real and apparent water losses and unbilled authorised consumption constitutes a water distribution network's non-revenue water (NRW) (Table 1). In 2006, the World Bank estimated that an average of **40 - 50% of the water produced** in developing countries is non-revenue water. [2]

Developing countries are estimated to have an annual NRW volume of 27 billion m³ according to calculations drawn up by the World Bank based on an average of 35% of the system input water being lost. This represents approximately USD 6 billion in revenue that water utilities lose every year. [2]

Table 1 Standard terminology for the water balance according to the IWA [3]

System input volume Q_i	Authorised consumption Q_A	Billed authorised consumption Q_{BA}	Billed water exported	Revenue water	
			Billed metered consumption		
			Billed unmetered consumption		
	Water losses Q_L	Unbilled authorised consumption Q_{UA}	Apparent losses Q_{AL}	Unbilled metered consumption	Non-revenue water
				Unbilled unmetered consumption	
		Real losses Q_{RL}	Unauthorised consumption		
			Customer meter inaccuracies and data handling errors		
			Leakage on transmission and distribution mains		
			Leakage and overflows at storage tanks		
			Leakage on service connections up to point of customer meter		

The role of water loss reduction and pressure management

Water loss reduction (WLR) in general and **pressure management** in particular could play a significant role in improving this situation. For instance, halving the amount of lost water mentioned above would yield enough water to supply an additional 90 million people.

[1] **Pressure management reduces real losses** since decreasing pressure directly diminishes leakage from pipelines and household connections.

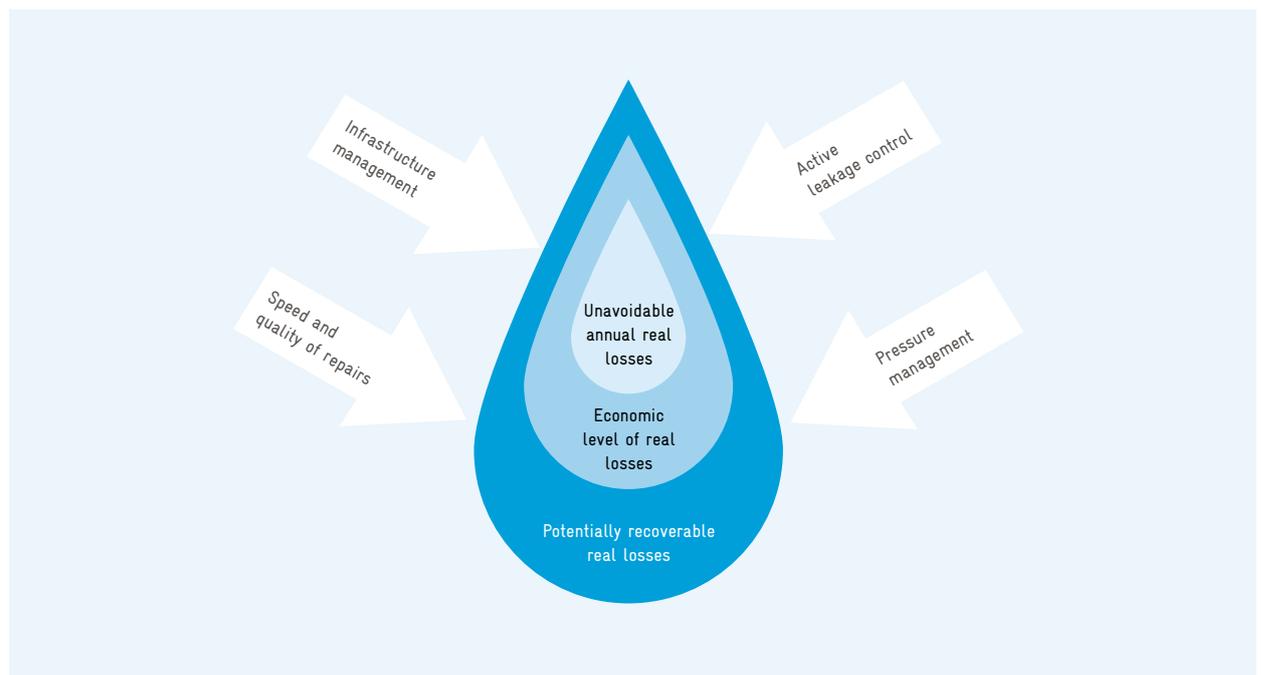
WLR often represents an **efficient alternative** to exploiting **new resources**, which frequently involves cost-intensive measures, such as new dams, deep wells, seawater desalination or even transferring water from one river basin to another. Therefore, **water loss reduction** and **pressure management contribute** to sustainable and **integrated water resources management (IWRM)**.

Many strategies and methods for reducing water losses have been developed over the past two decades. Nevertheless, **many water utilities** around the world have yet to implement **sustainable water loss reduction strategies** despite their obvious benefits.

A sound **WLR strategy** consists of an initial **situational analysis** to assess and visualise **non-revenue water** in accordance with the **water balance** of the *International Water Association (IWA)* in which geographical-based information systems play a crucial role. In a second step, clear **objectives and targets** need to be formulated for the water distribution network. Finally, an **action plan** has to be devised for the implementation phase.

The *IWA Water Loss Task Force* defined four principal methods for combating **real water losses** (*Figure 1*): (i) **pressure management**, (ii) active leak control, (iii) speed and quality of repairs and (iv) infrastructure management. A single method or a combination of different methods will constitute the most efficient and economic instrument for WLR depending on the local situation. [4]

Figure 1 The four principal methods against real water losses according to the IWA Water Loss Task Force



Pressure management

Pressure management can be defined as the “practice of managing distribution network pressures to the optimum levels of service while ensuring sufficient and efficient supply to legitimate uses”. [5]

Benefits of pressure management

Pressure management helps to reduce real water losses by decreasing background, reported and unreported leakage. Unnecessary or excess pressure is reduced, and strong pressure fluctuations are eliminated. This, in turn, decreases pipe breaks and bursts in water distribution networks, thus helping to extend the life of the network.

Table 2 summarises the benefits of pressure management for water utilities, customers and water resource protection. Pressure management can be an **immediate and cost-effective solution** even at low initial pressures.

Table 3 shows the savings reached in four South African pressure management installations. Payback times are thus normally just a few months.



Photo: © T. Baier, 2008

Table 2 Benefits of pressure management [6]

Benefits	Description
Water resources	Reduced consumption and thus diminished water stress, as well as additional exploitation costs
	Lower flow rates from leaks and bursts
Water utility	Lower repair costs for mains and services
	Deferred replacements and extended asset life
	Reduced cost of active leakage control
	Reduced frequency of bursts and leaks
Customer	More stable supply
	Fewer problems for customer plumbing and appliances
	Mitigation of health risks

Table 3 Summary of savings from four Cape Town installations [7]

Area	Water savings (m ³ /year)	Construction costs (USD)	Value of savings (USD/year)
Khayelitsha	9.0 million	335,000 (in 2001)	3,352,000
Mfuleni	0.4 million	212,000 (in 2007)	170,000
Gugulethu	1.6 million	188,000 (in 2008)	603,000
Mitchells Plain	2.4 million	967,000 (in 2009)	904,000
Total	13.4 million m³/year	USD 1,702 million	USD 5,029 million/year (± 600,000)

Installing a pressure management system

There is no standard solution when it comes to pressure management. Every distribution network has its own characteristics and has to be studied individually to develop an optimal solution that takes into account technical, financial, environmental and social aspects. However, **pressure management is likely to be economically efficient if two out the six criteria listed below apply to your system:**

1. Real water losses > 15%
2. Losses > 200 l/day/connection
3. Pressure amplitude > 10 m (1 bar)
4. Frequent pipe bursts
5. Average age of pipelines > 15 years
6. Household connections > 2,000

Installing a pressure management system involves the following steps: (i) **selecting a suitable pressure management area** and separating it from neighbouring zones; (ii) **installing a pressure reduction valve (PRV)**, a pressure sensor and a **flow meter** at the inlet point to the

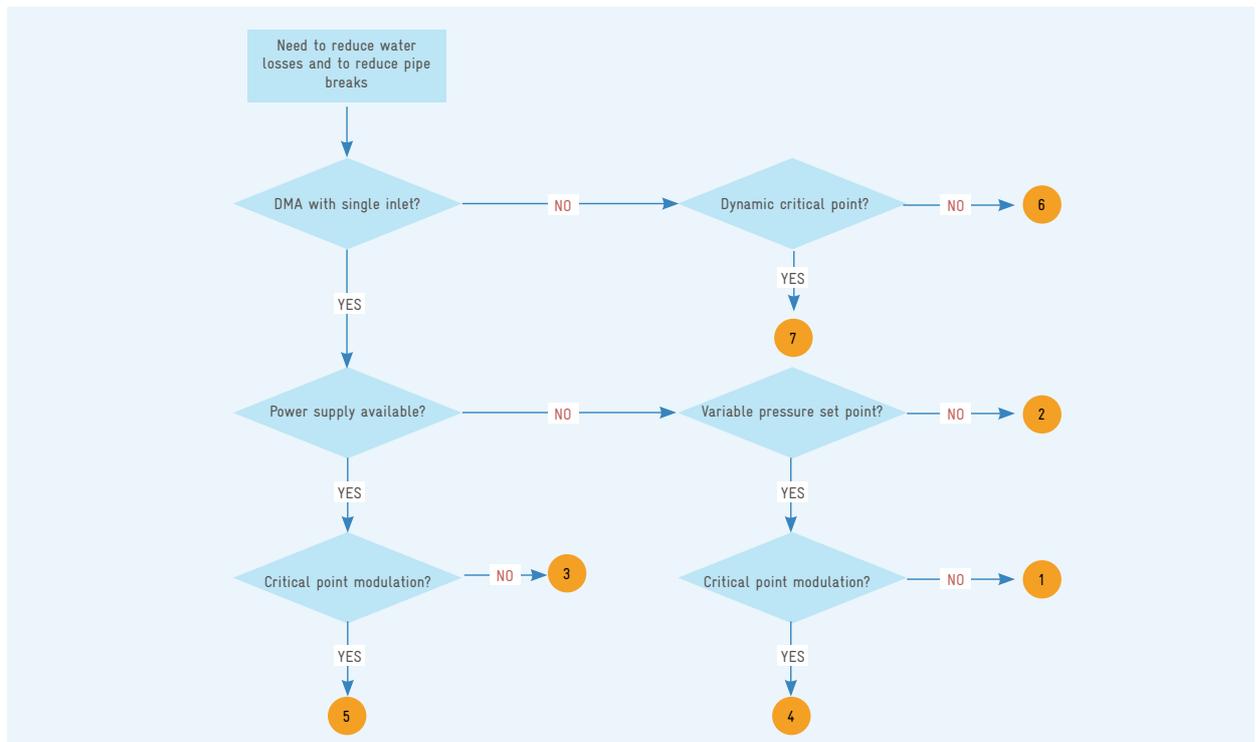
pressure management area. Additional technology is needed for advanced pressure management systems.

Pressure management solutions typically involve modulating pressure by operating valves at specific local points, thus influencing water flow. A flow chart, as shown in [Figure 2](#), can be used in combination with [Table 4](#) to select the most appropriate solution:

Table 4 Explanation of the different use cases for Figure 2

Use case	Pressure management solution
1	Local point modulation, diaphragm valve with fixed outlet pressure
2	Local point modulation, diaphragm valve with time or flow modulation
3	Local point modulation, plunger valve with time or flow-based modulation
4	Critical point modulation, diaphragm valve with time or flow-based modulation
5	Critical point modulation, plunger valve with time or flow modulation
6	Multiple inlet
7	Multiple inlet, dynamic DMA

Figure 2 Decision support diagram for the selection of the optimum pressure management solution



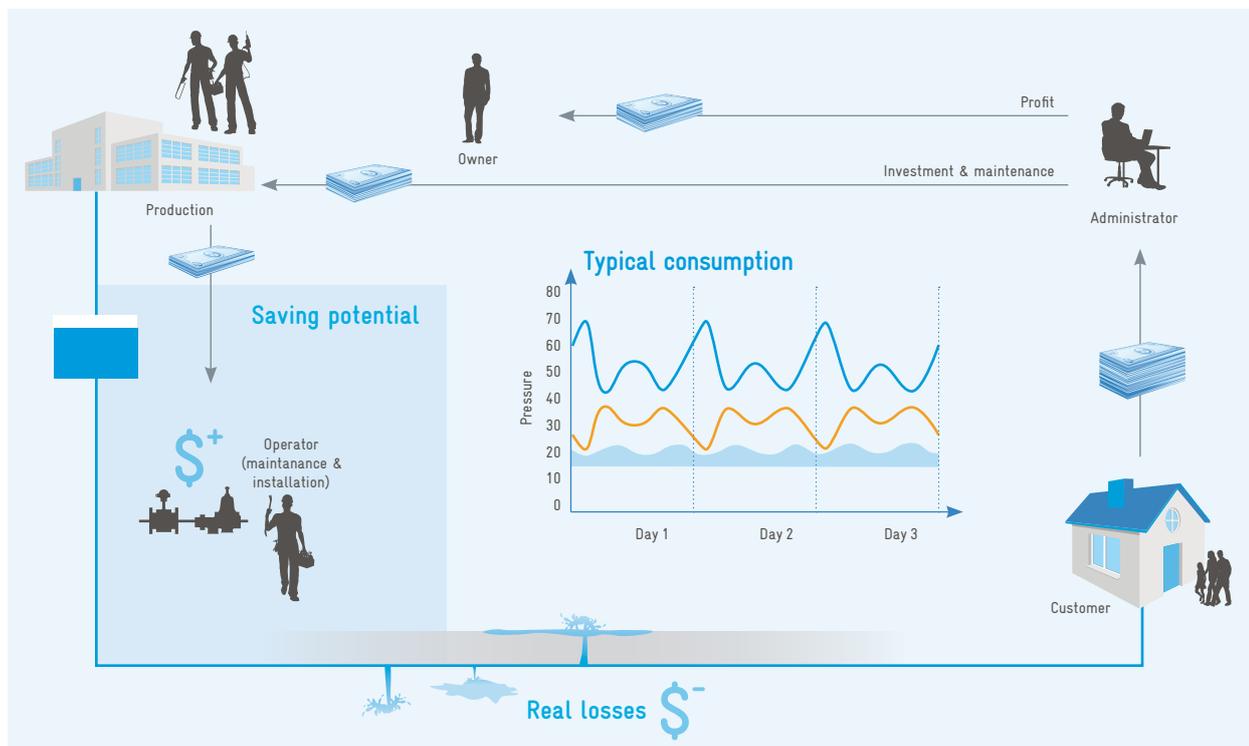
Political and financial framework for water loss reduction and pressure management

Sustainable WLR, including pressure management, is complex and involves many aspects. Effective and efficient water management requires that political, financial and managerial aspects be considered when promoting technical solutions. **Crucial factors for the success of WLR** include water laws and policies, the existence of WLR strategies, the structure of water utilities including private sector commitment and existing knowledge and information, e.g. about the water distribution network. **Incentives and/or financial instruments** for implementing WLR can advocate strongly for WLR. Moreover, **stakeholders** themselves and their structural settings can

influence the progress of WLR by promoting or inhibiting WLR. The different stakeholders that may profit from WLR by means of pressure management include producers, owners, operators and customers (Figure 3). These **stakeholders** have to be **considered and addressed** when developing **WLR and pressure management action plans**.

Many countries already have water strategies dealing with water loss reduction. However, WLR implementation often requires **new forms of sharing responsibilities** and changes to traditional consumer behaviour. Long-term WLR will only be successful if a water utility's **top management is fully committed**.

Figure 3 Stakeholders profiting from WLR by pressure management



Guidelines for water loss reduction

The *guidelines for WLR with a focus on pressure management* have been developed as an incentive and guide to tapping the enormous hidden potential of WLR and pressure management. The explanations provided in the technical manual are written to provide the reader with rapid insight into the specific field of WLR.

The guidelines consist of:

- **A summary for decision makers:** geared towards decision-makers and stakeholders at the national level as well as water utility managers.
- **A technical manual:** geared towards utilities' planning and design departments and operating staff, including supplementary materials to facilitate practical application.
- **Training materials:** geared towards engineers and technicians involved in pressure management, in particular.

Contents of the technical manual

Chapters 1 and 2: Introduction to the guidelines and to water loss reduction

The purpose of these guidelines for capacity development on WLR is explained at the beginning of the technical manual. This explanation is followed by a general introduction to WLR and to pressure management as one of the central instruments for reducing losses from pipe bursts and leaks.

Chapter 3: Understanding water losses

Understanding the different types of water losses, their causes and effects is the cornerstone to successful WLR. The terminology of the standardised IWA water balance is presented as a mean of distinguishing between and quantifying the different components of real and apparent losses. Basic leakage hydraulics is explained. Furthermore, the reasons for real and apparent losses are depicted, and the negative impacts of leakage are categorised and described. Economic, technical, social and environmental impacts are considered.

Chapter 4: Developing a technical strategy for water loss reduction

When developing a technical **strategy for WLR**, the status of water losses from a water distribution network needs to be assessed, adequate WLR targets have to be formulated and the necessary and most appropriate steps should be drafted in a custom-made WLR action plan. Different methods of setting up a detailed **water balance**, which forms the basis for quantifying the actual level of NRW in a distribution network, are explained. A water balance should combine desktop studies with data from field research. Hence, a variety of field methods are presented for assessing and quantifying real water losses from transmission and distribution pipes as well as from storage tanks. Key data on real and apparent losses explain how **performance indicators** can be calculated and how to use them to assess potential savings and to set **WLR targets**. Finally, the major steps for setting up an **action plan** are outlined. Here it is essential to have proper knowledge of the types and the scale of water losses in a water supply system before trying to implement WLR measures.



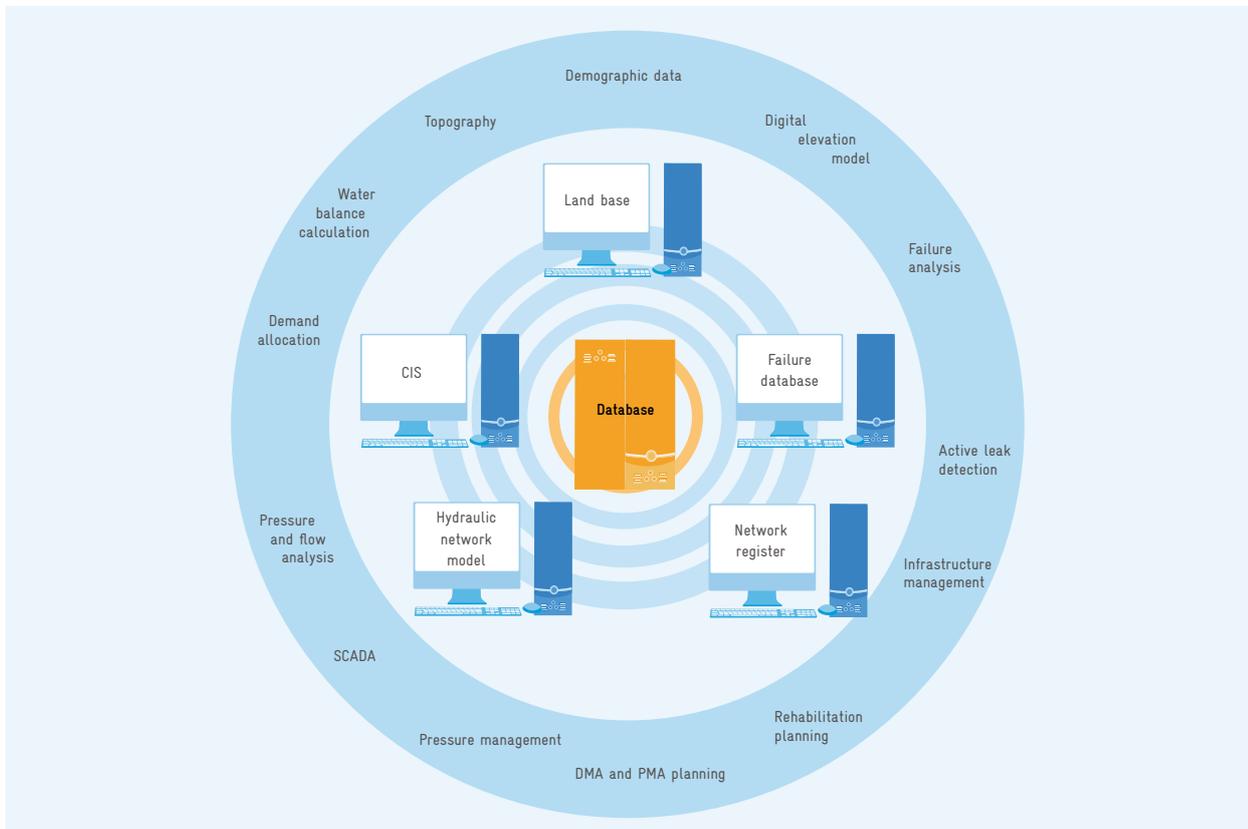
Photo: © P. Klingel, 2006

Chapter 5: Data and information prerequisites for water loss reduction

GIS-based information systems are considered to be key prerequisites for efficient WLR. Five central information systems and their relevance for WLR in general and for pressure management in particular have been distinguished and are described (Figure 4):

1. The **landbase** is an electronic spatial map of a water distribution network's entire service area and forms the basis for all other information systems.
2. The **network register** offers an overview of all facilities, transmission and distribution pipes, service connections in a water distribution network and their accessories. The current status of the network can be assessed based on the age and estimated life span of its components. This forms the basis for long-term replacement and investment planning.
3. **Hydraulic network models** can calculate the pressure and flow rates at any point in the network for all supply scenarios. These models are crucial for designing and operating water distribution networks and are required to design optimal interventions, especially when implementing advanced pressure management.
4. The **failure database** provides valuable information about the ageing behaviour and condition of different network components and is thus useful for identifying vulnerable sections of the network and replacement planning.
5. The **customer information system (CIS)** and the billing records are indispensable for comparing water input and water consumption into a zone and thus necessary for calculating the water balance.

Figure 4 Links between various GIS-based information systems and WLR



Chapter 6: Methods and instruments for water loss reduction

The principal intervention methods for WLR are recapitulated with a particular focus on the technical aspects of pressure management.

Continuous monitoring:

The design and implementation of district metered areas and their importance for continuously monitoring leakage levels is explained. This approach reduces leakage detection time, known as the awareness time, and helps to locate leaks faster, thus decreasing the location time.

Active leakage control:

Active leakage control consists of three main tasks:

1. Creating awareness of leaks
2. Detecting and locating leaks
3. Repairing leaks

The importance of each step is explained, and state of the art technologies are briefly outlined for each step.

Leak repair and infrastructure management:

The purpose and key issues of leak repair works and infrastructure management are discussed.

Pressure management:

An overview of the fields of application and the potential benefits of pressure management is provided. Different types of valves and pressure modulation and their respective advantages and disadvantages are explained in detail. Furthermore, the procedure for implementing a typical pressure management project and selection criteria for the most appropriate solution are specified.

Chapter 7: Case studies

Several case studies from countries including Jordan, Brazil, Peru and Burkina Faso reflect the different aspects involved when successfully implementing pressure management. This includes hydraulic modelling, installing plunger valves and calculating actual water savings.

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Case study: Ain Al Basha, Jordan

Ain Al Basha, a northern district of the Jordanian capital Amman, was estimated to have a NRW level of almost 50% in 2005. The very high percentage of real water losses used up a lot of financial and natural resources, thus limiting the supply of water to service customers. Furthermore, strong pressure variations within the system led to frequent pipe breaks and high leakage figures.

Addressing this situation, a project with the objective to reduce real water losses by means of effective pressure management and increasing the capacity of network operators was implemented.

The impact of the project inter alia includes a reduction of water losses by approx. 40%. The water saved has been used to increase water supply. At the same time, less water needs to be pumped into the network, as the *Water Authority of Jordan (WAJ)* has become more efficient. Furthermore, pipe bursts were diminished by controlling and reducing pressure, and financial savings as well as the life-time of the pipe system have increased.



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The guidelines will be made available for download free of charge on the project's homepage:
www.waterlossreduction.com

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