DOCUMENTATION OF BEST PRACTICES IN NON-REVENUE WATER MANAGEMENT IN SELECTED MEDITERRANEAN COUNTRIES

ALGERIA, ISRAEL, JORDAN & MOROCCO

February 2013

Version	Document Title	Authors	Review and Clearance
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The SWIM Programme (2010 – 2014)

Contributing to Sustainable Water Integrated Management in the Mediterranean

Funded by the European Commission with a total budget of approximately €22 million, Sustainable Water Integrated Management (SWIM) is a Regional Technical Assistance Programme aiming to contribute to the effective implementation and extensive dissemination of sustainable water management policies and practices in the South-Eastern Mediterranean Region in view of increasing water scarcity, combined pressures on water resources from a wide range of users, desertification processes and in connection with climate change.

The SWIM Partner Countries (PCs) are: Algeria, Egypt, Israel, Jordan, Lebanon, Libya[1], Morocco, the occupied Palestinian territory, Syria and Tunisia.

SWIM aligns with the outcomes of the Euro-Mediterranean Ministerial Conferences on Environment (Cairo, 2006) and Water (Dead Sea, 2008) and also reflects on the four major themes of the draft Strategy for Water in the Mediterranean (SWM), mandated by the Union for the Mediterranean, namely: Water Governance; Water and Climate Change; Water Financing and; Water Demand Management and Efficiency, with particular focus on non-conventional water resources. Moreover, it is operationally linked to the objectives of the Mediterranean Component of the EU Water Initiative (MED EUWI) and complements the EC-financed Horizon 2020 Initiative to De-Pollute the Mediterranean Sea (Horizon 2020). Furthermore, SWIM links to other related regional processes, such as the Mediterranean Strategy for Sustainable Development (MSSD) and the Arab Water Strategy elaborated respectively in the framework of the Barcelona Convention and of the League of Arab States, and to on-going pertinent programmes, e.g. the UNEP/MAP GEF Strategic Partnership for the Mediterranean Large Marine Ecosystem (MedPartnership) and the World Bank GEF Sustainable Mediterranean.

The Programme consists of two Components, acting as a mutually strengthening unit that supports much needed reforms and new creative approaches in relation to water management in the Mediterranean region, aiming at their wide diffusion and replication.

The two SWIM Components are:

- A Support Mechanism (SWIM-SM) funded with a budget of €6.7 million and
- Five (5) Demonstration Projects funded with a budget of approximately €15 million

For more information please visit http://www.swim-sm.eu/ or contact info@swim-sm.eu

[1] THE SITUATION IN SPRING 2012 IS THAT FOLLOWING FORMAL EC DECISION ACTIVITIES HAVE BEEN STALLED IN SYRIA WHILE LIBYA HAS OFFICIALLY BECOME A PARTNER COUNTRY OF THE SWIM PROGRAMME

Acknowledgments:

Special thanks are extended to the responsible ministries, institutions, associations and officials from both the public and the private sector in the four countries (Algeria, Israel, Jordan and Morocco) for availing the relevant information necessary to document the existing best practices in the management of non-revenue water, be it at a national level, or site specific; involving pilot cases. The people and institutions that have been consulted, and/or provided the project with the relevant documents are many. They have all been identified in the annex, as references on the subject in the respective countries (ANNEX 1). To all of them we extend our deep gratitude and appreciation for their invaluable cooperation.

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ACRONYMS

BP	Best Practice
CA	Contracting Authority
CB/MEP	Capacity Building/Mediterranean Environment Program
DN	Nominal Diameter
DG	Directorate General
DMA	District Metered Area
ENPI	European Neighborhood and Partnership Instrument
ENPI/SEIS	ENPI Shared Environmental Information System
EU	European Union
GIS	Geographical Information Systems
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit, GmbH (German International Cooperation)
HDPE	High Density Polyethylene
IWA WLTF	International Water Association Water Loss Task Force
JICA	Japan International Cooperation Agency
JWWA	Japan Water and Wastewater Association
KFW	Kreditanstalt für Wiederaufbau (German Development Bank)
L/Hr	Liters per Hour
M^3	Cubic Meters
MeHSIPPPIF:	Mediterranean Hot Spots Investment Program - Project Preparation and Implementation Facility
MoU	Memorandum of Understanding
NRW	Non-revenue Water
O&M	Operation and Maintenance
PCs	Partner Countries
PRV	Pressure Reducing Valve
PSP	Private Sector Participation
SIV	System Input Volume
SWIM	Sustainable Water Integrated Management (program funded by the EU)
SWIM-SM	Sustainable Water Integrated Management –Support Mechanism Project
TOR	Terms of Reference

Algeria

ADE	Algerian Water (National public institution, under the supervision of the Ministry of Water Resources, in charge of the whole country to ensure, among other things, the distribution of drinking water)
ABH-CZ	Hydrographic Watershed Agency; Chellif-Zahrez
AD	Algerian Dinar
BP	Best Practice
NGA	Algerian Mean Sea Level (geodetic datum)
HDPE	High Density Polyethylene
NRW	Non-revenue Water

Israel

IWWA	Israel Water Works Association
NIS	New Israeli Shekel
PMA	Project Management Area

Jordan

ACWUA	Arab Countries Water Utilities Association
GWA	Governorate Water Administration
JD	Jordanian Dinar
MWI	Ministry of Water and Irrigation
NGWA	Northern Governorates Water Administration
PMU	Project Management Unit
WAJ	Water Authority of Jordan

Morocco

hABH	Hydraulic Watershed Agencies
AFD	French Development Agency
CT	Call to Tender
DB	Database
GP	Good Practice
SS	Special Specifications
EMFM	Electromagnetic Flowmeters
DPA	Directorate of Heritage
DR	Regional Directorate
DRi	ONEP (National Office for Drinking Water) Regional Directorates
DRPE	Directorate for Water Research and Planning
NRW	Non-revenue Water
GMAO	Computer-Assisted Maintenance Management
Excl. tax	Excluding tax
LPEE	Public Laboratory of Testing and Study
LYDEC	Lyonnaise des Eaux de Casablanca (Casablanca Water Company)
IEA	International Water and Sanitation Institute - ONEE (National Office for Electricity and Drinking Water)
MAD	Moroccan Dirham
MEMEE	Ministry of Energy, Mines, Water and the Environment
Mm^3	Million cubic metres
NGM	Moroccan Mean Sea Level
ONE	National Office for Electricity (becoming ONEE Electricity Branch after merging with ONEP)
ONEE	National Office for Electricity and Drinking Water
ONEP	National Office for Drinking Water (becoming ONEE Water Branch after merging with ONE)
PAP	Performance Improvement Program
RADEEF	Independent State-Owned Company for the Distribution of Water and Electricity of Fez
RDF	Research on leakage
SAEP	Drinking Water Supply Systems
SEM	Marseilles Water Company
GIS	Geographic Information System
TSP	Portable Input Terminal
EU	European Union

Executive summary

The purpose of this report is to identify and document existing best practices (BPs) in the management of non-revenue water (NRW) in selected beneficiary countries of the European Union (EU) - funded Sustainable Water Integrated Management - Support Mechanism (SWIM-SM) project; namely, Algeria, Israel, Jordan and Morocco, with the objective of disseminating these BPs for knowledge exchange and sharing of experience in reducing NRW among the project countries (PCs). To this effect, SWIM-SM identified and documented three exemplary BPs for the monitoring, assessment and control of NRW in each of the four countries. Identification of the BPs was guided through a questionnaire that was developed by the project and used to various extents to guide discussions and help identify three exemplary best practices in each country and their performance against a set of guiding criteria provided in the Terms of Reference (TOR); and shown below:

Impact: This criterion relates to the impact that the Best Practice had on one or more of the following:

- Physical and/or administrative losses
- Institutional capacity in non-revenue water management: monitoring, assessment and/or control of NRW.
- Changing people's attitudes and behaviours towards illegal tapping.
- Frequency of Illegal tapping
- Customers satisfaction to service delivery
- Any other impacts not listed above

Technical Feasibility (as applicable): in terms of one or more of the following:

- Reliability
- Needs for expertise within the organization (indicating if its low, medium, high)
- Requirements for technical resources in the market
- Prospect of success
- Practicality
- Any other aspects not indicated above

Financial feasibility: Expressed in terms of Benefit/Cost Ratio

Affordability: Ability to mobilize resources for the implementation of the BP

The best practices identified in this report were the result of several consultations, and interviews with the private and public operators, water supply departments and other stakeholders from the municipal water sector. In addition, use was made of scientific journal publications, annual reports, existing national and international guidelines, and standards, surveys, regulations, procedures, case studies, websites; as applicable in the four countries in support of the identified BPs.

As a result, 11 exemplary BPs were identified; three in Israel, three in Jordan, three in Morocco and two BPs in Algeria.

Metering and replacement of water meters is a best practice presented by Algeria, Israel and Morocco; and is identified as part of the existing best practices in Jordan. This practice allows better control of apparent losses due to metering inaccuracies and illegal use.

Metering was presented in the two Algerian case studies. The first case study was coupled with the installation of bulk flow meters, network segmentation, partial rehabilitation of the network within a selected segment, in addition to other actions involving updating the related GIS system, and subscribers' information. The second study involved metering of big consumers who are not connected to the network.

In Israel, metering is practiced by all the water companies involving large campaigns to install water meters for every private and public consumer, and replacement of the aging meters every five years; resulting in dramatic reductions in NRW. In Morocco's case study, an integrated metering strategy included a set of actions that started with putting in place a meters' database to enable the analysis and prioritization of problems and ending with the implementation of a plan of action for the reduction of apparent losses.

Metering and replacement of water meters is highly feasible, involving in the case of Israel, an investment return period of 1-3 years. However its cost may be prohibitively expensive where the financial situation of the water company does not allow wide spread replacement/installation of meters. Support from the central government and/or donors, is therefore warranted. Another option is to divide the city area into several areas/segments, so that the earning of the first segment, balances the cash flow required for the replacement in the second segment.

Implementation of water loss surveys (both administrative; through customers interviews and physical; to locate sources of physical losses) is a practice implemented in Israel that allows the water corporation to understand which elements of the system contribute most to NRW and accordingly help guide planning for investment. This practice is promoted as the first line of action towards NRW. Compared with changing aging systems or implementing new system-wide technologies, the survey costs are low and can be recovered in few months.

Pressure management is another practice that results in high reductions in the physical loss component of the NRW; with benefits outweighing costs. It is considered as a cost effective leakage management activity involving reduction in the consumption of energy. This practice is presented by Jordan and Israel, and has proven technically and financially feasible in mountainous topography in the two countries and under conditions of intermittent water supply in Jordan. The practice however requires availability of funds and know-how.

Detection of losses and leakage repair in the Moroccan case study of Fez involved the installation of pressure reducing valves, and network modeling based on which a study for the improvement of network efficiency and rehabilitation was prepared and implemented. The corresponding increase in the network efficiency from 53.3% to 63.3% during eight years, and the associated water savings in terms of amounts and monitory values were encouraging. The cost of the investment (equally shared between la Régie de distribution d'Eau et d'Electricité de la ville de Fès (RADEEF) and the German development Bank (KFW) was recuperated before the end of the eight years.

The success of the **micro Private Sector Participation (PSP)** experience in Madaba water administration in Jordan attracted the attention of some water authorities in the Middle East and the Gulf states; as a case to learn from in their reform process. Micro PSP can be considered as a fast track option for service improvement in preparation for other kinds of PSP in the operation and management of water and wastewater systems. The results included increased water and wastewater revenues and increased collection rates. The secret to the successful implementation of such an experience is to take the necessary time in the preparatory phase to transfer know-how to the local private sector up to the final pre-qualification.

Finally; two closely related best practices are presented by Jordan and Morocco. These are: (a) the adoption in Jordan of a licensing System for accrediting registered contractors for **Service Connection Installation**; coupled with training and the development of guidelines for improving the performance of staff who supervise the installation and the plumbers who execute the work; and (b) a service connection management policy in Morocco; involving procurement policies, standardization and guidelines, control of materials and implementation of services, and providing assistance to the partners and subcontractors. Although the case studies from the two countries did not quantify the feasibility or impact of this practice, such practices are profitable in the short and medium terms, considering that most of the leakage occurs in service connections.

The Best Practices for each country are presented in **four chapters**; one for each country. Each Chapter is organized following the same structure: Section one introduces the status of non revenue water management in the country. This is followed by a general inventory of the existing BPs in each country (Section two). Three exemplary BPs are then selected in Section three based on the discussions with the stakeholders and are evaluated against the criteria mentioned above. Section four presents a more detailed discussion of each BP. All contacts details together with the technical documents related to each BP, are presented in two separate annexes for all the countries (ANNEX 1 and ANNEX 2; respectively). Each document provided by the countries can be accessed in the same language it was drafted; through the respective hyperlink made available in ANNEX 2 of the report.

Introduction

Non-revenue water is defined as the water that has been produced and lost before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies). High levels of NRW are detrimental to the financial viability of water utilities, as well to the quality of water itself. NRW is typically measured as the volume of water "lost" as a share of net water produced. However, it is sometimes also expressed as the volume of water "lost" per km of water distribution network per day.

The International Water Association (IWA) has developed a detailed methodology to assess the various components of NRW. Accordingly NRW has the following components:

1. Unbilled authorized consumption (e.g. for fire fighting or, in some countries, for use by religious institutions)
2. Apparent losses (water theft and metering inaccuracies)

   (Both 1 and 2 above are referred to as Administrative NRW – comprised of (a) unbilled metered consumption, (b) unbilled unmetered consumption, (c) unauthorized consumption and (d) customer metering inaccuracies - See items marked in the solid line in **Figure 1: The IWA 'best practice' standard water balance**below.

3. Real losses; also referred to as physical losses (from transmission mains, storage facilities, distribution mains or service connections), and consisting of (a) leakage on transmission and/or distribution mains, (b) leakage and overflows in storage at utilities' storage tanks, and (c) leakage on service connections up to the point of the customer's metering – See items marked in 2-solid lines in **Figure 1:** The IWA 'best practice' standard water balance

In many utilities the exact breakdown of NRW components and sub-components is simply not known, making it difficult to decide about the best course of action to reduce NRW. Metering of water use at the level of production (wells, bulk water supply), at key points in the distribution network and for consumers is essential to estimate levels of NRW

Apparent losses for developing countries, in particular theft through illegal connections have been estimated on average to account for about 40% of NRW. In some cities, apparent losses can be higher than real losses. Reducing apparent losses from illegal connections is often beyond what a utility can achieve by itself, because it requires a high level of political support. Moreover regularization of illegal connections which often occurs in poorer areas will in some cases, affect the poor.

Many programs to reduce NRW have failed in the long run, as they often focus on real losses, without sufficient attention being paid to apparent losses. To achieve permanent results, management procedures related to a utility's organization, procedures and human resources have to be changed. Additionally the implementation of a pressure management system is an efficient approach to reduce the total real losses in the long term. It is one of the most basic and profitable forms of optimizing a system and generally provides fast investment paybacks.

This report presents few examples of success stories and best practices used in reducing non revenue water in four SWIM countries; Algeria, Israel, Jordan and Morocco, with a view to provide opportunities for sharing experiences and knowledge within the region and learning about what made that story a success, while pointing at the difficulties in implementation; as applicable, and how they were overcome.

FIGURE 1: THE IWA 'BEST PRACTICE' STANDARD WATER BALANCE

<table>
<tr><td rowspan="9">System Input Volume (corrected for known errors)</td><td rowspan="4">Authorised consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water (NRW)</td></tr>
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</table>

1 DOCUMENTATION ON THE BEST PRACTICES FOR NON-REVENUE WATER MANAGEMENT - THE CASE OF ALGERIA

1.1 STATE OF NON-REVENUE WATER IN ALGERIA

In drinking water supply networks, non-revenue water in Algeria is estimated between 40 and 50%, split between technical losses and commercial losses which play a relatively important role. This is not acceptable, both from the ecological and the economical point of view. For this reason the government has launched a massive operation for the rehabilitation of drinking water supply systems in all major cities in the country based on network upgrade studies and works and support actions for the Algerian Water (ADE) with a view to effective and economical technical and commercial management. To the same end, it should be noted that the management of drinking water supply services in four large cities is delegated in partnership with European foreign companies managing public water services.

The current different operating activities (listed below) performed both technically and commercially have proved inadequate and have not achieved the expected results in terms of improving the yield of networks. This is mainly due to the significance of the age of the network, lack of means of intervention, the low revenue of companies managing the drinking water supply services and the unavailability of suitable management:

- sustained leak repair,
- partial rehabilitation of networks,
- increased water volumes through mobilization of new water resources,
- reorganization of water meter reading,
- installation of macro- and micro-meters on networks and connections of subscribers,
- fight against water theft.

Also, a pilot distribution network segmentation project for the city of Tizi-Ouzou was initiated by Algerian Water (ADE), in the Tizi-Ouzou area. This project which was localized within a defined space sector has managed to benefit from all human, material and financial resources so as to allow for the evaluation of expected positive impacts.

This pilot project, conducted horizontally by local ADE structures, in the Tizi-Ouzou area, was initiated in view of large-scale actions as part of a national program for the rehabilitation of drinking water supply systems for which the state is responsible.

1.2 IDENTIFICATION OF BEST PRACTICES (BP) CONCERNING NRW IN ALGERIA

1.2.1 Methodology

Identifying best practices for reducing non revenue water in Algeria was made through interviews at the level of the Directorate-General for ADE, and three divisions of the same Directorate-General responsible for network operations, customers and new projects respectively. These interviews continued at the level of ADE areas (ADE sectors) of the city of Tizi-Ouzou (100km east of Algiers) and the city of Blida (50 km to the west of Algiers), concerning non-revenue water in public drinking water supply networks.

As concerns non-revenue water on the level of users, through wells and boreholes not connected to public networks, interviews took place at the Directorate-General of the Hydrographic Watershed Agency of Chelef-Zahrez (ABH-CZ) at Chelef (225 km west of Algiers).

1.2.2 Interviews with key stakeholders

The interviews conducted in December 2012 and January 2013 with the administrators mentioned above have allowed for discussions on the financial and ecological importance of very high water losses in water supply systems and on the absolute need for constant efforts against this scourge by using best practices. To this end, efforts for the Tizi-Ouzou area are focused on strengthening measurements, both at level of networks and at the level of subscribers connected, , for a segment of the network. In other words for a division of the network for greater control in terms of exploitation.

1.2.3 Questionnaire prepared by the consultant

The issue was approached through a series of brainstorming sessions with the primary responsible executives of ADE and ABH-CZ at central and decentralized levels. During these meetings, the very high level of non-revenue water in water supply systems was noted as well as measures put in place for the reduction thereof.

1.2.4 General inventory of best practices concerning NRW in Algeria

Concerning best practices implemented by the ADE and ABH-CZ services to fight against non-revenue water, they mainly focus on:

- The detection and repair of leaks on a linear network of more than 100,000 km(ADE repaired over 200,000 leaks in 2011)

- The installation of meters on the production and distribution networks (ADE has installed more than 300 meters)

- The installation of meters on the connections of subscribers (ADE installed more than 200,000 meters in 2011)

- The installation of meters by ABH-CZ on individual water catchments for industrial use, not connected to a public network.

- The segmentation by valves enabling isolation of network sections.

1.3 IDENTIFICATION OF THREE MODEL METHODS OF BEST PRACTICES

Based on interviews with key stakeholders, the three model best practices, presented below, were discussed. Best practice in the detection and repair of leaks in the city of El-Affroun (BP3)this has not been considered, given the level of implementation as observed in the field, which did not allow for conclusions to be drawn.

1) BP1: Segmentation of the drinking water distribution network combined with a meter installation program.
2) BP2: Recording of individual water catchments not connected to a public network combined with a meter installation program.
3) BP3: Detection and repair of leaks in the city of El-Affroun.

1.3.1 BP1: Segmentation of the drinking water distribution network combined with a meter installation program

1.3.1.1 Impact

This practice has had a positive impact on network management resulting in better control of water volumes injected into the distribution network.

1.3.1.2 Technical feasibility

Such a large-scale operation would require strong administrative, technical and managerial skills to identify, diagnose and map networks. Also, in this case and given the limited resources of ADE (Tizi-Ouzou area), this operation was limited to a network of one line supplying around 2,000 people.

1.3.1.3 Financial viability

This is a financially viable operation as it reduces losses and therefore energy costs associated with the production, transport and distribution of water. It also increases revenues because water previously lost will now be sold. Therefore it is of economic and financial, as well as of ecological benefit, because of conserved resources.

1.3.1.4 Affordability and ability to raise funds

Conducted on a large scale, it is an expensive operation that exceeds the financial capacity of the Tizi-Ouzou management company. In the case of Algeria and considering the appropriateness of such an operation both economically and ecologically, the public authorities have launched a vast drinking water supply systems diagnosis and rehabilitation operation in all 43 major cities in the country where the water supply is managed by ADE.

1.3.2 BP2: Recording of individual water catchments not connected to a public network combined with a meter installation program

1.3.2.1 Impact

The impact of this practice for the identification and installation of meters for individual catchments not connected to a public network, helps to strengthen the estimates of water volumes taken from different ground layers present on the ABH-CZ territory and to the create conditions for good management of these layers from a sustainable development perspective.

1.3.2.2 Technical feasibility

This is a census operation of individual catchments throughout the vast territory of ABH-CZ and installation of meters to measure the volume collected directly from different ground layers present on the territory. Such an operation, conducted on a large scale and in a systematic manner, is feasible provided that an adequate organizational framework as well as the necessary operational means are put into place at managerial, human and material levels and that the institutional framework is reinforced.

1.3.2.3 Financial viability

Financial and environmental sustainability is certain because the results of this operation convert into revenue for ABH-CZ and the public treasury which gets a part thereof, as well as savings in water usage provided that water users pay a fee.

1.3.2.4 Affordability and ability to raise funds

This is an operation requiring relatively high material, human and financial resources for which the ABH-CZ must be supported by the State. It also requires high-level engineering for the design, implementation and exploitation of results, for which the ABH should again be supported by the public authorities.

1.3.3 BP3: Detection and repair of leaks in the city of El-Affroun

As noted above, after a field trip, this operation of leak detection and repair on a well-defined network of the city of El-Affroun, undertaken in partnership with the Belgian Cooperation, was delayed in its implementation. The "leak detection campaign" phase did not start because of late receipt of the necessary equipment making it difficult to draw conclusions.

1.4 DOCUMENTATION OF BEST PRACTICES (BP)

1.4.1 BP1: Sectorization of the drinking water distribution network combined with a meter installation program.

1.4.1.1 Summary

This best practice called "sectorization of the drinking water distribution network combined with a meter installation program" focused on the work of network segmentation. It consisted of identifying a well-defined drinking water supply network in the city of Tizi-Ouzou and monitoring all supply and consumption points thereof. Indicators such as the volume served, the number of subscribers and the allocation per subscriber were recorded at the start of the operation and monitored throughout the rehabilitation of the network and the installation of segmentation valves. This was intended to reduce non-revenue water which would be around 40 to 50% of total production and to achieve the following objectives:

- Optimize network management.
- Control the volumes distributed.
- Update the subscriber file.
- Reduce the fixed rate count.
- Improve the quality of public service.

1.4.1.2 Description

Overview of the drinking water supply system of the city of Tizi-Ouzou

The city of Tizi-Ouzou is supplied with drinking water from surface and groundwater resources from the watershed of Oued Sebaou and the Taksebt dam, respectively. This supply is ensured by a hydraulic system consisting of 18 wells, 10 pumping stations, 16 storage tanks, a supply network of 64 km and a linear distribution network of 167 km.

The distribution network of the city of Tizi-Ouzou is an interconnected network without isolation valves allowing for segmentation. Therefore, in this case we propose that a study is undertaken to include a more refined segmentation.

In terms of water loss, this produces variable results with to a rate of return far below acceptable standards.

The public water service of the city of Tizi-Ouzou is technically managed by two centers, one for production and one for distribution, and commercially by two customer agencies, managing a portfolio of approximately 31,500 subscribers representing a network connected to approximately 200,000 inhabitants.

The population of the city of Tizi-Ouzou enjoys an average daily supply of 200 liters per capita through the provision of a daily distribution volume of approximately 41,000 m^3, or a quarterly volume of around 3.7 million m^3.

In terms of macro-metering, the city supply system has 19 meters for measuring water volumes produced and 29 meters for measuring water volumes injected into the distribution network.

In terms of micro-metering, the water distribution company has set up 31,500 individual meters for measuring water distributed to users. For 1,900, representing 6%, water consumption is measured at a fixed rate by means of impaired meters.

On 31 December 2008, the overall rate of return recorded between production volumes and invoiced volumes (distributed) was 40% equating to large volumes of non-revenue water.

This alarming performance has led the water distribution company to start on a project of fighting against leaks and network segmentation to better stem the flow of non-revenue water.

In the absence of reliable statistics on various factors and possible sources of gains in the reduction of non revenue water, a pilot project has been in progress to determine the importance of each factor to improve the overall volume of non-revenue water.

Actions in the context of this segmentation project

1) Dividing the network of the city of Tizi-Ouzou into nine (9) sectors.

This pilot project started by dividing the drinking water distribution network for the supply of the city of Tizi-Ouzou into nine hydraulic sectors, mainly based on supply points.

2) Choosing a sector.

Given the limited resources available to the unit in relation to human, material and financial resources, the choice to manage this process of segmentation has focused on a single sector, namely, sector 4.

This sector is supplied with water from six storage tanks with a total capacity of around 8,000 m^3 located at altitudes ranging from 240 to 256 of the Algerian Mean Sea Level (NGA).

Drinking water supply is provided by a distribution network consisting of 31,000 meters of lines made of different materials (Asbestos Cement, Steel, Cast Iron, High Density Polyethylene (HDPE).

This distribution sector covers drinking water requirements of a population of 33,000 inhabitants, divided into 13 districts, representing 5,100 subscribers, 950 of which are charged at fixed rate.

3) Specific actions for the sectorization operation of sector "4".

As a result of the selected sector mapping and the specification of the sector water supply points, the following were undertaken:

- installation of a large-diameter meter at the start of each of the six supply tanks mentioned above.

- updating of the network geographic information system by introducing new partial rehabilitation actions within the context of improving the distribution service through the repair of leaks and network equipment.
- updating the subscriber files as a result of a thorough investigation.
- replacement of 1,300 individual meters with new ones.

Thereafter and for the same reasons of insufficient human, material and financial resources, it was decided to split the selected sector into four sub-sectors and to assess the outcomes of this sectorization project in relation to non-revenue water on a sub-sector selected from these four sub-sectors, namely the "July 5 City".

"July 5 City" consists of nine buildings with a population of nearly 2,000 inhabitants corresponding to 300 subscribers.

To evaluate expected gains in terms of reduction of non-revenue water, actions were completed along the lines of greater control of the network, specific to this sub-sector. These consisted of:

- At the start of the distribution network, installation of a block valve and a large-diameter meter.
- Checking the tightness of isolation valves within the limits of the sub-sector.
- The implementation of a leak detection and repair operation.
- The implementation of rehabilitation works over the entire internal network of the "July 5 City".
- Installation of valve and meter at the entrance of the city to measure incoming volume.
- Installation of dividing meters at the entrance of each building of this city.
- Control of individual meters that has resulted in:
    - Sealing all counters to deter fraud.
    - Replacement of 171 meters with new ones.

Results

Results obtained at the "July 5 City" after upgrading networks are presented in the table below:

TABLE 1: COMPARATIVE STATE OF REVENUE AND INVOICED VOLUME

Periods	TURNOVER IN (AD)[2]	Rate of change	Invoiced volumes in m^3	Rate of change
1st Quarter 2009	642,600	13%	14,350	12%
1st Quarter 2010	725,870		16,070	

[2] Algerian Dinar (1 AD = 0.0096406 EUR)

TABLE 2: CHANGE OF REVENUE VOLUMES (NOTED AFTER UPGRADE OF METERING OVER TWO DIFFERENT PERIODS)

Revenue volumes (m^3) - 4th Quarter		Rate of change	Revenue volumes (m^3) - 1st Quarter		Rate of change
2008	2009		2009	2010	
1,551	1,858	20%	1,359	1,581	17%

TABLE 3: COMPARATIVE STATE OF REVENUE WATER (NOTED ON A SAMPLE OF 200 SUBSCRIBERS, IDENTIFIED IN VARIOUS SUB-SECTORS, AFTER NETWORK UPGRADE)

1st Quarter (m^3)		Rate of change	2nd Quarter (m^3)		Rate of change	3rd Quarter (m^3)		Rate of change
2008	2009		2008	2009		2008	2009	
6,007	7,372	33.8%	6,018	7,987	32.8%	8,569	10,326	20.5%

This sectorization project has mobilized additional funding of five million Algerian dinars, or U.S.$65,000, mainly devoted to network equipment, such as isolation valves and large and small diameter meters.

Current operation costs related to GIS updating, updating the subscriber files, and the works for leak detection and repair are added to this financing.

The consequences of this operation have allowed for significant improvements in the management of sector "4" public service, both technically and commercially.

Technically, the following have been noted:

- Better use of the network as a result of the update of the geographic information system.
- Optimization of network management through facilities acquired in control and checking of valve and connection leaks.
- While working on networks, cutting the drinking water supply, limited to the area of intervention, is now possible owing to the segmentation of the networks.
- Continuous monitoring of volumes distributed.
- The removal of unauthorized connections through compliance thereof.

Commercially, the following have been noted:

- A reliable customer database owing to the update of the subscriber files.
- Improved network performance by 3 points or reduced losses by 3 points.
- The improvement of invoiced volumes by 8.5 points.
- The improvement of revenue by 9 points.

At the "July 5 City" commercial results are even better because of the finer segmentation and are as follows:

- The improvement of invoiced volumes by 12 points.
- The improvement of revenue by 13 points.

Reduction of non-revenue water by 20 points during the first year of implementation of the project, becoming 17 points in the second year.

This operation, conducted on a relatively small sample of the network, has allowed to establish and assess positive developments achieved in terms of improving the performance of the network and thus reducing non-revenue water. It is worth reproducing this operation throughout the network of the city of Tizi-Ouzou.

To do this, this type of operation requires the mastery of technical and managerial expertise, the availability of appropriate equipment including diagnostic devices for networks and continuous updating of the mapping thereof, significant means of intervention, and adequate funding.

Such operations, which will have a definite impact on a large scale, on the reduction of non-revenue water, exceed the financial capacity of the water management company of Tizi-Ouzou; thus, they require major funding from the State. To this end, the Algerian government has launched a massive study project for the diagnosis and rehabilitation of drinking water supply systems of 43 major cities managed by ADE.

1.4.1.3 References

1. Ministry of water resources. 2008. Specification standard for the management by concession of the public service of drinking water supply and regulations thereunder. Official Gazette of the Algerian Republic, no. 8, 13 February 2008, pp.12-21.
2. Hattoum.Y and Bouayad.A. 2008. Commercial aggregates of sector 4. ADE area of Tizi-Ouzou.
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1.4.2 BP2: Recording of individual water catchments not connected to a public network combined with a meter installation program

1.4.2.1 Summary

In Algeria, the integrated management of water resources is carried out at the level of a watershed unit by a hydrographic watershed agency. Among other things, each agency is responsible over its jurisdiction for developing and updating the hydraulic cadastre and hydraulic balance of the hydrographic watershed and collecting for this purpose any statistical data, documents and information on water resources, withdrawals and consumption, with a view to sustainable development management.

Since 2005, these agencies have had their missions extended, by way of the Finance Act, to the collection of the consideration fee for the use of water resources by industrial users, tourism and services, not connected to a public network.

Therefore in the following, we will focus on the best practice implemented by the ABH-CZ over its jurisdiction for the collection of fees for water used by users through individual illegal catchments not connected to a public network. This best practice is a systematic survey of users combined with installation of meters to reduce unauthorized use of water resources and therefore tending towards a substantial reduction of non-revenue water. As well as leaks, "unauthorized use", "water theft" or even "water piracy" are a source of economic loss and environmental consequences harmful to the community, resulting in the need to fight against them with the use of appropriate practices and programs.

1.4.2.2 Description

The following text focuses on the collection of fees for industrial use of public water resources over the territory of the Cheliff-Zahrez hydrographic watershed agency (ABH-CZ) to highlight the best practices implemented by this agency to reduce unauthorized use of water resources. Possible gains form an important part of non-revenue water.

Actions to achieve the objectives of reducing non-revenue water.

This operation was conducted mainly in two stages, the update of user files and the organization of awareness campaigns to achieve results. These stages are described below:

1) Update of the user files.

The file update operation has been conducted since 2005, consisting of a systematic survey of all users and mobilizing important human and material resources.

This census has been ongoing and, at the end of 2011, resulted in a consolidated file as follows:

TABLE 4: NUMBER OF WATER USERS BY SECTOR IN THE TERRITORY OF THE HYDROGRAPHIC WATERSHED AGENCY

Year	Industry	Tourism	Services	Total
2005	83	4	425	**512**
2006	98	11	556	**665**
2007	90	14	620	**724**
2008	150	20	667	**837**
2009	157	21	697	**875**
2010	158	21	778	**958**
2011	160	20	750	**930**

It should be noted that census items vary each year. Taking as an example the year 2011, during which 60 new users were registered, while 88 others were removed for various reasons (interruption of activity, water points untapped, name changes, changes in activity and death).

It is important to note that at the outset of this census action, users of public water voluntarily participated in the census operation, motivated by a rumor concerning getting financial help from the State which was ultimately granted only to farmers, for the establishment of wells and boreholes in the context of agricultural development programs. However, since their exclusion from the State financial assistance granted only to farmers , they have made it difficult for ABH-CZ to continue this census action with the same success.

In carrying out this action, the services of the ABH-CZ have met with the main constraints listed below:

- Resistance, or absolute refusal of users to pay the fee because water use has always been free up to the year 2005, the date of implementation of this fee as a result of the Finance Act, payable by all individuals, currently exempting farmers who draw water from groundwater and deep aquifers through wells and boreholes which they establish, equip and operate by themselves.

- Difficulties in equipping water meter installations, resulting in only 40 of 930 users actually having a metering system, which forces ABH-CZ to fixed rate billing, which is often a source of dispute.
- The absence in the ABH-CZ of any means of enforcement obligating users to pay this fee.
- The lack of coordination in implementation between the different players within the water sector.
- The inadequacy of means of intervention in relation to the size of the territory covered by the ABH-CZ.
- Difficulties of implementation by the services of the ABH-CZ of the regulatory provisions laying down the procedures for the application of the fee.
- Inadequate qualifications of the staff involved in the census of water points, assessment, billing of volumes consumed, collection and settlement of disputes.

The work of collecting information and identifying users continues through:

- Implementation of an update of the file of water users subject to the fee, by cross-checking data collected from relevant local governments and institutions. Regarding the drilling of wells, the local directorate of water resources grants permission to conduct drilling. With regard to the use, for example, of a bore hole for the purposes of a hotel infrastructure, the local tourism directorate is involved, as is the administration of the Commercial Register to issue the authorization for implementation. It is through these cross-checks that the ABH-CZ locates and identifies various individual water points existing on its territory.
- Actual billing based on the results of the quarterly campaign reports of meter readings.
- Annual fixed rate billing, operated in accordance with regulatory provisions introduced, and water withdrawals for users that do not have meters. This principle of fixed-rate billing is a source of contention leading to action, which, depending on the case, is treated either amicably or in court. Fortunately, this latter long and costly solution ends in most cases to the benefit of ABH-CZ.

2) Awareness campaign

In addition to operational and management actions for the fulfillment of its tasks relating to the reduction of non-revenue water, the ABH-CZ has led, directed towards industrial users, services and tourism operators, users of water points not connected to public networks, public awareness and popularization campaigns concerning individual and environmental benefits linked to the reduction of non-revenue water.

These awareness campaigns have focused on the following main topics:

- The necessity of measuring water to eliminate fixed-rate billing, which leads to waste and litigation.
- The economical use of water and the fight against leaks to reduce energy costs and consequently, for industrial users, to reduce production costs and ensure sustainable water management for the environment.

Awareness actions have been brought to the attention of interested parties through debate meetings, on-site visits, special programs broadcast by local radio and the publication of brochures and leaflets to raise awareness.

However, it should be noted that the scope of these actions is limited with regard to the difficulty of the task, the reluctance of users, the lack of material and financial resources deployed and the lack of qualified personnel assigned.

Results

Following the implementation of the census program for users not connected to the public network, the assessment of the activity of reducing non-revenue water resulted in a steady increase in revenue water volumes during the period 2005-2011. The table below shows the very encouraging changes recorded:

TABLE 5: VOLUMES OF REVENUE WATER IN M^3 (2005-2011)

Years	Volumes of revenue water in m^3
2005	2,265,084
2006	2,307,008
2007	2,630,199
2008	2,581,456
2009	3,079,597
2010	3,424,925
2011	4,085,089

In 2005, actual metering represented 9% of the total volume of revenue water at fixed rate and in reality, 29% in 2007 and 44% in 2012.

TABLE 6: INVOICED AND COLLECTED AMOUNTS IN ALGERIAN DINARS (AD)[3]

Years	Invoiced and collected amount in AD	Collected amount in AD
2005	56 627 100	
2006	57 675 200	284,236
2007	65 754 975	9,976,912
2008	64 536 400	28,028,575
2009	76 989 925	55,152,106
2010	85 623 125	76,109,000
2011	102 127 225	66,717,138

This growing trend is the result of the integration of new users and the revaluation at fixed rates of volumes consumed by high water consumers.

Meter installation, to reduce non revenue water from users not connected to the public network and having a personal water catchment, has been slow with regard to the number of meters installed (5 in 2005, 40 in 2011) but it has contributed significantly to the improvement of accountability for volumes collected.

[3] 1 AD = 0.0096406 EUR; Cost of m^3 of water = 25 AD

This meter installation operation must be continued, given its positive impact on economical use of water, within the framework of bringing together all stakeholders in the water sector, strengthened both in terms of the institutional aspect for the implementation of strict regulations and in terms of the operational plan for highly publicized and coordinated implementation.

Despite all the actions performed by the ABH-CZ along the lines of reducing non-revenue water, the contractor believes they should be reinforced through measures:

- To ensure greater coordination at the local level between the various stakeholders in the water sector for strict compliance with the regulations for implementation, the operation of individual water catchments and measuring the volumes of used water. This is achieved through the establishment of an appropriate institutional framework organizing and regulating the construction and operation of individual catchments with a view to sustainable water management.
- To augment, at local level, awareness and popularization programs related to the actual accounting for water volumes used with a view to savings, the fight against waste for sustainable management of water resources. These programs call for eventual funding to design communication campaigns mobilizing strongly at all levels.
- To provide skills training for local personnel responsible for implementing all technical, regulatory and communication provisions related to the accountable management of water resources.

1.4.2.3 References

1. Supplementary Finance Act. 2005. Water tariff for industrial uses, tourism and services. Official Gazette of the Algerian Republic, 25 July 2005, Article 19.
2. Ministry of Water Resources. 2006. Decree laying down technical arrangements for fixed-rate billing of the fee relating to the removal of water from the public water sector for industrial use, tourism and services. Official Gazette of the Algerian Republic, no. 84, 24 December 2006, p.16.
3. Watershed Agency of Chelef- Zahrez. 2013. Activity report. Internal Memo. ABH-CZ. Directorate General. Chlef.
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5. Watershed Agency of Chelef- Zahrez.2013. ABH-CZ Presentation. Directorate General. Chlef.
6. Watershed Agency of Chelef- Zahrez. 2011. Evaluation report on actions of water savings awareness 2005-2011. Directorate General. Chlef.

1.5 CONCLUSION AND RECOMMENDATIONS

The consequences of sectorization works (BP1) have allowed for significant improvements in the management of public service, both technically and commercially. **Technically**, the following has been noted:

- Better network management through use facilities acquired.

- Continuous monitoring of volumes distributed.

Commercially, the following has been noted:

- A reliable customer database owing to the update of the subscriber files.
- Improved network performance by 3 points or reduced losses by 3 points.
- The improvement of invoiced volumes by 8.5 points.
- The improvement of revenue by 9 points.

These sectorization works, which have a definite impact on the reduction of non-revenue water, exceed the funding capacity of the management company. Therefore, they require major funding from the State. To this end, the Algerian government has launched a massive study project for the diagnosis and rehabilitation of drinking water supply systems of 43 major cities managed by ADE.

The operation of meter installation, to reduce non-revenue water from users not connected to the public network and having a personal water catchment (BP2), has been slow with regard to the number of meters installed (5 in 2005, 40 in 2011) but it has contributed significantly to the improvement of accountability for volumes collected.

The actions performed by the ABH-CZ along the lines of reducing non-revenue water should be reinforced and maintained by all ABHs in the country through:

- greater coordination at the local level between the various stakeholders in the water sector for establishing an appropriate institutional framework.
- increase at the local level of awareness and popularization programs related to accounting for water volumes used with a view to savings on all levels and in the context of sustainable management of water resources.
- skills training over all staff levels and areas of ABHs locally responsible for the implementation of programs to reduce NRW.

2 DOCUMENTATION OF BEST PRACTICES IN NRW MANAGEMENT – CASE OF ISRAEL

2.1 OVERVIEW OF NRW MANAGEMENT IN ISRAEL

In 2009 an investigation committee was established in Israel because of the water shortage crisis. One of the reasons for this crisis was high level of NRW.

According to 2010 reports, the average NRW rate in Israel is 12.9% (76.7 million m^3/year): this value is composed from 2% of physical NRW caused by leakages and pipeline bursts, and from 10.9% administrative NRW mainly caused by lack of public consumptions registration, inaccurate water meters, lack of water meters and illegal connections to the water supply network leading to illegal consumption (hereinafter "illegal connections"). In some smaller cities the picture is more severe up to level of 30-40% NRW, while in the bigger cities the rates are lower than national average.

When the value of NRW in specific local authority is more than 12%, it is fined because of the lack of efficiency in the system, according to water authority regulations. Only 99 out of 201 local authorities, managed to keep reasonable value of NRW according to the standards.

In 2001, the water and the sewage corporation's law was legislated in Israel. The purpose of the law was to improve water supply services efficiency and quality by means of separating this activity from municipalities.

The main coping methods with physical NRW are maintenance, replacement and rehabilitation of the pipeline on a regular base, pressure management and fast leakage detection.

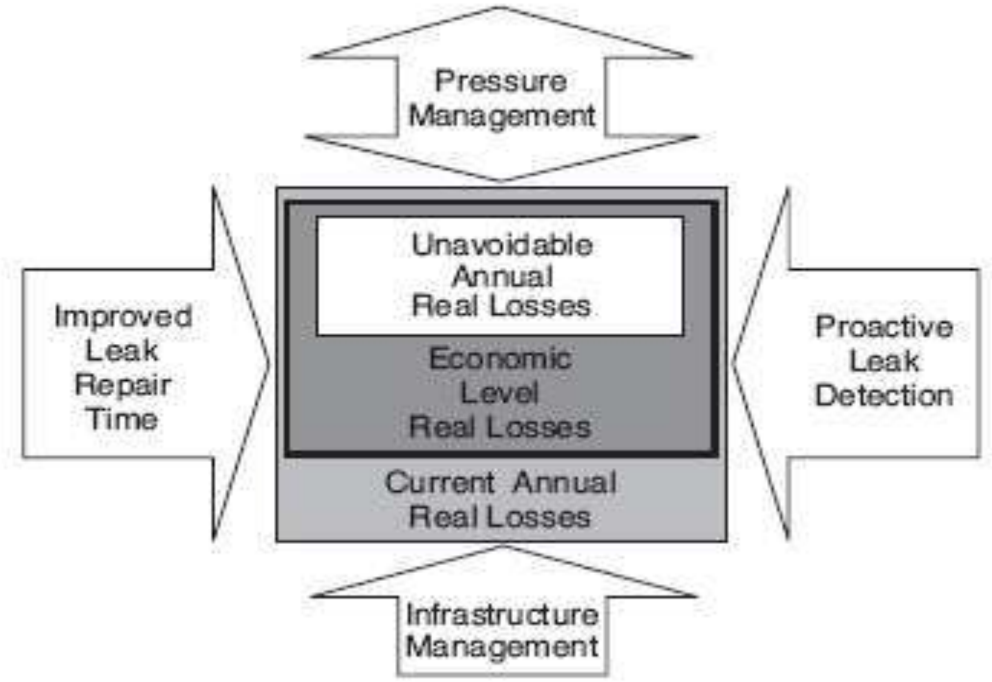
The generic four approaches toward water loss reduction were developed by the IWA Water Loss Task Force (WLTF) as demonstrated in **figure 2**.

Dealing with administrative NRW requires mainly methods of proper water metering, renewing old water meters according to the regulation (every five years), installing water meters in public places and halting illegal connections.

A survey conducted at 2006 (by Dr. Ofira Aylon of Neeman Institute - Technion), showed that NRW reduction using above said methods can prevent annual loss of 30 million m^3 of fresh water a year in Israel. According to the assumption that the alternative cost of water production in Israel is approximately 0.5 US Dollars ($) per meter cube ($m^3$) preventing such NRW value saves 15 million US$ a year.

The purpose of this report is to present the best practices that deal with reducing NRW in Israel, and to identify and document NRW reduction methods from the technology and administrative aspects.

FIGURE 2: IWA - WATER LOSS TASK FORCE DEFINITION OF THE FOUR WATER LOSS MANAGEMENT CONCEPTS



It should be noted that all definitions of revenue and non-revenue water (NRW) used in Israel refer to those adopted by IWA (See **Figure 1**)

2.2 IDENTIFICATION OF BEST PRACTICES IN NRW IN ISRAEL

2.2.1 Methodology

A series of interviews was conducted in September 2012, in order to identify the best practices of NRW management that were successfully implemented in Israel. The interviews assisted in understanding the water supply sector situation with regards to NRW and focusing on three exemplary practices to be documented at this report. The questions of the interview and the summary of the interviews are exhibited in the individual country report.

2.2.2 General inventory of NRW practice in Israel

In Israel there are few practices that are implemented successfully to reduce the NRW:

Water meters replacement and installation

The standard water meters are to be replaced in Israel once every five years. Nevertheless before the establishment of the municipal water corporations, many of these meters were outdated. Two other associated problems are faulty / malfunctioning / broken meters, and lack of metering on many supply connections. The first and basic step in NRW control (mainly administrative) is replacement of old and broken meters and installation of meters on all consumer connections (see more details below).

Advanced wireless metering system

This system allows quick identification of water leakages and irregular demand of water in real time. This system alerts when there is a problem, and allows the water corporation to check the source of the leak close to the discovery time and to fix the leakages quickly. Quick discovery and fixing prevents water waste in leakage, and is regarded by the IWA – WLTF as a basic water loss treatment method.

Installing this system requires changing water meters in the water supply system of the city, to meters that are capable to transmit an output to long distance data transmission system. This system was installed in the city of Ra'anana (75,000 population, 15 km^2). In 2000 a re-evaluation of water management in the city took place. One of the goals was to install advanced wireless system. As part of this process new water meters replaced existing old ones and between 2000 and 2005, 25,000 units were installed. This procedure resulted in a decrease of NRW from an average of 13.8% to average of 7.7% in the years after the replacement. After the replacement of the water meters, the municipality began to implement the advanced wireless system, and that reduced NRW level to 5.75% on average.

The system was also installed in the Misgav regional council (21,000 population, 35 settlements, and covering an area of 200 km^2. It is now being installed in several other cities such as Rishon Lezion, Modiin, Nes Ziona and being planned in many others.

Pressure management system

Dynamic adjustment of the pressure in the water supply system according to the demand in real time (this system is installed in Haifa which is mountain city with altitude variation of 400 meters, and 270,000 population). The system is based on pressure regulating valves which are controlled locally or from remote control center, according to the minimal required momentary pressure in each zone in order to supply the required demand (more details below).

NRW survey

A process designed to locate all the factors causing NRW, both administrative as well as in the pipeline connecting the water supplier and the consumer (more detailing below).

Water Meters $QN\ 1\,{}^{1}/_{2}$

The common metering equipment in most local authorities has a nominal flow rate (QN) (in private consumption) of 2.5 m^3/hour expressed as $QN\ 2\,{}^{1}/_{2}$, which is less sensitive for minor flows. During the last years, Haifa city started using water meters that have a nominal flow rate of $QN\ 1\,{}^{1}/_{2}$. The nominal flow rate of the meter, affects its sensitivity to measure flow rate range including very small flow. The result is a higher level of accuracy, also in low flow rates.

Combined water meters

These are water meters that are adapted to high and low flow rates having a double mechanism. The relevant meter side is activated according to the actual flow rate. Those meters are designed for industrial and commercial consumers because the range of the flow rate is more varied.

Control systems

This includes a real time transmission to a control center from all water facilities. In case of a problem, the system produces warning alarms, which makes it possible to fix the problem quickly before the water leakage or shortly after the leakage starts. The control system provides data for future planning. The installation of the system in the city of Netanya (200,000 population, area of 30 km^2) achieved a reduction of 50% in NRW.

Replacing old pipeline

This includes replacement of pipeline that has passed its lifetime expectancy, low level materials (especially asbestos-cement pipes that were used in the 1960's), and leakage prone areas known for history of bursts. Most of the municipal water corporations manage massive operation of piping replacement as top priority when established, to fix the negligence of many years. The activity is costly and complicated due to working on live infrastructure in the city streets. It is usually spread over a number of years; 5-10 year program of network rehabilitation.

Active discovery of hidden leakages

This operation started to be part of the daily work routine in the water corporations. This system requires a daily check of the pipeline using mainly acoustic-based equipment and visual inspection of pipe bursts.

Installing instruments to prevent water hammer

Water hammer is generated from quick shut of pipe flow and can burst pipes creating consequent leakages that will lead to loss of water. The different techniques to prevent this phenomenon includes: slowly opening and closing of valves and pumps start-ups; choosing the right place, size and kind of air valve (kinetics, automatically or combined); water-hammer pulsation damping equipment etc.

Enforcing and supervision

This involves the use of legal and regulatory means to deter people from stealing water. The regulations allow various tools; the extreme cases being confiscation, water supply halt and bank accounts seizure.

District Metered Area (DMA)

A rather new method implemented in Israel, dividing the city to several zones that are metered for inflow and consumption separately. The management of the system allows focus on NRW issues quickly, efficiently and precisely. The method requires installation of regional meters on the city supply mains as well as local metering and transmission of information to a control center (this practice is implemented in the city of Netanya, 200,000 population).

2.3 IDENTIFICATION OF THREE EXEMPLARY BEST PRACTICE METHODS

Based on the interviews with the key stakeholders, the three exemplary best practices that are chosen for further detailed reporting:

1. NRW Survey.
2. Water meters replacement and installation.
3. Pressure management.

Both (1) and (3) are implemented at most of the cities in Israel and they achieve high results in reducing NRW. In addition, the benefit from these practices is higher than the costs. In parts of the settlements, there are more advanced technologies that are implemented (like advanced wireless system), and the future goal is to install those advance practices all over the country.

The next section examines as applicable each of the three BPs mentioned above, against the criteria defined in the Terms of Reference (TOR) and presented in the **EXECUTIVE SUMMARY**.

2.3.1 BP1: NRW Survey

2.3.1.1 Impact

NRW survey deals with both physical and administrative losses:

In the administrative aspect, the purpose of the practice is to identify damaged water meters, illegal connections, complaints calls, abnormal meter reading differences between the reading times, etc.

In the physical aspect, using the practice helps the water corporation understand which water supply system elements contribute to NRW; like aging and defective pipelines, malfunctioning accessories etc.

Through water balances and reports, this method allows the water corporation to estimate the extent of the NRW and its main reasons while through physical examination in the field throughout the pipelines, the water corporation can find the source of the NRW.

As a result of using this practice, the extent of illegal connections reduced significantly.

The NRW survey is considered in the Israeli water sector as the primary action to be taken in dealing with NRW issue, having the most impact on water saving and focusing on efficient future actions.

2.3.1.2 Technical feasibility

The reliability of this practice is very high because it deals with most aspects of NRW and gives a real picture of the situation of the water supply system and the NRW rate.

The survey can be made by the water corporation staff that can provide inside information about consumption, flow rates of water and situation of pipeline before performing the survey. There are consulting companies that can also perform the survey in cooperation with the water corporation, to increase the efficiency (for example DHV MED company made a survey for "Mei Lod" corporation in the year of 2010 in city of Lod 70,000 population).

The demand for this practice is very high. Today, most of the water corporation is promoting this practice and implement it in the cities as first line of action toward NRW. The water authority supports this line and publishes technical bulletin for actions instructions.

2.3.1.3 Financial feasibility

The benefits from this practice are significantly high (millions New Israeli Shekels[4] (NIS)/year) compared to the costs (hundreds thousands NIS one time). Full survey is performed at once for all the water utility system and takes several months to complete depending on number of teams performing and size of system. It should be repeated after long periods like 5-10 years, not yet done in Israel. Compared to other practices, the survey costs are relatively low and the investment can be returned in few months period.

2.3.1.4 Affordability

This practice doesn't require a lot of resources to implement because most of the work is made by human resources; mostly the water corporation staff with leadership of dedicated consultants from the engineering market.

2.3.2 BP2: water meters replacement and installation

2.3.2.1 Impact

This practice deals with administrative loss: replacing of aging and broken water meters, installing new meters in places where they were not installed and in places suspected with illegal connections.

The ability of this practice to control administrative NRW is very high because installing water meter in every spot in the system increases the ability to measure the right values of water consumption.

This practice reduces the number of illegal connections because increasing the number of the water meters doesn't leave a lot of options to steal water. The frequency of illegal connections decreased significantly wherever a massive replacement and installation of new meters occurred.

2.3.2.2 Technical feasibility

Because the water meter gives specific and accurate data, the reliability of the practice is very high. On the one hand, installing the water meters doesn't require special expertise because it's a technical operation and can be done by a regular maintenance staff. On the other hand, understanding the meaning of the water meters' logs, accumulated data and knowing the best places to install them in the system is more complicated and requires understanding of the water supply systems. In addition, it's important that people within the organization will operate the practice because the technique requires acquaintance with the existing water supply system.

2.3.2.3 Financial feasibility

This practice requires one time investment by installing new water meters and replacing the old ones. After the installation of these water meters the activities are monitoring and controlling the data and maintaining the meters. The benefit from this practice, expressed in reducing the NRW, is immediate and much higher than the costs as evident in Israeli examples. Typical payback-period of this investment is between one year (in older cities and more neglected piping situations) to three years (where higher level of infrastructure is installed). The financial practice is to divide the city area to several domains of replacement,

[4] Approximate currency rate: 5.0 NIS = 1.0 Euro

so the earning of the first domain balances the cash flow when investing the second one etc. After first cycle, the meters should be replaced based on planned program; once in five years, which is the Israeli regulated standard for water meter accuracy lifetime.

2.3.2.4 Affordability

The implementation this BP isn't complicated because it requires only to identify the places where there is a lack of water meters or aging water meters and replace them with new ones. The investment rate can be stretched along time, so the earning from first phase can already create the affordability for second phase etc.

2.3.3 BP3: pressure management

2.3.3.1 Impact

This practice deals only with physical losses. While high pressure in the pipeline can increase the water losses because higher amount of water will come out from the holes in the system, high level of pressure is still required in order to transport water to the higher places in the supply system.

According to the practice, in order to overcome the problem with physical losses, it is required to split the system into different pressure zones. Within each zone, the pressure is kept optimal, as needed for proper supply, by means of pressure regulating valves installed at all supply mains to the zone. In more advanced applications, an optimized overall control of the system flows and pressure is applied, including pumps operation. In Israel, it's acceptable to maintain a supply pressure level of 3-5 atm. at customers' supply demand points, whilst the minimal standard for water supply pressure according to Israel Water Authority instructions is 2.5 atm.

Beside the immediate impact of reduced losses from leakage, this practice helps to preserve the pipeline for a longer time as well as save energy.

2.3.3.2 Technical feasibility

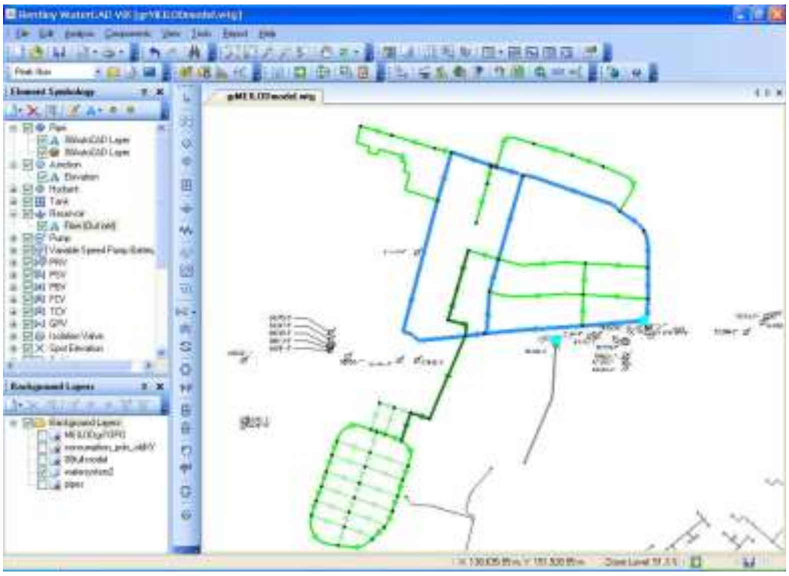
The technical feasibility of this practice is very high, as long as the pressure is preserved in the supply zones by regulating valves.

The practice is complicated and requires know-how in several aspects:

- Regulating equipment like pressure control valves
- Flow control measures as valves, computerized controllers, software, and transmission systems etc.
- Engineering tools to set the level of pressure that is required in different time and zones, amongst water distribution modelling of various scenarios.

Reducing the water pressure affects dramatically the physical NRW reduction. The level of success in operating this BP is very high where implemented in Israel. An example for this is in the city of Kiryat Shmona (23,000 population, mountain topography), where the NRW reduced from 26% to 5.5% in few months of implementation

FIGURE 3: EXAMPLE OF SUPPLY ZONE DISTRIBUTION MODELING (CITY OF LOD)



2.3.3.3 Financial feasibility

The immediate benefit from this practice is water loss reduction and elimination of other actions to reduce NRW. The benefits are typically much higher than the costs of procurement and installation of pressure management equipment. In addition, using this practice extends the life time of the existing pipelines and saves energy.

2.3.3.4 Affordability

Current pressure control techniques available in the market are mainly flow/time modulation, two point control (flow or pressure), critical point control (real time or through self-learning algorithms). All of these provide solutions for networks with excess or varying pressure and will reduce losses. There are several experts in the local market as well as two large Israeli-international manufacturers of pressure regulating valves for this purpose (Dorot, Bermad).

2.4 DOCUMENTATION OF THE BEST PRACTICES

2.4.1 BP1: NRW Survey

2.4.1.1 Summary

As presented in **Figure 1**, NRW refers to the water which does not generate revenues and can be placed under two categories: real losses (physical/technical) and apparent losses; also known as administrative/commercial losses. The real losses occur when water is lost through cracks and leaks in the distribution system. The apparent or commercial losses encompass incorrect or missing meter readings, billing inaccuracies as well as inaccurate customers' information. The practice is implemented by visits to customers' homes in order to verify their account information, ensure that meters are providing accurate readings and other activities related to reducing the amount of non-revenue water.

The survey is performed at the municipal water corporation initiative in order to understand the level of NRW and reduce its rate. The study is taken by consulting experts and technicians with required equipment and engineering tools as detailed below. Duration may take few months and up to a year depending on the size of utility and the expert resources deployed to the mission. More detailing is below in this chapter.

This practice includes two kinds of surveys:

Administrative survey – is done in order to quantify and locate key factors of the administrative water loss. The first step for making a change in the city water system is to study the existing situation with regards to the registered amounts of water at the inlet and outlet of the system. This study includes:

- Checking if there is a match between the main inlet water meter readings and the cumulative water accounts of the customers - this figure defines the general administrative NRW;
- Examination of the maintenance level of the distribution pipelines and meters – in order to asses associated data accuracy and relate consumption regions to relevant mains;
- Identifying problematic areas in the pipeline related to unauthorized consumption due to illegal connections, and/or metering inaccuracies as a result of aging / malfunction / missing water meters, and those areas with significant pipes' leakage etc.).
- Understanding the general situation through interviews with the water system maintenance staff as they hold the history log of occasions like pipe bursts, illegal connections, old systems that are not well documented etc.

Physical survey - The physical survey follows the administrative survey to complete the picture and generate action items for physical improvements. It **is done in order to locate sources of physical water loss** by checking hidden and revealed leakages in the pipes, with visual inspection in walking over pipes or by advanced detection methods using specific detectors (mostly based on acoustic effects due to vibration generated in leaking pipes and detection of water presence under grade).

The purpose of the NRW survey is to deeply understand the existing situation in the pipeline and consuming points, and according to this knowledge get an idea what kind of methods will be suitable to deal with the NRW reduction.

This practice proved itself as a crucial step in the process dealing with reducing NRW in Israel.

2.4.1.2 Description

The water corporations started implementing the water loss survey practice because they realized that before investing a lot of resources on improving the pipeline system it is critical to understand which tools will be suitable to the system and also if the benefits in this improvement is larger than the costs. The financial costs in changing the aging systems or in implementing new system-wide technologies are usually very high. The survey can prevent the replacement of the system's parts and improve NRW by organizing the water management in efficient way and with lower costs.

Naturally, where authorities have used computerized systems as a part of the system management, the relevant data could be produced for the NRW survey more easily. A good example for water corporations that used computerized systems is in the cities of Netanya and Haifa.

The methodology of the survey includes:

1. Review of the theoretical background information (utility piping maps, design data of demand-supply and pressure, consumer database, calculations);
2. Collect data from the water corporation (e.g.: water metered volumes at the inlet and outlet of the system, consumption data, maintenance levels and logs, etc.) and complete the missing data from field excursions.
3. Process and analyze the data; analyze the results and conclusions;

The necessary recommendations for the future plans can be formulated accordingly. Examples of such recommendations as raised by DHV survey done for the city of Lod (70,000 residents) at 2011 are listed below:

- Install meters on identified illegal connections region and other unmetered supplies (like city gardening and swimming pools).
- Divide the city to several DMAs with separate inlet metering on each header.
- Reduce number of supply connections for the national water company from 15 to 5.
- Install online metering registration of flows.
- Install remote transmission wireless meters

Water system management includes control provisions (mainly flow meters and pressure regulation) that allow understanding the rates of the different NRW components. Installation of control provisions like that is the first step for understanding which changes are required in order to improve the system.

Collecting the data is not an easy task, but it allows getting assessment of the physical and commercial water loss. Such data includes:

- Registered data of all the water consumption – usually taking the last one to two years' information from the billing center of the water utility.
- Water metered at the inlet of the systems; system's input, usually originating from two main sources:
    - Production from wells (metered at the well)
    - Inlet from national water company (billed monthly)

The gap between system's input and the authorized consumption (whether metered or unmetered) represents the non-revenue water (refer to **Figure 1**).

- Estimating the authorized consumption. There is a problem to obtain values for the authorized consumption that is not paid because it is not measured on a regular basis (usually public gardens and buildings). Hence, part of the authorized consumption is estimated based on the survey that may include: gardening, water for cleaning the pipeline and the ponds, water for fire, swimming pools etc.
- Estimating the value of the commercial loss that is caused by unauthorized consumption (illegal connections), and lack of accuracy of water meters and error in registering the data. This estimate is more complicated and the data will be only an assessment. Illegal water consumption can be estimated according to anticipated use (usually as liter per day per capita in case of municipal uses, or water needed per unit area and crop type in case of irrigation). For water meters, it is possible to estimate the level of accuracy and multiply it with the numbers of water meters.

- Calculating the real physical loss – possible only where data is available in areas that are simultaneously metered on-line for inflow and demand. **Figure 1** demonstrates the various classifications for NRW analysis that are used to quantify the survey results:
- Administrative NRW includes the items marked in the solid line of **Figure 1**
- Physical water loss includes the items marked in the 2-solid lines of **Figure 1**

The principal components in **Figure 1** are:

- System Input Volume: the annual input to a defined part of the water supply system.
- Authorized Consumption: the annual volume of metered and/or non-metered water taken by registered customers, the water supplier and others, implicitly or explicitly authorized to do so. It includes water exported and leaks and overflows after the point of customer metering.
- Non-Revenue Water (NRW): the difference between System Input Volume and Billed Authorized Consumption. NRW consists of Unbilled Authorized Consumption and Water Losses.
- Water Losses: the difference between System Input Volume and Authorized Consumption, consisting of Apparent Losses and Real Losses.
- Apparent Losses consists of Unauthorized Consumption and Metering Inaccuracies.
- Real Losses: the annual volumes lost through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering.

Regarding difficulties in implementation, the main issue is data availability for several reasons (poor documentation, old systems, transfer from municipality to water corporation). The crucial information is the physical mapping of the utility infrastructure and the operating parameters of inflow, demand and pressure levels. This problem is overcome by performing Asset Survey which maps the whole "as built" system status. The activity requires specialized technical services for locating the pipes and some many field checks and may take few months for a city. The end result is a GIS documentation of infrastructure with properties of the assets like pipe diameter, type of material etc.

2.4.1.3 Reference

1. Enlarging water availability in Israel by reducing water loss and sewage leaking, Dr. Ofira Ayalon, Shmuel Ne'eman Institute in the Technion, Haifa 2009
2. Minimization of water loss in urban water supply systems – Instructions for systematic implementation in Israel, Water Authority 2010
3. Mey Lod, preliminary water loss survey, DHV MED 2010
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5. National water and sewage authority activity report 2011
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7. Lambert, A., "Water Loss, IWA Task Force- Assessing non-revenue water and its components: a practical approach", water 21,vol2, pp50-51, 2003.

2.4.2 BP2: Water meters' replacement and installation

2.4.2.1 Summary

This practice includes installation of new water meters in every private and public consumers, and changing the aging and damaged water meters.

The purpose of this practice is to have all the consumption billed, and to get accurate water balance that includes every consumer with a full picture of the water consumption in the city. This practice helps to reduce NRW dramatically at most places and leads to minimization of the costs of water losses for the water corporations.

The main success of this best practice comes from:

- Installation of water meters on consumers connections that were not metered
- Installation of water meters on public consumers
- Replacement of aging and damaged water meters

Example for public consumption - in the years 1998-2000, the Ministry of the interior promoted a large campaign to install water meters in the public sector (like public gardens and municipal institutes). According to reports from the authorities, water meters were installed for most of the public consumers; consuming about 64 million m^3 per year (around 8% from all the urban consumption). This operation reduced the administrative NRW in Israel.

Example for private consumption – in 2011, the water corporation of Lod city (70,000 population) installed meters for some 10,000 inhabitants that were already connected for few years to the municipality water supply system but without metering. This action itself reduced the NRW dramatically from 40% to about 20-25%.

2.4.2.2 Description

According to surveys that were made in several local authorities in Israel (recommendation document, 2000), most of the NRW was caused by the lack of proper municipal water consumption metering and/or registration. It includes public building, public gardening, fire department, illegal connections etc. In addition, inaccurate water meters due to physical deterioration caused inaccurate registration. Another factor was wrong application of meters; not in accordance with the technical specifications (the sensitivity of the measurement doesn't allow to measure low flow rate). Another reason is illegal connections; consumed water which is not metered.

This situation created different problems that the authorities needed to deal with in the past and the water corporations in the present: loss of water and consequently financial losses due to lack of payments for the NRW. The latter poses financial difficulties on the water corporations which do not allow them to invest in maintenance, operation and rehabilitation of the pipeline system as they should. This situation led to development of this practice.

The following graph and table demonstrate the effect of installing water meters on the NRW percentage and amounts between 1998 and 2000 (according to data delivered by Nir Bar-Lev; the head of engineering management of Ra'anana city).

FIGURE 4: NRW CHANGE IN RA'ANANA, % OF NRW OVER THE YEARS OF 1996-2007

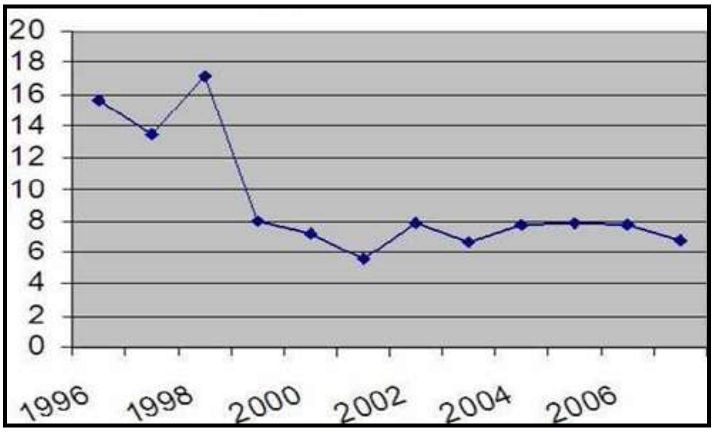


TABLE 7: WATER CONSUMPTION AND NRW IN RA'ANANA BETWEEN 1996-2007

NRW [%]	NRW [m^3]	Consumptions [m^3]	Water inlet [m^3]	YEAR
15.7	1,336,547	7,170,853	8,507,400	1996
14.5	1,287,338	7,561,332	8,848,670	1997
15.5	1,381,623	7,534,013	8,915,636	1998
9.5	859,601	8,166,343	9,025,944	1999
7.9	678,061	7,922,581	8,600,642	2000
4.9	394,992	7,692,156	8,087,148	2001
9.9	849,436	7,728,984	8,578,420	2002
7.8	648,726	7,720,096	8,368,822	2003
7.4	656,028	8,170,152	8,826,180	2004
8.4	734,982	7,983,978	8,718,960	2005
4.7	398,975	8,103,895	8,502,870	2006
6.8	656,967	8,253,973	8,910,940	2007

We can see from the graph and table above, significant decrease of the NRW between the years of 1999-2001, with an average NRW rate of 7.4% versus more than 15% before change. This change started in the end of the 90's when a team that dealt with the supply and use of the water was established with the purpose of reducing the urban NRW and to encourage consumers to save water. During the past 10 years, the NRW was reduced by more than half of the value of 1996. As indicated above, the main change in NRW happened between 1999 and 2001, when replacing the old water meters started. Installing the new water meters saved about 500,000-600,000 m^3 of water a year.

The replacement of the meters is done by the meter supplying companies and there are no technical difficulties to perform.

The investment return period of the replacements varies from one year to three years as explained in the identification section of this report. No specific costing data is available for the projects demonstrated.

2.4.2.3 References

1. Enlarging water availability in Israel by reducing water loss and sewage leaking, Dr. Ofira Ayalon, Shmuel Ne'eman Institute in the Technion, Haifa 2009
2. Minimization of water loss in urban water supply systems – Instructions for systematic implementation in Israel, Water Authority 2010
3. Mey Lod, preliminary water loss survey, DHV MED 2010
4. National water and sewage authority activity report *2011*
5. Dauber, Y., Water supply data of municipalities and water corporations at 2010,*Water Authority 2011*
6. WWW.WATER.GOV.IL

2.4.3 BP3: Pressure management

2.4.3.1 Summary

Physical leakage flow from pipeline crack or whole is rated $Q = A \times P^X$ (Q=flow, P=Pressure, A=area and shape coefficient, X=leak factor) whereas the factor X was studied worldwide to be within range 0.5-2.5. Thus the pressure in the piping system is a critical factor in the flow and quantity of the NRW in case of leakages.

Water pressure has an important purpose in regularly supplying water in the general water system, and especially overcome the difficulty in supplying water to high places.

Operation of this practice requires knowing the pressure profile in the water distribution network throughout the day and in the different seasons of the year, the consumption profile of every zone, and detecting irregular events - such as pressure surge or sudden drop or unexpected high flow at night time - and irregular levels of NRW.

Using pressure management can reduce the physical NRW dramatically in the system.

FIGURE 5: TYPICAL PRESSURE REDUCTION VALVE STATION ON WATER MAINS

2.4.3.2 Description

Pressure management is considered the single most beneficial, important and cost effective leakage management activity.

High pressure in the water system has different problematic aspects:

- Fixing and maintenance of specific leakage in the pipelines can raise the water pressure in other places of the systems, which can lead to an increase in water losses.
- The water comes out from the faucet under high pressure, and therefore the consumer uses a bigger amount of water than he needs.
- With regards to the physical NRW, water that flows in the pipelines under high pressure tends to flow out from every possible hole. Therefore, it's clear that from every crack or damaged connector there are more leakages, and the high pressure of water increases the volume of the leakages and with time, expands the holes and cracks.
- Supplying water under high pressure means high consumption of energy.

Dealing with these problems requires continuous matching between the pressure and the water supply systems demands, according to the level of consumption and the pressure demands on critical points.

According to the new Israeli guideline on the level of water pressure in the water network, the maximum pressure in the peak hours should not exceed 5 atm. The minimum dynamic pressure should not go under 2.5 atm at street level.

Planning water pressure zones includes the following steps:

- The planner will use data related to the water consumption forecast from the water supply master plan.
- The planner will perform network modeling of peak consumption scenario and of the low hours' consumption in every pressure zone.
- The planner and the engineer of the water corporation, will measure the actual pressure in several critical intersections in the water network
- The planner will compare the actual pressure to the pressure data from the modeling in order to make sure that the modeling results match those from the field (validation or calibration processes). It's recommended to perform the tests in the low hours (02:00-04:00 am). A difference in pressure between modeling and actual measurement of ±2 m in flat areas and of ±5 m in mountainous areas could be accepted as reasonable. If the difference is bigger, the water corporation and the planner need to locate the reasons (in the field or in the model) and fix them.
- The planner will mark in the plan the lines where the pressure exceeds 5 atm and where the pressure is lower than 2.5 atm.
- The planner will hand over a recommendation of changing the limits of the water pressure zones, including shifting of lines from one water pressure zone to another, and installing dynamic or static water pressure regulating valves.

There are different technologies that allow controlling the water pressure in the system:

- Division of the system to isolated sub-zones, allowing use of suitable value of pressure for the specific zone. This method is especially important when the water system includes private houses and multi-storey neighborhoods, or when there are areas in the water system that are separated in the topography with elevation differences.

- The introduction of pressure management areas (PMAs) and DMA management requires defining the area of the network, closing the boundaries and measuring the inflows and outflows - whether for DMA analysis or to control inlet pressures. Clearly where the topography dictates, the planning of PMAs and DMAs should be undertaken as one overall concept, although implementation of one stage may come before the other.

Figure 2-6 below demonstrates the water pressure difference as a result of the location/elevation of the properties: water is distributed to customers through a network of water supply zones. Water reservoirs are located in high points in each water supply zone. Water is distributed from the reservoir across the zone using a gravity or pump-pressurized system. Water pressure varies at different locations in the zone depending on property's elevation and proximity to the reservoir/pump. Properties in low areas receive higher water pressure. Properties in high areas receive lower water pressure.

FIGURE 6: WATER PRESSURE DIAGRAM

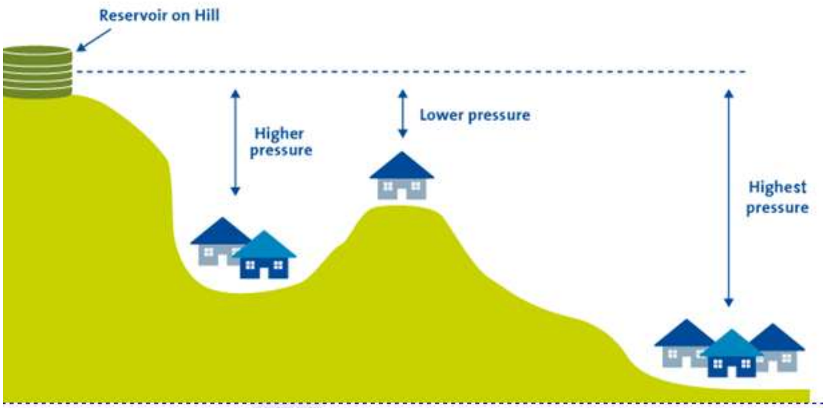


Figure 2-7 shows an example for equal pressure lines created in network distribution modeling (city of Lod, 70,000 population). The planned water pressure is expressed in isobars which allow understanding and design of pressure zones that meet demand pressure without exceeding maximum pressure.

Maintaining the pressure valve is done by the following methods:

- Use of dynamic pressure system, i.e. the pressure changes according to the demands. In this way, in the hours that the consumption decreases, the pressure decreases as well, but still allows a normal supply of water to the different consumers. When the demand rises, the system matches the water pressure accordingly. The use of dynamic pressure system allows reducing the leakages that happen because of high pressures and reduces the value of NRW.
- Use of pressure holding equipment: there are 2 kinds of pressure holding equipment: pressure management level one where the pressure is maintained constant during the day; and pressure management level 2 where 2 different pressure values are set during the day; depending on demand.

FIGURE 7: EXAMPLE FOR MODEL RESULTS WITH FLOWS AND PRESSURE ON ISOBAR BACKGROUND (KPA)

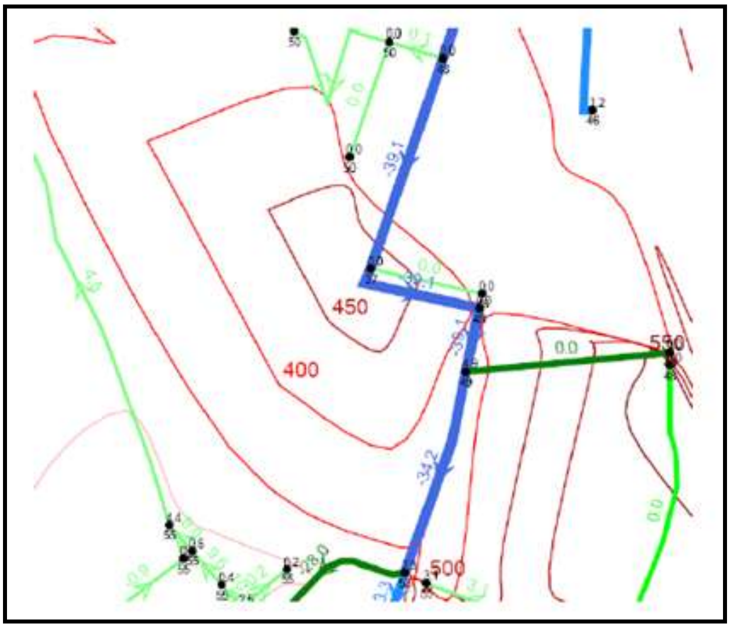
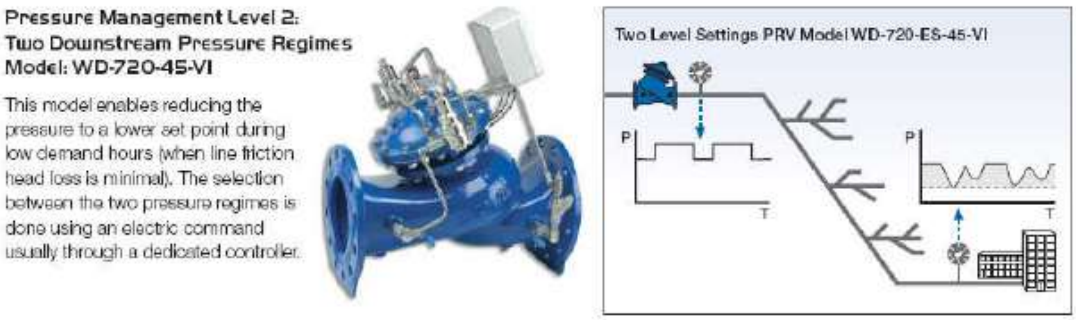


FIGURE 8: EXAMPLE FOR PRESSURE MANAGEMENT EQUIPMENT LEVEL 2



A case study that demonstrates how pressure management reduces the NRW was conducted in Haifa (270,000 population). The water department of Haifa municipality, managed to keep a reasonable range of NRW at 7-8%, despite the mountainous topography that requires high pressure in water supply.

Water systems, that are planned to assure proper and reliable supply in the peak demand hours, provide pressure values that are higher than required for their ordinary activity. The systems work according to plans designed to meet future needs or peak times. Accordingly, the water pressure is higher than the requirements for regular supply. This can be controlled by proper pressure management to avoid the related NRW and energy loss.

2.4.3.3 References

1. Enlarging water availability in Israel by reducing water loss and sewage leaking, Dr. Ofira Ayalon, Shmuel Ne'eman Institute in the Technion, Haifa 2009
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3. Mey Lod, preliminary water loss survey, DHV MED 2010
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5. National water and sewage authority activity report 2011
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7. Lambert, A., "Water Loss, IWA Task Force- Assessing non-revenue water and its components: a practical approach", water 21, vol2, pp50-51, 2003.
8. Morrison, J., "Water Loss- IWA Task Force Managing Leakage by District Metered Areas: a practical approach", water 21, vol5, pp44-46, 2004.
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11. WWW.WATER.GOV.IL
12. WWW.SYDNEYWATER.COM.AU

2.5 CONCLUSIONS AND RECOMMENDATIONS

Israel is coping with NRW issues intensively since early 2000's, mainly after the shift of urban water supply from municipalities to dedicated water companies (the 52 municipal water corporations). Normal accepted NRW level is envisioned at 5-10% compared to actual NRW of 15-40% in various cities until year 2000.

The following practices for NRW registration, control and reduction have been tried successfully:

- Water meters replacement and installation
- Advanced wireless metering system
- Pressure management system
- NRW survey
- Water Meters QN 1 1/2
- Combined water meters
- Control systems
- Replacing old pipeline
- Active discovery of hidden leakages
- Installing instruments to prevent water hammer
- Enforcing and supervision
- District Metered Area (DMA)

Based on the interviews with the key stakeholders, the most effective and recommended BPs to start dealing with the NRW issue is to conduct a water loss survey and pressure management installation. These practices result in high NRW reductions and the respective benefits outweigh the costs.

The ultimate physical actions that reduce dramatically the water loss are installation of water meters (replacing old / damaged / missing) and renewing the old piping infrastructure. The latter is highly expensive and complex to execute, thus another added value of the NRW survey is the ability to plan infrastructure renewal according to priorities of water loss reduction.

3 DOCUMENTATION OF BEST PRACTICES IN NRW MANAGEMENT – CASE OF JORDAN

3.1 OVERVIEW OF NRW MANAGEMENT IN JORDAN

Jordan is among the countries adopting IWA approaches from the early stage in dealing with NRW issues. Thus, most of the features promoted by IWA are already in practice in Jordan. But due to Jordan's widespread intermittent supply system and IWA's basic dealing with continuous supply, there are several aspects not fully addressed by the IWA guidelines.

Despite the major investments within the last decade, reduction of NRW rates in Jordan has not been significant. Reports issued by the Ministry of Water and Irrigation show that only a slight drop in the level of NRW has been noticed as shown in the table below. This is partly due to the facts that apparent or administrative losses make up a big share of the NRW. It is assumed that approximately 50 percent of the total NRW is due to the components of apparent losses.

TABLE 8: NON-REVENUE WATER IN JORDAN (2005-2010)

Year	2005	2006	2007	2008	2009	2010
%	46.30	44.50	44.30	43.88	43.12	43.59

The components of NRW are physical and administrative losses. The estimated respective value of these components in Jordan is 50% of NRW level. The causes of physical losses are mostly aged water pipelines, frequent bursts and service connections; being galvanized type. While the administrative losses are due to many factors such as; illegal tapping, inaccuracy of water meter, incorrect reading.

In 2004, the Ministry of Water & Irrigation (MWI) has espoused different policy to manage the NRW. However the true experience was dedicated to change local water utilities' attitude and ideas to address NRW issues. The policy was oriented towards: establishment of governmental companies working on commercial basis, involving the private sector in certain tasks of water management, improving and developing the capacity of the water utilities to address NRW issues and helping them reduce NRW efficiently in combination with DMA establishment, and pressure management.

The basic principle for calculating the NRW is the flow balance adopted by IWA; (refer to **Figure 1**).

The main approaches to deal with the physical losses in Jordan are: daily network maintenance, replacement of deteriorated pipes including service connection and the yearly program of rehabilitation; in addition to pinpointing hidden leakages. While the yearly campaign to discover illegal tapping, water meter replacement and utilizing hand held units for more accurate reading are the major activities to improve the administrative losses.

3.2 IDENTIFICATION OF BEST PRACTICES FOR NRW

Jordan attempted different practices to reduce NRW. Some had good and long term impact while others had relatively good impact but for short duration. Moreover, water shortage and customer complaints may prevent the water utilities from fulfilling their plans and activities. Below is a listing of the NRW reduction practices:

3.2.1 General inventory of NRW practice in Jordan

Replacing the galvanized type service connection, deteriorated and small size Network Pipes

This practice is common in Jordan; due to the fact that most of the leakage occurs in the galvanized service connection. Thus all utilities are instructed to replace these pipes with polyethylene types. Many small diameter pipes were installed and still under operation to serve small communities. But due to the increase in the population most of these pipes are not capable to serve those customers during the supply time which is 2 days per week. Under these conditions of supply, these pipes are subject to high pressure and burst. The replacement of deteriorated network pipes mostly depends on the report issued by the control room and maintenance department. The replacement plan is conducted according to the age and frequent bursts of the networks.

Water Meter Replacement and Sealing Program

The water meter replacement and sealing program has a big impact on NRW reduction. More than 90% of the customers' water meters are class B. Studies and research have shown that this type of water meter will not be able to read low flows of 30 Litres per Hour (L/Hr) after certain time, resulting in under registration which has a big contribution to NRW. Jordan established a policy that all water meter nominal diameters (DN 15, 20, 25) which passed 2,000 cubic meters of water or which are 5 years old (whichever comes first) should be replaced. In addition, sealing of already installed water meters is a continuous process to minimize illegal uses. A minimum penalty of 30 dollars is imposed for broken seals, in addition to payment of the estimated water consumption during the time between the last two readings (billing is quarterly in Jordan).

Micro-Private Sector Participation (PSP) Experience in Jordan

Micro-PSP is a relatively new concept in Jordan. After some experience with the time consuming process involved in the Management Contracts in Amman and the Northern Governorates Water Administration (NGWA), the Micro-PSP approach was proposed as a fast-track option to achieve service improvements. Yet, it was also clear that due to the limitations of the Micro-Scale PSP approach, it had to be seen rather as a complementary, preparatory stage for all kinds of PSP in the operation and management of water and wastewater systems in Jordan. The objective of exploring the concept Micro-PSP is a goal in itself in Jordan. In addition to other objectives related to cost reduction, management innovation and performance improvements, the creation of a market for local private companies to support the reform process in the water sector was perceived as a crucial economic issue.

Individual Service Connection Survey

This method is not internationally established yet but specifically developed by the NRW team in the country based on their experience, and adapted to suit the Jordanian situation. The concept behind this survey is that in addition to surveying main lines for leaks it is necessary to check every service connection and customer meter for possible illegal connection and leaks.

Establishment of District Metered Area (DMA)

Experience from work in pilot areas shows that, under current overall NRW situation in Jordan, if any DMA is found to have baseline NRW of 25% or less, it should not be given priority for countermeasures, as it would require more effort to reduce NRW by the same extent in comparison to other areas with much higher NRW baseline. Thus the baseline determination works should proceed to other DMAs. The same applies to the NRW level after countermeasures. If NRW is reduced to 25% or less due to countermeasures in a given DMA then the latter should be put under lower priority and NRW reduction works should be focused on other DMAs.

Licensing System for Service Connection Installation

It is a well-known fact that most of the leakage cases happen along service connections. Major causes are generally derived from aged deteriorated pipes, poor workmanship during pipe connection and installation, use of substandard pipe materials and improper trench preparation for protecting pipes from damage. Among these causes, there are many causes that can be avoided if the contractor works according to the official instructions, and if the relevant utilities' staff carries out strict supervision on the contractors during the installation of the service connections. This will eventually contribute towards the reduction of Non-Revenue Water (NRW).

Pressure Management "Pressure Control System"

As in many other developing countries, intermittent water supply is widely practiced in Jordan for several reasons that include scarcity of water resources, inadequate storage and distribution facilities. The intermittent supply system is detrimental to the behaviour of water networks. Pressure control in areas of excessive pressure, helps in overcoming many such negative effects caused by an intermittent supply system. The mountainous nature of the service areas in Jordan and the intermittent way of water supply; increase the water pressure in the networks and therefore, result in increasing the number of bursts in the pipes, in addition to the negative direct impact on water meters. To deal with this type of problem, a big investment in the procurement of Pressure Reducing Valves (PRV), zoning, hydraulic modelling, construction of new reservoirs, etc. is required (as is the case in Amman and other water utilities in the major cities).

3.3 IDENTIFICATION OF THREE EXEMPLARY BEST PRACTICE METHODS

The following 3 cases were selected based on discussions with the stakeholders and will be elaborated and evaluated against the criteria set out in the terms of references and presented in the **Executive summary**

3.3.1 BP1: Micro-PSP Experience in Jordan

3.3.1.1 Impact

- The application of the Micro-PSP approach which was implemented in Madaba Administration had a big impact on the reduction of NRW; especially on the side of administrative losses. Three components of administrative losses were addressed. These were (a) billing, (b) illegal water uses and (c) replacement and re-sealing of water meters. The PSP approach resulted in increased billed amounts with respect to (WRT) the base year, increased number of detected illegal uses, and increase in the number of water meter replacement and re-sealing; respectively, as depicted in the tables below:

TABLE 9: EFFECT OF MADABA PSP ON BILLED AMOUNTS IN MADABA WATER ADMINISTRATION

Year	Billed With Tariff Effect	Billed Increase WRT Base Year %	Billed Without Tariff Effect	Billed Increase WRT Base Year %
2005	879,137		879,137	
2006	1,540,853	175%	1,370, 716	156%
2007	1,604,555	183%	1,401,718	159%
2008	1,587,493	181%	1,372,710	156%
2009	1,618,202	184%	1,384,052	157%
2010	1,724, 962	196%	1,491,053	170%
2011	2,084,655	237%	1,542,645	175%

TABLE 10: EFFECT OF MADABA PSP ON NO. OF ILLEGAL WATER USE

	2006	2007	2008	2009	2010	2011	Total
Number of reported cases	591	512	479	410	481	516	2,989
Estimated volume in m3	126,841	134,083,	220,472	146,454	143.745	183.003	954.598

TABLE 11: EFFECT OF MADABA PSP ON WATER METER REPLACEMENT AND RE-SEALING

	2006	2007	2008	2009	2010	2011	Total
Water meter re-seal	4,963	3,237	2,961	3,151	5,013	3,031	22,356
Replaced water meters	2,391	1,615	3,242	2,209	2,975	1,594	14,026

The Micro-PSP provides a good management tool for monitoring, controlling and assessing the NRW reduction through different activities; building capacity, awareness and incentives. The institutionalization of such system has been noted by changing the behaviour of both the staff on the one hand and the customers on the other.

The new communication style between the company and the customers paved the way for confidence-building which was very important in changing the attitude of the customers regarding illegal tapping and thus reduced the water consumed illegally.

Despite the achievement, the documentation of the application of Micro-PSP did not include the customers' satisfaction for the service delivery, which was very important to complete the picture of the success story.

3.3.1.2 Technical feasibility

The results achieved in the project encouraged the Water Authority of Jordan at MWI to replicate the experience gained from Madaba in other water utilities such as Balqa and Karak. The need of expertise are always required especially; in the assessment and development of the concept, including its applicability in other activities. However the available skills among MWI/WAJ staff and their active contributions provided good technical resources to run these kinds of projects.

The prospect of success for this type of project is almost certain if the following elements are met: the political will, stakeholders acceptance of the win-win scenario approach and establishment of benchmarks for the achievements.

As mentioned above the practicality of this type of project encouraged MWI/WAJ to award two contracts for two additional water utilities; Balqa and Karak, and the initial result is showing good performance in both utilities as shown in the tables below.

TABLE 12: BALQA FINANCIAL INDICATORS IN JORDANIAN DINARS (JDs[5])

Year	2011	2012	Increase
Billings (JD)	5,114,366	6,996,390	36.80%
Collections (JD)	4,517,631	6,671,859	47.68%

TABLE 13: KARAK FINANCIAL INDICATORS (JDS)

Year	2011	2012	Increase
Billings (JD)	2,049,021	3,024,401	47.60%
Collections (JD)	1,973,588	2,551,963	29.31%

3.3.1.3 Financial feasibility

The financial feasibility of the project showed that after one year, the accumulated additional cash was higher than the accumulated cost, and the break-even point for the full contractual costs was in the seventh quarter.

3.3.1.4 Affordability

The affordability of the implementation of similar project is manageable. However it requires a strong political will in most cases.

[5] 1 JD = 0.708 US DOLLARS

3.3.2 BP2: Licensing System for Service Connection Installation

3.3.2.1 Impact

Analyses of the components of real losses assist in identifying where the largest components occur in any individual system, and how these components are influenced by the utility policies. The large number of joints and fittings in the service connections between the main and the edge of the street result in a relatively high value for background leakage in this part of the infrastructure (A.O. Lambert (UK) "Water Losses Management and Techniques" 2001). The establishment of a special licensing system for the installation of house connections is one of the most important measures to control the physical losses as well as to reduce illegal uses. Accordingly MWI/WAJ issued an official instruction "in cooperation with the Contractors' Association" for the implementation of a country wide licensing system involving contractors registered for the installation of service connections. The system was supplemented with the publication of related guidelines and the implementation of training of both the contractors; as a prerequisite for getting their license, and the relevant utilities staff; responsible for supervising the installation work.

The agreement between the MWI/WAJ and the Contractors Association for this system and its implementation is considered as a basis for licensing the contractors. The application of this system will have a significant impact on the reduction of NRW; in terms of both the technical and administrative components.

3.3.2.2 Technical Feasibility

This system is technically very important to control the losses and the possibility of its application is available at all levels. The approval of the Contractors' Association to apply this system is one of the success stories on the cooperation between the public and private sector. In addition, through the training of its own staff, MWI/WAJ is now able to train the contractors in addition to the staff of other utilities. However, yearly refreshment training is needed and should be done by experts to keep their potential at an adequate level. All the technical resources (tools and equipment) are available in the market with moderate prices, which enhances the smooth application and implementation of the system. The application of such a system is not difficult, but there must be a strong decision and good governance to put this system in an institutional framework that serves the public interests. All the materials needed for the training are available in the central warehouse of MWI/WAJ, as part of the material used in the installation of house connections for customers. However, the point of weakness in the long run is to maintain and replace the tools and machinery used in the training which requires a special budget.

3.3.2.3 Financial Feasibility

The cost of this system is reasonable except for the above mentioned point (see 3.3.2.2). However payment of the prescribed fees by the contractors for the training of their staff, will contribute towards the costs of procurement and maintenance of the material and tools required for the training. Meanwhile the licensing system is expected to have significant impact on the service connection losses and thus should increase the financial benefits. So far the impact of implementing this system on the losses has not been monitored.

3.3.2.4 Affordability

Implementation of this system requires mobilization of resources from different parties (contractors, network operators, technicians, etc.), well-trained utilities' staff, premises for training, availability of materials and enforcement.

3.3.3 BP3: Pressure Control System

3.3.3.1 Impact

The pressure management in water networks is considered one of the most essential elements to reduce NRW, which is reflected positively on the physical and administrative losses. The impact of the pressure control system implemented in two pilot projects (in Fuheis area at Balqa Governorate Water Administration (BGWA) and Sanfahah and Arwayyemm Areas at Tafieleh Governorate Water Administration (TGWA)) showed great results; involving the reduction of both the pressure on the water networks and the NRW ratio as follows:

Fuheis Area: Reduction of pressure by 57 m (from 93 m to 36 m), while the NRW was reduced from 36% to 18%.

Sanfahah & Arwayyemm Area/Tafieleh Governorate Water Administrations (GWA): the average pressure was reduced by 44 m (from 141 m to 97 m) and NRW ratio from 40% to 15%.

As a result of the pressure reduction; the number of pipe bursts and customer complaints was significantly reduced in the areas.

3.3.3.2 Technical Feasibility

The pressure management approach is a good tool to reduce physical and administrative losses and technically is feasible for implementation, and applicable under intermittent supply condition. Lower NRW could be achieved by managing pressure in the selected pilot areas. Reduction of NRW below 20% (5~10% below that achieved by active NRW reduction measures such as leak detection, repair, and defective meter replacement) was possible. However, the pressure management under intermittent supply was found to have some potential challenges; mainly related to customer complaints arising due to delayed time of water reception due to the reduced pressure.

3.3.3.3 Financial feasibility

The financial feasibility for such projects is challenging due to the investment and payback period, the results from reported figures show that the recovery period is between 2-5 years. The longer recovery period is caused by higher investment required for new distribution network in the area. The analysis is intentionally simplified and takes into consideration only the direct components of both costs and benefits. Indirect components such as supervision cost and benefits due to reduced burst frequency have not been included in the analysis considering the overall accuracy of the whole exercise.

3.3.3.4 Affordability

The ability to mobilize resources for the implementation of this BP is subject to the NRW level and the system of water supply. Most of the water system improvement activities are directly or indirectly related to NRW loss reduction. However, to increase the effectiveness of pressure reduction activities and highlight the importance of NRW reduction, utilities should allocate the budget and commitment for the sustainability of the activities. The success to implement these activities or failure to do so should also be taken as a criterion for performance evaluation of the stakeholders.

3.4 DOCUMENTATION OF THREE NRW BEST PRACTICES

3.4.1 BP1: Micro-PSP Experience in Jordan

3.4.1.1 Summary

The Micro-PSP approach was proposed as a fast-track option to achieve service improvements in Jordan, and as one of the possible means to set the stage for other kinds of PSP in the operation and management of water and wastewater systems in the country. Micro-PSP does not only help reduce costs, and improve performance in the utilities, it also assists in the creation of a market for local private companies to support the reform process in the water sector.

The first Micro-PSP pilot project in Jordan can already be described as a great success. The project provided opportunities for the local private firms to participate and contribute to the water and wastewater services operation and considerably improved cash flow in the sector. Compared to large-scale PSP models, the required funding is much smaller and the preparatory phase shorter.

As a result of its success, the Micro-PSP contract which was first implemented in Madaba has not only been extended for another three years, but was also expanded in terms of outsourced tasks. Ultimately, the up scaling might also take place in a regional context - already some water sector authorities of other countries in the Middle-East and the Gulf States are investigating the Micro-PSP pilot study in Madaba to learn from it for their own reform processes.

3.4.1.2 Description

The Micro-PSP approach implemented in Madaba (2005-2008, extended till 2011) provides valuable information about the possibilities, but also the challenges of Micro-PSP in Jordan. The total number of water customers in Madaba Governorate is 19,500, of which 94% were household customers; large consumers play only a minor role in Madaba.

The situation of WAJ Madaba was dominated by severe problems in the customer management areas: customers were lost due to faulty application processes, the billing was often incorrect due to estimations, bills were not distributed due to poor information systems and the collection was ineffective; all of which led to very high Non-revenue water (NRW) ratios. Ten years before the Micro-PSP started, NRW ranged from 49-66%. A total revenue improvement potential of approximately 1.9 Million JD was estimated.

The following is a list of the target goals defined by WAJ

- Improved water and wastewater revenue;
- Reduced customer outstanding amounts;
- Improved customer management efficiency;
- Installation of computer aided customer management;
- Technical and administrative development of Madaba customer management organization.

Madaba was chosen as a pilot region for several reasons; these included but were not limited to:

- Relatively large improvement potential,
- Relatively small customers' base, so that task complexity is easier to handle,
- Proximity to Amman makes cooperation with WAJ Headquarters and general transactions and logistics easier,
- Strong interest from the local stakeholders in Madaba.

Due to the limited knowledge base of the competent companies in the tasks relevant for the contract, a very detailed preparatory workshop involving interested and competent companies was organized to support the transfer of knowledge and a better understanding of the expected activities. Furthermore and in order to ensure adequate build-up of the local competences, the time horizon for the Micro PSP project considered the time needed to transfer the know-how up to the final prequalification"

The services required under this Micro-PSP were:

- The Management of water & wastewater billing and revenue collection including the implementation of Geographical Information System (GIS) based tools;
- Implementation of Customer Information System; and
- Implementation of Sewerage Database within Madaba Governorate

The Terms of Reference and the contract clearly defined many details about the activities to be undertaken and the performance variables to be used. The contract was divided in two phases.

Phase 1 (Preparatory Phase): was seen as the basis for the re-engineering of the business processes. In Phase 1 the necessary systems and equipment were put in place, the databases were refined and the staff was trained. The remuneration for Phase 1 is in effect a fixed fee.

Phase 2: is called the **Performance Management Period** during which the private company takes over the performance based operations, i.e. meter reading, billing, collecting, bill objections handling, technical and financial inspections and follow up, service disconnection and prevention of illegal use.

An incentive scheme was built into the contract, whereby the private operator receives a certain percentage of the extra revenue collected during the year (compared to the base year). This percentage had to be specified by the bidders as part of their bid (should not be less than 10%) and was considered one of the award criteria. The winning bidder; Engicon offered a relatively high percentage of 14% and the total costs for the contract was about 900,000 JD.

Since the contract is a service contract for billing and revenue collection, the contractor brings in only a small number of its own staff. Forty two (42) employees mainly from the subscription department staff were seconded by WAJ to the company, but remaining on the payroll of WAJ. However, the contract foresaw bonus payments also for the seconded staff, and these bonus payments were part of the bidding variables.

The regulatory process is embedded in the contract, involving clearly defined targets. Monitoring is undertaken by the Project Management Unit (PMU) of WAJ, with a particular focus on verifying the contractor's performance in the collection of revenues, based on which incentives are disbursed.

The private partner managed to decrease the high NRW considerably and to improve the financial situation of WAJ significantly, through the collection of additional revenues. Both the net billed and net collected amounts have increased remarkably: the former increased by almost 80% between 2005 and 2008 while the latter by 84% during the same period.

In 2005, WAJ had collected revenue of less than 1 million JDs. In 2006 about 1.1 million JD were collected, in 2007 almost 1.7 million JD and in 2008 more than 1.75 million JD. These figures do not include the additional collected amounts due to tariff increase or the subscription of new customers. Hence, the accumulated additional cash for WAJ after three years reached almost 1.7 million JD.

This created a stronger financial position for WAJ; costing the government less in subsidies to WAJ/Madaba. One year after the implementation, the accumulated additional cash was higher than the accumulated cost, i.e. the contract "paid for itself". If the full costs for the services over the three years contract are considered and compared with the accumulated additional cash for WAJ, the break-even point for the full contractual costs would be in the seventh quarter.

The cash collection almost doubled over the three years, and the net benefit for WAJ, after deduction of all service payments to Engicon, is almost 1 million JD. Hence, the Micro-PSP proved to be a financial win-win partnership; both for the company and for WAJ.

The funding required for Micro-PSP is normally much less than that required for large-scale PSP models and the preparatory phase is shorter. This coupled with the service and operation improvements in the utility involved in Micro-PSP and the subsequent increase in cash flows, offers a good example of success that is worth replicating and up-scaling.

Despite its success in Jordan, not all expectations have been met: the start-up period with more than 2.5 years was longer than assumed; dependency on external funding requirements could be reduced but remained important, especially during the preparation time and the back-up partners. A critical issue was also the availability of competent local private companies to take over the tasks that WAJ intended to outsource via Micro-PSP. Hence, strong capacity development efforts are required to establish the long-term success of the Micro-PSP concept and to create a competitive market within Jordan.

3.4.1.3 References

1. Final Report: Water & Wastewater Billing & Revenue Collection Services Contract for Madaba Governorate, January 2012.
2. Improving Water Utility Performance through Local Private Sector Participation, Lessons Learned from the Micro-PSP in Madaba, Jordan, Discussion Paper Series No.1
3. Using Local Private Sector to reduce NRW by Improving Billing and Collection, the case of the Micro-PSP in Madaba, Jordan. GIZ office Amman, GIZ-Jordanien@giz.de.

3.4.2 BP2: Licensing System for Service Connection Installation

3.4.2.1 Summary

Experience has revealed that most of the leakage cases are derived from service connections. The service connections have such important roles in reducing leakage but it is a fact that the causes of many leaks, regardless of their being underground or above ground, are related to a lack of proper installation of service connections. Such connections can be easily damaged from external load like traffic as well as internal high water pressure, unless they are installed carefully according to the MWI/WAJ standards.

Accordingly, MWI/WAJ, in corporation with Japan International Cooperation Agency (JICA) introduced new instructions for the quality management of service connection installation which requires that any contractor who works for service connection installation obtains license/certification from MWI/WAJ.

This license is only issued to the contractors who have qualified “pipe- installation” staff trained and certified by MWI/WAJ. In order to avoid any sub-standard installation, the service connections have to be also installed by the qualified trained staff. MWI/WAJ in-house staffs who supervise the service connection installation work are also trained by MWI/WAJ Training Center at Marka, to enhance their knowledge and skills.

As an output of this approach, two official documents were produced; (1) a “Guideline for Service connection installation and (2) a booklet comprising 21 articles of applicable regulations and procedures to be used in accrediting the contractors for the installation of service connections. Together with the training, it is foreseen that the new system will contribute to the improvement of quality of each service connection and reduce water losses in the Kingdom.

3.4.2.2 Description

It is a well-known fact that most of the leakage cases happen along service connections. Major causes generally arise from aged deteriorated pipes, poor workmanship during pipe connection and installation, use of substandard pipe materials and improper trench preparation for protecting pipes from damage. Many of these causes can be avoided if the contractor observes, during the installation of the service connections, the related instructions issued by MWI/WAJ, and if MWI/WAJ in-house staff performs strict supervision on the contractors during the installation work. This will eventually contribute to the reduction of NRW.

In view of the above a guideline for the installation of service connections was produced. The guideline aimed at:

- Improving the performance of staff who supervise the installation;
- Improving the performance of the plumbers who execute the work; and
- Offering the best and safe technique for using High Density Polyethylene (HDPE) pipes as service connections.

The institutionalization of the new licensing system required building capacity of both the contractors’ employees and MWI/WAJ staff responsible for the supervision of the service connections installation to enhance their knowledge and upgrade their skills. To this effect, the guidelines are used as a background document for training, which covers among other topics: materials specifications, site preparation and land cutting, trench preparation, leakages, installation of the connections and water meters, pipes protection, over ground installations including protection from frost and stress and backfilling.

During the implementation of the program several key problems hindered the work such as lack of available tools and equipment in MWI/WAJ training centre and lack of available funds for procurement. In 2009, MWI/WAJ and Japan International Cooperation Agency JICA signed a Memorandum of Understanding (MoU) for a grant agreement which included;

- JICA will conduct a full implementation of the program by securing all needed material and tools.
- MWI/WAJ will provide all necessary pipes and fittings and commitment for the sustainability of the program.

The curriculum of the training course for service connection installation consisted of lectures, practice, practical test and paper test. The program provided the following essential knowledge and skills:

- Service connection installation;
- Understanding the outline of the licensing system;
- Clear understanding of MWI/WAJ responsibilities and contractors' responsibilities;
- Understanding of MWI/WAJ standards for trench preparation and pipe laying work;
- Theoretical and practical acquisition of pipe connection techniques,
- Skill upgrading for the installation of polyethylene pipes, since polyethylene pipe is becoming the more dominant pipe material for service connection in the Kingdom.

Furthermore a booklet comprising 21 articles of applicable procedures to be used in accrediting the contractors for the installation of service connections was also prepared and disseminated as binding instructions. According to the new instructions, the performance of the accredited contractors is evaluated each year based on several indicators that are prepared by the service connections committee whose members are pooled from the water administrations. These indicators include compliance of the contractors with MWI/WAJ standards for the installation of service connections, and the presence of a certified technician during the installation work. In case of violations, the contractor is banned from working for three months. Should violations recur, the banning would last for six month. Any more violations after that would result in discrediting the contractor who becomes ineligible for further contracting of service connection installation.

3.4.2.3 References

1. WAJ standard drawing for trench construction, 1998, p 24
2. Japan Water and Wastewater Association (JWWA) Design Criteria p 65 & 66.
3. SYABAS' Standard Specification for Pipe Laying Works, First Edition, May 2007, Syarikat Bekalan Air Selangor Sdn Bhd, Technical Services Division, Kuala Lumpur

3.4.3 BP3: Pressure Management (Pressure Control System)

3.4.3.1 Summary

As in many other developing countries, intermittent supply is widely practiced in Jordan for several reasons that include scarcity of water resources, inadequate storage and distribution facilities. The intermittent supply system is detrimental to and changes the behaviour of water networks. Pressure control, in areas of excessive pressure, helps in overcoming many such negative effects caused by an intermittent system.

Pressure reduction for the purpose of NRW reduction within an existing intermittent water supply system can be a highly sensitive task. Even if the hydraulic analysis is properly conducted for the planning, in practice, water pressure may become lower than the planned reduced pressure due to various unexpected reasons caused by [a] existing distribution pipes which actually have smaller diameters than those recorded in the network drawing, [b] leakages from service pipes, [c] unexpected requirements of higher pressure for new houses (at elevation higher than pre-existing houses) and [d] unknown closed valves.

The unexpectedly low pressure may cause serious customer complaints, especially when the timing of filling their water tanks is significantly delayed due to late arrival of water to their homes. The complaints may sabotage the use of PRVs.

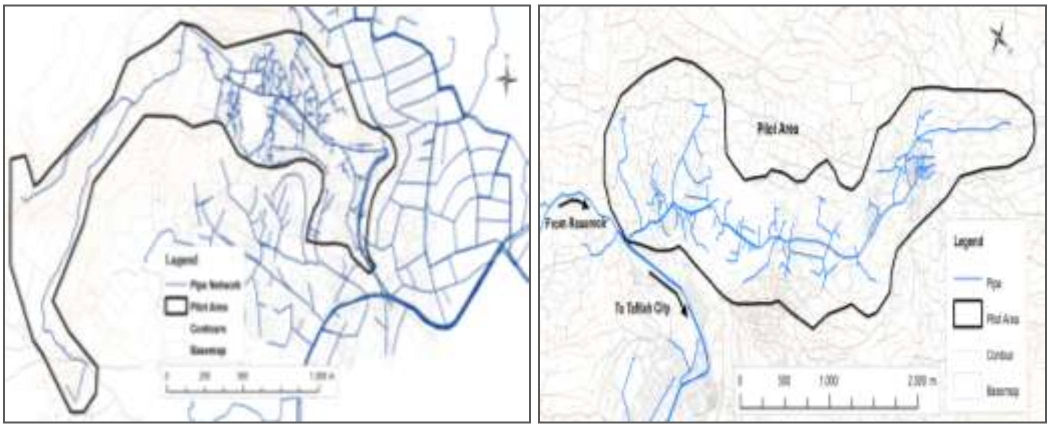
In order to address these issues, two pilot areas were selected. One of these was Fuheis in Balqa GWA and the other was Sanfahah & Arwayyemm in Tafilah GWA. Both pilot areas had high water pressure problems caused mainly by hilly terrain and inadequate distribution network management.

3.4.3.2 Description

The selected two pilot projects Fuhais in Balqa governorate and Sanfahah & Arwayyemm in Tafilah governorate were part of a steeply sloping hilly terrain and supplied through a single feeder line. Approximate elevations of inlet, highest point, and lowest point within the area were 847, 850, and 650 m in the former and 1040, 1150, and 995 m in the latter.

Before introducing the pressure control system in Fuheis, the area used to be supplied sometimes by pumping from a reservoir located at lower area and sometimes by gravity from another transmission line. Supply in Sanfahah & Arwayyemm area has been always by gravity from a reservoir located at elevation of 1353 m.

FIGURE 9: SCHEMATIC DRAWINGS OF TWO PRESSURE CONTROL PILOT AREAS IN FUHAIS - LEFT, AND SANFAHAH & ARWAYYEMM– RIGHT)



Key features of the above areas are summarized in the below table

TABLE 14: KEY FEATURES OF FUHAIS AND SANFAHAH & ARWAYYEMM PILOT AREAS

Description	Fuhais Area	Sanfahah & Arwayyemm Area
Number of active connections	567	480
Material of distribution mains	Steel	Steel
Material of house connections	PE and GI	GI
Supply hours	48 Hr/week	24 Hr/5days
Water pressure at area inlet	9-19 bar	17-29 bar
Maximum pressure measured within the area before pressure control	34 bar	23 bar
NRW ratio before pressure control	31% (832 /customer/day WSP	40% (1627 L/customer/day WSP)

Pressure control methods and results:

Hydraulic models considering pressure dependent discharge (representing customers with house tanks of sizes equal to their demand) were prepared with EPANET software. These models were used to determine suitable numbers, locations, and pressure reduction ranges of PRVs. In addition, improvement works required in the area such as adjustment of area boundary, new interconnections and disconnections essential for reducing spatial pressure gradients were also identified with these models.

NRW Reduction Results

Fuheis Area: NRW was measured several times in order to assess the effect of basic NRW reduction measures (such as leak detection and repair, defective customer meter replacement) and pressure management at various stages. The results are summarized in the following table:

TABLE 15: IMPACT OF PRESSURE CONTROL ON NRW IN FUHAIS PILOT AREA

Description	1st Survey	2nd (Baseline Survey)	3rd Survey	4th Survey	Final Survey
Supply start date and time	2009/06/27 9:00	2010/03/20 8:30	2010/06/12 9:00	2010/10/30 9:00	2011/02/11 9:00
Supply stop date and time	2009/06/29 9:00	2010/03/22 8:30	2010/06/14 9:00	2010/11/01 9:00	2011/02/13 9:00
Supply duration (hours)	48.0	48.0	48.0	48.0	48.0
System input (M3)	2,586	1796	3045	2,253	1,655
Customers consumption (M3)	1,800	1149	2102	1660	1358
NRW (M3/week)	786	647	943	593	297
NRW % of system input	**30.4%**	**36.0%**	**31.0%**	**26.3%**	**17.9%**

The results show that with basic NRW reduction measures and pressure reduction, NRW was lowered to about 18% from baseline value of 36%. In volumetric term, NRW was reduced by 350 m^3/ week (647-297=350 m^3/week, or 18,200 m^3/year). With the current number of active customers in the pilot area standing at 567, this translates to a reduction of 618 L/customer/week which is equivalent to an annual saving of 32.1 m^3/customer.

Sanfahah & Arwayyemm Area: NRW was measured several times in order to assess the effect of basic NRW reduction measures (such as leak detection and repair, defective customer meter replacement) and pressure management at various stages. The results are summarized in table 10 below:

TABLE 16: IMPACT OF PRESSURE CONTROL ON NRW IN SANFAHAH & ARWAYYEMM PILOT AREAS

Description	1st Survey (Baseline)	2nd Survey	3rd Survey	Final Survey
Supply start date and time	2009/8/4	2009/12/13	2010/11/23	2011/3/23
	11:00	13:00	12:25	11:50
Supply stop date and time	2009/8/5	2009/12/14	2010/11/24	2011/3/24
	11:00	13:00	12:40	12:05
Supply duration (hours)	24	24	24.25	24.25
System input (M3)	1,827	1,219	1,951	1,477
Customers consumption (M3)	1,090	928	1,561	1,253
NRW (M3/5 days)	737	291	390	224
NRW Percentage of system input	**40.3%**	**23.9%**	**20.0%**	**15.2%**

An innovative method (using GIS software programs to draw service pipes automatically) has been developed in order to model each customer's roof tank for the analysis of an intermittent supply system. The method was revealed to be effective, in the pilot projects, for planning pressure reduction aimed at NRW reduction.
This method helps to minimize negative impacts of pressure reduction, primarily the extension of the time required to fill all the customers' water tanks. This minimization of the required time is important in order to avoid uneven water supply to different locations in terms of the timing of water reception and residual pressure.

Through the pilot projects, it was found that the accuracy of distribution pipe data in the GIS database was more important than building more complicated models. It was also understood that low pressure problems can be caused, unexpectedly, due to several reasons during the implementation of a planned pressure reduction. The low pressure problems may cause serious complaints from customers, which may sabotage the continuation of the planned pressure reduction. Therefore, the experiences obtained from solving the unexpected low pressure problems were quite important for the capacity development on NRW reduction in Jordan.

3.4.3.3 References

1. Guideline on Distribution Network Management for NRW Reduction MWI/WAJ, June 2011.
2. Battermann, A. and Macke, S. 2001. A Strategy to Reduce Technical Water Losses for Intermittent Water Supply Systems. Thesis

3. Ingeduld, P., Svitak, Z., Pradhan, A. and Tarai,A. 2006. Modelling Intermittent Water Supply Systems with EPANET, 8th Annual WD Symposium
4. Epanet Free-Software to simulate water piping- (www.softpedia.com)

3.5 CONCLUSIONS AND RECOMMENDATIONS

Despite the major investments within the last decade, reduction of NRW rates in Jordan has not been significant. Reports issued by the Ministry of Water and Irrigation show that only a slight drop in the level of NRW has been noticed. This is partially due to severe water shortage in the country and related customers' complaints which can prevent water utilities to fulfill their NRW reduction plans and activities. In addition, apparent or administrative losses represent a big share of the NRW. It is assumed that approximately 50 percent of the total NRW is due to the components of apparent losses.

Based on the previously elaborated NRW best practices, the three selected approaches are key practices for NRW reduction; the Micro-PSP is focusing on the apparent losses while the pressure management and the licensing for service connection installation tackle physical losses.

The three approaches will contribute directly and/or indirectly in reducing the NRW; the Micro-PSP will affect the improvement of the financial issues with minimum cost; through increasing billings, collections, and reducing the illegal uses. Moreover, the pressure management practice will have a big impact in reducing high pressure in the networks, which means reduction of bursts and leakages. On another dimension; the improvement of service connection installation quality will reduce the leakages at the end-user level.

As a recommendation; the three selected best practices could be implemented at any water utility and are especially recommended in water scarce countries like Jordan. It is also recommended to build the capacity of water networks engineers and operators and exchange information and knowledge through training programs, workshops, conferences and publications. In this context; the Arab Countries Water Utilities Association (ACWUA) www.acwua.org, headquartered in Amman, Jordan is working intensively on building the capacity of utility members and exchanging experiences on NRW management and reduction.

4 DOCUMENTATION ON THE BEST PRACTICES FOR NON-REVENUE WATER MANAGEMENT - THE CASE OF MOROCCO

4.1 STATE OF NON-REVENUE WATER IN MOROCCO

The long-adopted policy in the water sector in Morocco through the implementation of a significant water infrastructure (more than 128 dams for a total holding capacity of nearly 17 billion m^3) has allowed it to have to good control over its water resources, ensure better use of water and meet the needs for drinking water and irrigation. However, the water sector faces several constraints and challenges, namely:

- The climatic and hydrological context of Morocco characterized by erratic rainfall and a succession of drought periods;
- The growth of urban and tourist populations puts pressure on conventional limited water resources.
- Overexploitation of groundwater is reflected by a net reduction of water reserves, the drying up of sources and/or significant deterioration in the quality of water by seawater intrusion.

Faced with these constraints combined with the scarcity of water resources and climate change, efforts are required to preserve and manage water resources available in a rational and sustainable manner.

The key water policy players in Morocco is the Ministry of Energy, Mines, Water and Environment (MEMEE) and the Ministry of the Interior as guardian of the communities. At the operational level, the responsibilities are divided between three private contract holders (Lyonnaise des Eaux de Casablanca (Lydec), the contract holder in Casablanca; Redal, the contract holder in Rabat; and Amendis, the contract holder in Tangiers and Tetouan), 12 municipal state-owned companies and the National Office for Drinking Water (ONEP). In addition to these institutions, 9 hydraulic watershed agencies (ABH) under the supervision of MEMEE are responsible for resource management.

ONEP is responsible for planning across the country. It is also the main operator providing almost all of the production. It is also the leading distributor providing distribution in 600 medium and small cities and rural areas.

Distribution in the cities of Casablanca, Rabat, Tangiers and Tetouan is provided by private contract holders. Distribution in other large cities (Fez, Marrakesh, etc.) is provided by state-owned companies which are 12 in number.

The average yield of water distribution networks in Morocco was approximately 70%. Each year, 300 million m^3 of drinking water are lost out of around one billion m^3 produced.

The new national development strategy in the water sector has raised water savings as a priority of government policy in this area. In this context, the development of a new national plan to improve yields of drinking water distribution networks is primarily intended to give new impetus to efforts by public operators in the sector.

The goal of this plan is to achieve 80% overall efficiency of distribution networks by 2020.

4.2 IDENTIFICATION OF BEST PRACTICES CONCERNING NRW IN MOROCCO

4.2.1 Methodology

Under the terms of reference, the definition of target operators was dictated by a set of criteria, of which the key criterion is the representative nature of the sample (vis-à-vis the population of operational actors in the distribution of drinking water).

Thus the following three operators have been identified:

- The National Office for Drinking Water, recently merged with the National Office for Electricity to establish the National Office for Electricity and Drinking Water (ONEE), representing the national level, both urban and rural.

ONEE produces more than 80% of all water produced in Morocco and distributes approximately 30% of all water distributed nationally.

- A local public operator, namely the Water and Electricity Distribution state-owned company for the city of Fez (RADEEF). RADEEF distributes approximately 7% of all water distributed nationally.
- An operator representing the private sector, namely REDAL, a subsidiary of Veolia Environnement, contract holder at Rabat-Salé. REDAL distributes approximately 10% of all water distributed nationally.

  The percentage of water distributed by the three operators is around 50%. The percentage of water produced by ONEE alone exceeds 80%.

A questionnaire was prepared with a sample sent to the various operators, and a series of interviews was conducted on the basis of the detailed questionnaire. The results of the interviews were sent for comments and remarks to various executives of the three operators, and reports amended according to feedback from partners.

The overall approach, as reflected in various interviews, is virtually the same for all operators. Nonetheless, differences appear in pace and priorities given to areas of NRW reduction. All operators adopt the water report of the International Institution for Water (IWA) for the characterization of various elements of NRW.

4.2.2 Interviews with key stakeholders

A series of interviews was conducted in November 2012, in order to identify the best practices for NRW management implemented in Morocco. The interviews helped to understand the situation of the water supply sector as concerns NRW and focused on three model practices to be documented in this report. The three principal operators are ONEE Water Branch, the Independent State-Owned Company for the Distribution of Water and Electricity of Fez (RADEEF) and REDAL, contract holder for water and electricity distribution in the area of Rabat-Salé. Efforts and good practices applied by each of the three operators as well as meeting reports are presented in different documents. This analysis allows to highlight that NRW is the focus of the concerns of all operators.

4.2.3 General inventory of best practices concerning NRW in Morocco

All operators have introduced a number of good practices in NRW management, of which the main ones are:

With regard to design and implementation of projects:

1. The choice of processing methods adapted to the quality of raw water with recycling of wash water;

2. The application of necessary standards for the selection of suitable materials and approval testing at the plant and on site.
3. Conducting studies specific to the improvement of yields and strict monitoring of the works arising.

With regard to exploitation:

1. The upgrade of transport and distribution networks of new management contracts:
2. Segmentation of networks with equipment sectors by flowmeters for monitoring night flows and control of pressure balance and protection of networks;
3. Conducting leak detection and repair campaigns by means of ONEP and the private sector.
4. Rehabilitation of dilapidated conveyance facilities and leaking distribution networks through performance improvement programs funded by international donors with goals to achieve after commissioning projects;
5. Improvement of connection devices and technical guidance for their implementation;
6. Improvement of water measuring, large and small scale:
7. Leak research and detection
   - Network regulation
   - Network modeling
   - Network segmentation
8. Maintenance and preventive maintenance
9. Concurrent actions
   - The establishment of procedures for the operation and continuous updating of network plans:
   - The care and maintenance of networks by means of ONEP and the private sector (Market frameworks, micro-business)
   - Awareness and training of ONEP and micro-business staff ensuring management and operation of production and distribution facilities.
   - The establishment in 2010 of a geographic information system (GIS) and Computer Assisted Maintenance Management (GMAO) (ongoing).

With regard to the commercial level:

1. The reliability of volumes billed through:
   - The widespread use of Portable Input Terminals (TSP);
   - Systematization of contradictory meter readings for contract holders, state-owned companies and large consumers
   - Reducing losses in internal installations, through the assistance provided to different users for:
   - Regular monitoring of drinking water consumption for large consumers, combined with warning messages in case of ascertaining abnormal consumption;

- Research and repair of internal leakage; this action is combined with the application of deterrent tariffs for any consumption of drinking water considered excessive (excessive consumption means any consumption four times higher than the historical average consumption recorded over two years).

2. Strengthening assistance and commercial control:

- Fight against all forms of water fraud
- The generalized use of metering (billing and management)

4.3 IDENTIFICATION OF THREE MODEL METHODS OF BEST PRACTICES

Based on interviews with key stakeholders, the three model best practices that are selected for a detailed report are listed below.

1) BP1: Metrology and measuring (ONEE Water Branch)
2) BP2: Leak detection (RADEEF)
3) BP3: Connection policy (ONEE Water Branch)

4.3.1 BP1: Metrology and measuring

This practice involves administrative loss: the replacement of old and broken water meters, installation of new meters in places where they had not been installed before and in suspected sites of illegal connections.

4.3.1.1 Impact

The accuracy of flow measurements, readings of customer meters and billing are the main factors affecting the calculation of the volume of NRW.

Commercial losses, due to the imprecision of customer meters, misuse of data and illegal tapping reduce income and generation of financial resources.

Water metering at all levels of the drinking water supply system is of vital interest for the development of the sector and optimizing the use of water resources. It also contributes to water savings by avoiding wastage of available resources and to consumer awareness.

Metering has also enabled:

- Better quantification of volumes distributed at the network end and at the subscriber end;
- Accuracy in calculating distribution performance;
- Successful segmentation of the network to ensure better management of distribution and performance of leak research operations;
- Optimization of project planning by controlling water needs and investments.

4.3.1.2 Technical feasibility

The new policy of metering has been implemented based on past experiences so that better technical feasibility is ensured. The presence of highly experienced field staff has helped in driving change and facilitated the mastery of the use of new meters and portable input terminals, based on training implemented by IEA. More specifically, the implementation of the metering policy by ONEE is oriented towards:

- selection of more accurate meters (C class) and performance of sensitivity tests on sample meters on site.

- The adaptation and standardization of recesses for easy installation and removal of meters.
- The introduction of portable input terminals (TSP) which facilitate greatly the acquisition and storage of data; the implementation of TSPs has reduced the number of meter readers per round. Agents have been redeployed on network management and leak detection and repair.
- Information obtained is underused in decision making. The establishment of a commercial information system is a project launched by the Commercial Directorate, which will integrate all business information with the other components of the ONEE water branch information system.

At the level of technical skills reinforcement, an independent metrology department was established at Directorate of Heritage (DPA) level.

This department provides human resources and equipment (measuring devices, calibration bench, etc.) and procedure manuals necessary for the smooth development of the measuring function.

it then proceeded to the establishment of a high-level training plan specifically oriented towards experimental aspects. The implementation of the training plan was entrusted to IEA.

Trained teams were given mobile units equipped with all the necessary measuring appliances.

However, difficulties remain and impede the implementation of the measuring policy including:

- The frequency of intervention of ONEE in rural areas. Indeed, networks and connections of new management contracts undertaken by ONEE require an effort to upgrade both in terms of facilities and staff on site.
  The size of the growing meter pool requires transition to greater monitoring efficiency. The establishment of ONEE's new semi-automatic test bench as part of the performance improvement program is a crucial and necessary operation.

4.3.1.3 Financial viability

Given the significance of volumes sold by ONEE, under-measuring by only 1% is certain to represent substantial sums in financial terms (e.g. 600 Mm^3 x1% or 6 Million m^3 or 36 Million MAD - Moroccan Dirham[6])

Legal aspect:

The legislation provides for requirements to ensure the balance of transactions between the operator and the customer and to protect the consumer by providing the right of appeal against any misuse by the operator. .

[6] 1 MAD = 0.09 EUROS

4.3.1.4 Affordability and ability to raise funds

In general, the coverage of metrology and measuring programs is funded through the operating budget of the regional directorates. Funding is based entirely on ONEE's own funds.

As part of its performance improvement program, ONEE has mobilized a fund of €100 million jointly financed by the KFW-AFD and the European Union (EU) amounting to 76%. This program includes the following components:

- Rehabilitation of distribution networks of approximately 35 centers;
- Establishment of remote management systems in 11 adductor systems;
- Rehabilitation of 7 treatment plants;
- Rehabilitation of about 14 production works (Adductor systems and pumping stations)
- Purchases (electronic flowmeters and mobile units and for Leak Research (RDF)
- Technical Assistance
- Studies and supervision of works
- Concurrent steps (construction of a calibration bench for small-gauge meters, etc.)

The eligibility of this component to for KFW-EU funding is not linked to ONEE's need to finance operations, but it reflects a desire for integration, shared between ONEE and finance donors, of all components of the performance improvement program.

4.3.2 BP2: Leak detection

This practice covers physical (actual) loss. Actual losses occur when water is lost through cracks and leaks in the distribution system.

4.3.2.1 Impact

Drinking water supply for the city of Fez is provided by:

- The groundwater resources of the Saiss basin, and
- The surface water resources processed by the treatment plant on the Sebu wadi

Water losses have a negative impact on efforts to mobilize water resources. National planning has set targets of 80% yield by 2015 for operators.

The action plan implemented by RADEEF has resulted in network performance improvement which from 53.31% in 2003 reached 63.28% in 2011. This yield constitutes a good performance, given the ground conditions of the city of Fez (Reliefs, etc.).

The reduction of physical losses can delay the need to invest in new sources. It also reduces operating costs, by reducing the frequency of breaks and faults in the distribution network.

4.3.2.2 Technical feasibility

RADEEF undertook a study to define the works of leak detection and repair. This study was carried out in December 2006 by the engineering consultant, Marseilles Water Company (SEM). This study was based on:

- The segmentation implemented as well as the measurement of night flows of water sub-sectors, sectors that were also divided into elementary entities to refine the analysis;

- statistical data available to the operating department concerning all leaks detected on the network both by the repair maintenance and preventive maintenance crews (RADEEF teams and subcontractors).

Thus the study has identified the sectors with the highest leakage as well as the location of leaks (on connection or pipes). A classification of these sectors was established by specifying the expected gains and necessary investments. Related tenders were then established, taking into account the geographical proximity of sectors.

The completion of the above actions faced a series of difficulties including:

- The nature of the terrain (topography, steep reliefs, etc.)
- Habitat type (Medina, etc.)
- The lack of network mapping in some sectors
- The variety of materials

The implementation of the program was achieved through an operational project by RADEEF teams. Scheduled operations were conducted with the support of the national and international private sector, both for implementation and for monitoring and control of operations.

The significant improvement in network performance has strengthened RADEEF's strategic choices for continued efforts to achieve the national output goal (80%).

In terms of skills-building. RADEEF provides training to relevant staff, mainly through the International Institute for Water and Sanitation of ONEE, within predefined conventions.

4.3.2.3 Financial viability

Accumulated gains generated during the 2003-2011 period amounted to 236 million dirhams for an investment of 230 million dirhams in the same period.

4.3.2.4 Affordability and ability to raise funds

Given the interest of fund donors to reduce physical losses, RADEEF has mobilized €20 million (MAD 230 million) of which €10 million have been funded by the French Development Agency (AFD).

4.3.3 BP3: Connection policy

4.3.3.1 Impact

The connection policy has contributed, in a major and direct way, to the reduction of water losses for all regional directorates of ONEE.

4.3.3.2 Technical feasibility

The Heritage Directorate, established in 2001, has made the connection policy one of the main axes for performance improvement. Diagnosis is made through yield improvement commissions. Actions to be implemented and performance indicators are validated through the development of annual internal management contracts between regional directorates and the ONEE directorate general. The evaluation of achieved performance is presented annually by each directorate to the ONEE executive committee, which includes the directorate general and the regional directorates.

4.3.3.3 Financial viability

Completed evaluations show that the actions carried out within the framework of the connection policy are very profitable both in the short and the medium term. Moreover, ONEE is aware of the positive impact of efforts to improve the yield of the distribution networks on the optimization of water production project planning requiring ever-increasing investments, especially for seawater treatment and desalination.

4.3.3.4 Affordability and ability to raise funds:

In addition to ONEE equity capital, yield improvement and, in particular, the connection policy is supported by international funders, including the KFW and the European Union as part of the performance improvement program.

4.4 DOCUMENTATION OF BEST PRACTICES (BP)

4.4.1 BP1: Metrology and measuring (ONEE)

4.4.1.1 Summary:

Commercial losses, sometimes called apparent losses, include water consumed but not paid for by the customer. Unlike leakage or reservoir overflows, in this case water loss is not visible. Commercial losses can amount to water volumes higher than those of physical losses and bear immediate financial impact because reducing commercial losses increases revenue.

The metering policy involves two types of meters, namely "large-gauge" meters or meters of large diameter, which measure wholesale water (distributors, large volume customers, management meters) and small-gauge meters, or meters of small diameter used by direct subscribers.

In 2003, ONEE undertook a comprehensive diagnosis of the metering function, which highlighted a number of shortcomings and areas for improvement.

The establishment of the database (DB) of meters was necessary to build and argue the analysis and prioritization of problems and the implementation of an action plan for reducing apparent losses. The strategy adopted since 2004 has focused on the following main aspects:

- Gradual implementation of new generation meters (high accuracy C class, with integrated valves), replacing the old meters.
- Equipping centers with portable input terminals (TSP)
- Renewal of older meters (>10 years)
- Strengthening of meter monitoring (test benches), with acquisition of devices for checking good operation of meters on site
- Adaptation of meter types to the quality of water (volumetric meters for centers where distributed water is soft)
- Improvement in the terms of reference and specifications of special requirements for the purchase of meters;
- Improvement of meter installation conditions and installation of electromagnetic flowmeters for large-gauge meters

- Support for skills building provided by the International Institute for Water and Sanitation (IEA) through the implementation of several training sessions for the benefit of operating teams.

All regional directorates agree on the conclusion that the measuring and metrology policy has helped to reduce water losses (NRW). The quantitative evaluation of metrology related to loss reduction has not been carried out. In fact, all players consider NRW reduction a comprehensive and integrated strategy.

Thus, the "Improving Performance Phase 1" program financed by KFW has integrated this section as a component and contributed to the achievement of objectives in the field of metrology.

The evaluation of the program in Phase 1 confirms that the actions taken have had a significant impact on reducing apparent losses. The "Improving Performance Phase 2" program, financed by KFW and the European Union, also has measuring and metrology as a component.

In addition to the impact on NRW reduction, metrology has led to a marked improvement in the image of the ONEE in relation to its customers. Thus, "large-gauge" metering operations have improved confidence and facilitated commercial management (less conflict, contradictory readings, etc.) at delivery points with distributors and large volume customers.

4.4.1.2 Description

The ONEE currently has a fleet of 1.5 million small-diameter meters of different brands, the age of which is broken down as follows:

- 57% aged less than 6 years (or 855,000 meters).
- 31% aged between 6 and 10 years (or 465,000 meters).
- 12% aged more than 10 years (or 180,000 meters).

ONEE has two calibration benches for **small-gauge** meters used for assessment tests on samples for tenders (AO), the acceptance testing of new meters and monitoring meter performance based on age (distribution studies).

The large-diameter meter fleet features 5,184 meters, 951 of which are electronic and 4,233 are mechanical meters.

In 2003, ONEE carried out a comprehensive diagnosis of the metering function, which highlighted the following key findings:

- Absence of a complete file on the technical characteristics of installed meters, and a database on the deviation in precision of ONEP meters in operation, according to different criteria (age, brand, type, meter model, water quality, etc.).
- Terms of reference and technical specifications of special requirements (of ONEP) have always favored the acquisition of speed-type, and not volumetric-type meters, and B-class instead of C-class meters with better accuracy at a low additional cost on average.
- The test bench of ONEP is not certified,
- The renewal plan is limited to meters older than 12 years due to budgetary constraints.

- On-site periodic inspections of installed meters are not conducted.
- Lack of detailed analysis of the changes in subscriber consumption to identify potential under-measuring.
- Manufacturers and suppliers of national meters did not all offer volumetric-type meters featuring improved precision and lifetime over the speed-type meters. To benefit from competition between different manufacturers and suppliers ONEP continued to acquire speed-type meters.

A series of improvement actions has been implemented since 2004, as part of an overall strategy for improving metering performance, and mainly:

- Improved SS for choosing C-class meters (high precision) and acquisition of meters with built-in valves since 2010 to eliminate fraud;
- Equipping ONEE centers with portable input terminals (TSP)
- Purchase of 1,398,700 C-class meters since 2004, or 93% of the total, including 1,000,000 volumetric-type meters representing 71.5% of purchases.
- Renewal of old meters aged over 10 years which under-measure between 6- 8% according to studies carried out by international experts: 634,600 meters replaced.
- Rehabilitation of two old test benches from Casablanca workshops.
- Performance of sensitivity tests with water load and endurance tests on samples from 12 centers within regional directorates (DR);
- Acquisition of 210 portable devices for on-site checking of good operation of subscriber meters for ONEE centers (ONEE design); estimate of one device to be provided to each center.
- Adoption of the use of volumetric meters for centers served with soft water, since these meters also have the advantage of operating in any position, and speed-type meters for areas with contaminated and calcite water.
- Improvement in the terms of reference and technical specifications of the SS for the acquisition of large-gauge mechanical meters.
- Studies to improve and upgrade metering stations;
- Rehabilitation and installation of approximately 986 electromagnetic flowmeters since 2004, replacing mechanical meters with the aim of improving the performance of specific stations, especially precision;
- Upgrading 1,230 mechanical metering stations;
- Installation of over 1,710 meters on sub-branches supplying rural areas;
- Award of a contract for meter calibration with the Public Laboratory of Testing and Study (LPEE) for new meters intended for billing subscribers and state-owned companies;
- Establishment of market framework calibration and preventive and corrective maintenance at regional level by outsourcing
- Improvement of installation conditions and replacement of large-gauge mechanical meters with electromagnetic flowmeters (DEM);
- Provision to DRs of SS types for the acquisition of DEMs under the KFW funded program to improve performance (PAP) II;
- Establishment of an awareness-raising and training plan for ONEE agents relating to metering and its importance for improving performance.
- Widespread implementation of a metering protocol with the state-owned companies

at billing level.

Other actions are underway as part of the metering and metrology policy, including:

- Construction of a new modern and fully automated calibration laboratory for small-gauge meters, with facilities required for certification as part of the second performance improvement program, at an estimated cost of 4.3 million dirhams (construction of premises and bench equipment).
- Gradual replacement of mechanical meters by DEMs considered more reliable and more accurate
- Continuation of the meter installation expansion program, and skills update for existing positions in order to comply with installation conditions ensuring high precision;
- Continuation of the program of changing older small-gauge meters;
- Establishment of an application relating to the management of metering databases.
- Research and Development (R&D) operations in progress:
- Testing and monitoring of 70 composite-body meters: in anticipation of eventual replacement (when conclusive results are obtained), of brass bodies (60% copper) the cost of which is continually increasing. The tests include:
  - ✓ metrological tests (already completed).
  - ✓ analysis of suitability for contact with food (completed).
  - ✓ monitoring of frost- and heat-resistant properties (in progress).
  - ✓ monitoring of durability (scheduled for December 2012).
  - ✓ Testing of 100 meters of "single-jet speed" type at Khouribga (very hard water).
  - ✓ Monitoring of meter performance (deposition of meters for testing accuracy in progress)
  - ✓ Monitoring endurance (blocking time) as compared with speed-type "multiple jet" meters that present frequent blockages in this region.

The assessment of the results of the actions undertaken in improving metering shows a set of strengths and weaknesses:

Strengths:

- The supply of small-gauge meters of better quality.
- Implementation of controls from reception to delivery, and on-site meter control at center level.
- Maintenance and control of large-gauge metering stations, including electromagnetic flowmeters, which was provided by entering into specific contracts by region.

Weaknesses:

Overall, the pace of implementation of operations is considered slow in comparison to forecasts. Delays are caused by the implementation of financial means and procurement procedures. Provisions have been made to minimize lead times, especially at the level of supplier inventory management. The following weaknesses can be broken down as follows:

- Only 207,617 old small-gauge meters were renewed as part of regional programs during this period.

- This operation, originally scheduled for 3-4 years, should include a total of 300,000 meters by the end of 2007.
- Delay in the introduction of a new calibration bench for small meters.
- Operations budgeted annually by the DRis and relating to the rehabilitation of large-gauge metering stations are only partially completed. Until the end of 2008, only 524 stations were equipped with DEMs of a total of 1,500 stations (conducive to this type of flow meters).

The implementation of the meter policy has helped to reduce water losses (NRW). The quantitative evaluation of metrology related to loss reduction has not been carried out. However, all players confirm this fact. Metrology has been identified as an important focus of the performance improvement program, in Phase I, funded by KFW, whose evaluation confirms that actions performed in the field of metrology have had a significant impact on reducing apparent losses. The "Improving Performance Phase 2" program, financed by KFW and the European Union, also has measuring and metrology as a component.

In addition to the impact on NRW reduction, metrology has led to a marked improvement in the image of the ONEE in relation to its customers. Thus, "large-gauge" metering operations have improved confidence and facilitated commercial management (less conflict, contradictory readings, etc.) at delivery points with distributors and large volume customers.

The ONEE metrology strategy will be supported in its vision. ONEE provides for enhancement of the means at the disposal of regional directorates as part of decentralization. The continuation of these actions is extended to the level of management contracts of regional directorates. Central support will continue to be provided through monitoring standards, continuous improvement of the purchasing policy, monitoring support (next-generation test bench) and the development and implementation of an integrated information system. All activities are supported by the enhanced capacity provided by the International Institute for Water and Sanitation of ONEE. Good practices acquired in this area (especially in the field of metrology) are available to operators in neighboring and friendly countries within the framework of international support programs run by the IEA.

4.4.1.3 References

1. Improved hydraulic efficiency of the AEP systems of ONEE (ONEE Presentation 3 December 2012).
2. Technical report on drinking water 2011, VEOLIA ENVIRONMENT
3. Procedures Manual for commercial management at ONEP centers, April 2011.
4. Presentation of management system for operation data (GDE) (ONEE Presentation 3 December 2012)
5. ONEE website - Water Branch; www.onep.ma

4.4.2 BP2: Leak detection and repair (RADEEF)

4.4.2.1 Summary

It is clear that improving the efficiency of the water distribution network is crucial for any drinking water network manager because of the economic and environmental challenges it presents.

In fact, improving network performance results in the decrease of lost volumes and consequently production volumes, which leads to:

- improved results for the drinking water activity due to reduced purchases and lower operating expenses;
- preservation of water resources, specifically at a time when climate change causes irregular water resources.

Aware of this problem and in order to deal with poor network performance (53%), since 2002 RADEEF has established an action plan for its improvement, relating to various aspects of the activity (studies, planning, operation, works, customer management, etc.).

The action plan implemented by RADEEF has resulted in network performance improvement which from 53.31% in 2003 reached 63.28% in 2011.

Accumulated gains arising during the 2003-2011 period amounts to 236 million dirhams for an investment of 230 million dirhams.

4.4.2.2 Description

RDF is an essential component for improving network performance. Thus, since 1991, RADEEF has implemented a cell and then a service dedicated to this task.

The service is provided equally well by subcontractors and by RADEEF teams which have been reinforced by adequate material resources.

On the other hand, RDF is oriented towards high leakage sectors identified by significant night flows, this latter being monitored regularly by segmentation meter readings.

Given the weakness of network performance, in 2002 RADEEF established an action plan the components of which will be described below

Network regulation:

In the face of excessive pressures caused by the topography of the city, RADEEF undertook the installation of pressure reducers, the number of which has increased from 2 in 1993 to 23 in 2011. Thus pressure exceeding 10 bars has been reduced to a maximum value of 6 bars.

In addition to this action, in 2008 RADEEF acquired pressure modulator devices that further reduce base pressure downstream from stabilizers during times of low consumption (night time).

This technique has allowed for the reduction of night flow by 50% in these sectors.

Network modeling:

The numerical simulation of the operation of the network is an essential step in its introduction. Thus in 2004, RADEEF developed a numerical model of the major water network (reservoirs, equipment, pipe with diameter DN ≥100 mm), with the addition of topological (altitude Z, characteristics of works and sections) and consumption data.

A measurement campaign (flow, pressure) was carried out in parallel for each zone of influence over 24 hours.

These two services have guaranteed model calibration as:

The difference between measured and calculated flows did not exceed 5%;

The calculated pressures approached those measured by ± 5 m.

Once the model was calibrated, a dynamic analysis was performed over 24 hours to highlight irregularities in the distribution network, namely:

- Excessive pressures at off-peak time (02:00);
- Low pressures at peak time (13:00);
- Excessive speed on segments.

Then, simulations were developed to overcome the shortcomings described above. They allowed for emergency work to be defined over the network. These are listed below:

- Implementation of pressure stabilizers in some sectors (Hay Takadoum, Belkhayat, BabGuissa, Sahrij Gnaoua, Bensouda, Hay Qodt Route de Séfrou);
- Switching of the Bouremanna area initially supplied by the Immouzer road reservoir (475 m Moroccan Mean Sea Level (NGM)) to the southern reservoir (450 m NGM);
- Switching of the Mont area supplied by the Séfrou road zone of influence (503 m NGM) to the Immouzer road zone of influence (475 m NGM);
- Switching districts Dhar Lakhmis and Benslimane from the Tghat zone of influence (523 m NGM) to the Northwest zone of influence (470 m NGM) initially supplied by the Sefrou road reservoir). In addition to the significant reduction in pressure in the area, this action has allowed for lower operating costs and significant flow gain

It should be noted that in June 2012 RADEEF launched a measurement campaign (flow and pressure) on the entire distribution network of the city of Fez which on the one hand has allowed for detection of high or even low pressures and the update of the mathematical network model on the other (ongoing implementation).

Study of performance improvement and definition of rehabilitation works:

After programming and starting on the implementation of the actions described above which are prerequisites for network rehabilitation works, RADEEF unamely

ndertook a study for the definition of rehabilitation works. This was based on:

- The existing segmentation as well as measurement of night flows of water sub-sectors, sectors that were also divided into elementary entities to refine the analysis;
- statistical data available to the operating department concerning all leaks detected on the network both by the repair maintenance and preventive maintenance crews (RADEEF teams and subcontractors).
- Thus the study has identified the sectors with the highest leakage as well as the location of leaks (on connection or pipes). A classification of these sectors was established by specifying the expected gains and necessary investments. Then

related tenders were established, taking into account the geographical proximity of sectors.

Network rehabilitation works:

1. Rehabilitation using RADEEF's own financial resources

RADEEF anticipated achieving rehabilitation of the network, especially in areas with an old system and/or where the night flows were significant. The following works were then carried out:

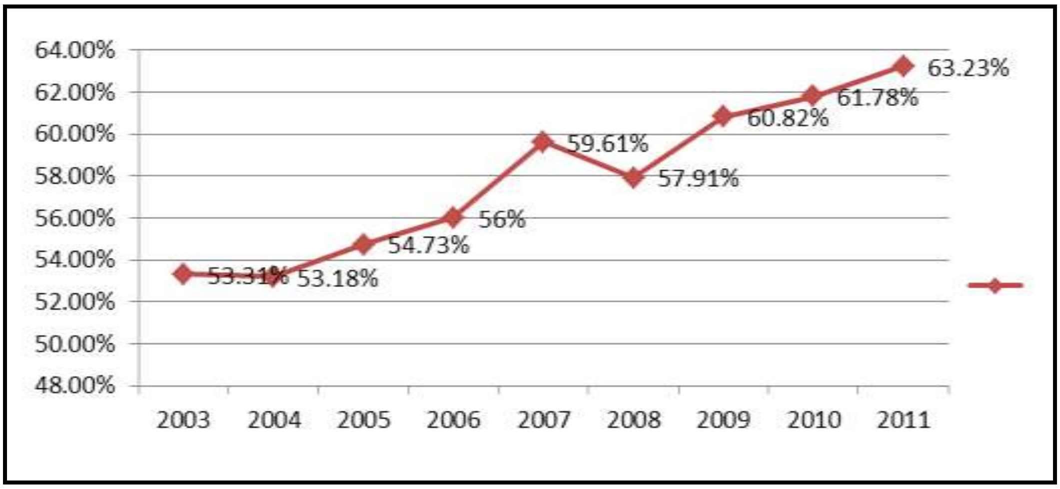
2. Rehabilitation financed by AFD (French Development Agency)

RADEEF obtained a loan of EUR 10 million to finance the rehabilitation works (100km pipeline and 25,000 connections). The definition of these works stems from the study prepared by the Marseilles Water Company (SEM) and described above. The Consulting Engineer also provides technical assistance for the works.

Results:

The action plan implemented by RADEEF resulted in a performance improvement of the network which from 53.31% in 2003 reached 63.28% in 2011, as shown by the following graph:

FIGURE 10: NETWORK PERFORMANCE (2003-2011)



On the other hand, the volume of water (in million m^3) and the amounts saved are listed below:

TABLE 17: WATER VOLUMES AND AMOUNTS SAVED (2003-2011)

Indicator	Unit	Execution								
		2003	2004	2005	2006	2007	2008	2009	2010	2011
Managed water	Mm^3/year[7]	70.61	69.88	69.71	70.18	67.02	68.66	69.17	69.61	70.51
Water volume sold	Mm^3/year	37,551	38,246	39,747	39,305	39,950	39,763	42,070	43,006	44,620
Performanc	%	53.18	54.73	57.02	56.00	59.61	57.91	60.82	61.78	63.28

[7] MILLION CUBIC METRES PER YEAR

e		%	%	%	%	%	%	%	%	%
Savings on managed water /until 2001	Mm^3/year	2,583	4,677	7,770	6,434	10,853	8,847	12,838	14,222	16,469
Accumulated volumes saved	Mm^3	2,583	7,260	15,030	21,464	32,317	41,164	51,418	60,964	77,432
Purchase tariff Excl. tax[8]	DH /m^3	3.04	3.04	3.04	3.04	3.05	3.05	3.05	3.05	3.05
Generated gain	MDH/year	7,854	14,217	23,622	19,558	33,102	26,982	39,155	43,378	50,229
Accumulated gains generated	MDH	7,854	22,071	45,692	65,251	98,352	125,334	156,636	185,797	236,026

The table below shows the change of performance indicators:

TABLE 18: CHANGE OF PERFORMANCE INDICATORS

Indicators	Unit	2006	2007	2008	2009	2010	2011
Number of customers	U	225,750	244,143	260,668	273,194	286,052	299,340
Network length	Km	1,824	1,899	1,981	2,140	2,288	2,490
Number of connections	U	135,437	138,775	141,932	144,775	148,575	152,490
Managed water	Mm^3/year	70.18	67.02	68.66	69.17	69.61	70.51
Water purchased	Mm^3/year	52.88	50.35	51.07	48.05	47.11	48.34
Water produced	Mm^3/year	17.31	16.68	17.60	21.13	22.51	25.07
Water volume sold	Mm^3/year	39.30	39.95	39.76	42.07	43.01	44.62
Number of customer/Km	U/Km	124	129	132	128	125	120
Linear loss index	m^3/d/Km	46.37	39.07	39.86	34.60	31.77	28.41
Linear consumption index	m^3/d/Km	59.03	57.65	54.84	53.86	51.50	49.10

4.4.2.3 References

1. Outline report on leak research; ONEE-Water Branch
2. Technical report on drinking water 2011, VEOLIA ENVIRONMENT
3. Manual of leak research, 2009 version ONEE-Water Branch
4. Action plan for improving the efficiency of the distribution network, RADEEF November 2012 MP3: Connection policy at ONEP
5. RADEEF website www.radeef.ma

[8] EXCLUDING TAX

4.4.3 BP3: Connection policy

4.4.3.1 Summary

Networks of drinking water distribution at the national level have average yields of about 70%, thus giving 30% water loss. Analyses of the causes of these losses show that 80% of leaks occur at the connections between subscribers and distribution lines.

ONEE, aware of this problem, has developed, particularly with the establishment of the Heritage Directorate, an NRW management policy, one of the cornerstones of which is the connection policy.

The diagnosis made by the regional directorates has enabled a strategy to be put in place based on the following main areas:

- Monitoring of standards and technology
- Purchasing policy, specifications
- Materials testing and implementation of services
- Support for suppliers, sub-contractors and partners (developers and planners)
- Decentralization and autonomy of regional directorates

The policy adopted has generally contributed to improved yields of the ONEP networks. Furthermore, the performance achieved in the reduction of water losses, the strategy adopted has reduced the cost of connection by almost 30%. The effort, however, will have to be supported in the coming years.

The management of operational activity is in part due to the effort of ONEP in terms of skills-building, centered on the International Institute for Water and Sanitation

The implementation of the 'Data Management operations' application will provide regional directorates with the data needed to facilitate the development of performance indicators that will guide future decisions on all aspects (technology and standards, improved connection guide, purchasing and inventory)

4.4.3.2 Description

The issue of connections has always been a challenge for the leadership of the ONEE Heritage Directorate. In fact, the findings made by either consultants or by leak research teams have shown that the weakest link in drinking water systems is the part connecting the subscriber to the network: over 80% of confirmed leakages arise at the connections, especially the connection equipment. The connection leaks are slow growth leaks which may remain undetected for long periods and lead to a significant cumulative loss.

The ONEE water branch has developed a strategy for the management of this aspect in the context of its overall strategy for managing NRW, driven by the Heritage Directorate (DPA), which provides motivation and guidance for monitoring, diagnosis and development of improved connection management plans. Regional directorates are actively involved in the work of committees created for that purpose.

There are several causes for leaking connections (quality of materials of parts and polyethylene pipe, collar support, height of recovery of the connection line, etc.). The main cause however remains the installation of equipment and pipes in the construction or rehabilitation of the connection.

The analysis carried out by the executives highlighted the main problems related to connection hardware, which have been identified as follows:

Lack of a clear and single strategy at ONEP specifying the technical solution to be adopted during purchasing for all ONEP entities. Indeed, the connection hardware comes from two different sources:

- ONEP material: Acquired by the central workshops in the framework of a joint procurement on behalf of the regional directorates, on the basis of detailed specifications.
- Material provided by the companies in the market during expansion or rehabilitation of networks with non-detailed specifications in order to benefit from the opportunities offered by the market and have good control of the services provided by the service providers
- Lack of skills in business or micro-enterprises in charge of carrying out the connections, particularly for the installation of connection items. Works are usually outsourced to existing local plumbers.
- Inadequate time frames to achieve the connections in the context of network expansion and rehabilitation projects. Typically, connections are made at the end of the contract period and are therefore subject to extreme stress on deadlines. This has a negative impact on the quality of the connection works.
- Deficiency in the quality of work of connections made by the developers and planners, as part of the "third party works".
- Lack of adequate quality control of connection items provided by the service providers. Control is often limited to quantitative control.
- Lack of approved laboratories for carrying out material control analyses for connection equipment.

For each regional directorate, the strategy adopted consisted of detailed analysis of the problems of connection management, based on common experiences and sharing, is detailed for each regional directorate in its management contract that sets out the objectives, the means and performance indicators of the regional directorate concerned, in particular in the field of connections. The agreed action plans are discussed, harmonized and validated by the management committee. Management of the problem of connections was performed by adopting the following actions and attitudes:

1. **Monitoring of standards and technology:**

Important steps have been taken in terms of technological monitoring and continuous improvement of connecting products and hardware. ONEP ensures regular attendance at various national and international exhibitions. Capitalization has resulted in improvements of the specifications and the implementation of standards in the implementation. The connection guide designed by ONEP teams is a standard used by ONEP teams and serves as a support for the training of operators around the world.

Steps have been taken to request a minimum list of equipment required for analysis and control from accredited laboratories providing metallurgical records and hardness tests . ONEP has also established a contractual framework for metallurgical analyses. This approach has had a very positive impact on ONEP's image, as a client for connecting hardware.

Adoption of innovative devices for connection items, of which the following may be mentioned as examples:

Tap equipped with an integrated connector with threaded tap outlet. This tap has the following advantages:

Excessive tightening of the nut without breaking

Requires no special wrench

Better adhesion to polyethylene pipe

Clamp collar with four bolts, or provided with a hinge on one side and two bolts on the other. This solution has the following advantages:

Good adhesion to PVC/PE pipes.

Allows spreading of the radial forces on the area covered by the collar and avoids damaging the pipe if excessive tightening of the collar occurs.

The security seal allows easy set up, removing fixtures with oakum, copper joints, etc. The face of the tap ensures the compression of the seal.

Anti-fraud polyethylene sealing collar for water meters. This solution has the following advantages:

Sealing collar, consisting of two half-collars with a tab engaging on each half-collar.

Each tab is broken when the collar is opened (anti-fraud).

2. Purchasing policy of connecting hardware:

Setting out the terms of reference for connecting hardware for all purchases made at central and regional level. Important clarifications were made to the specifications of various items, including references to a standard (national or other).

Bidding documents prepared by the Regional Directorates have incorporated a clause which provides that the provision of connection items must be charged to ONEE,

Establishment of a specification type to be observed by planners and developers for third-party works. Compliance checks should be carried out by sampling at the connections made in this context.

Autonomy of regional directorates:

All regional directorates have been equipped with a test bench for connections to ensure control at their level. The teams in charge have acquired extensive training on these issues at the International Institute of Drinking Water and Sanitation (IEA). Additional training on site is required to make these teams completely autonomous

3. Implementation of Connection Guide

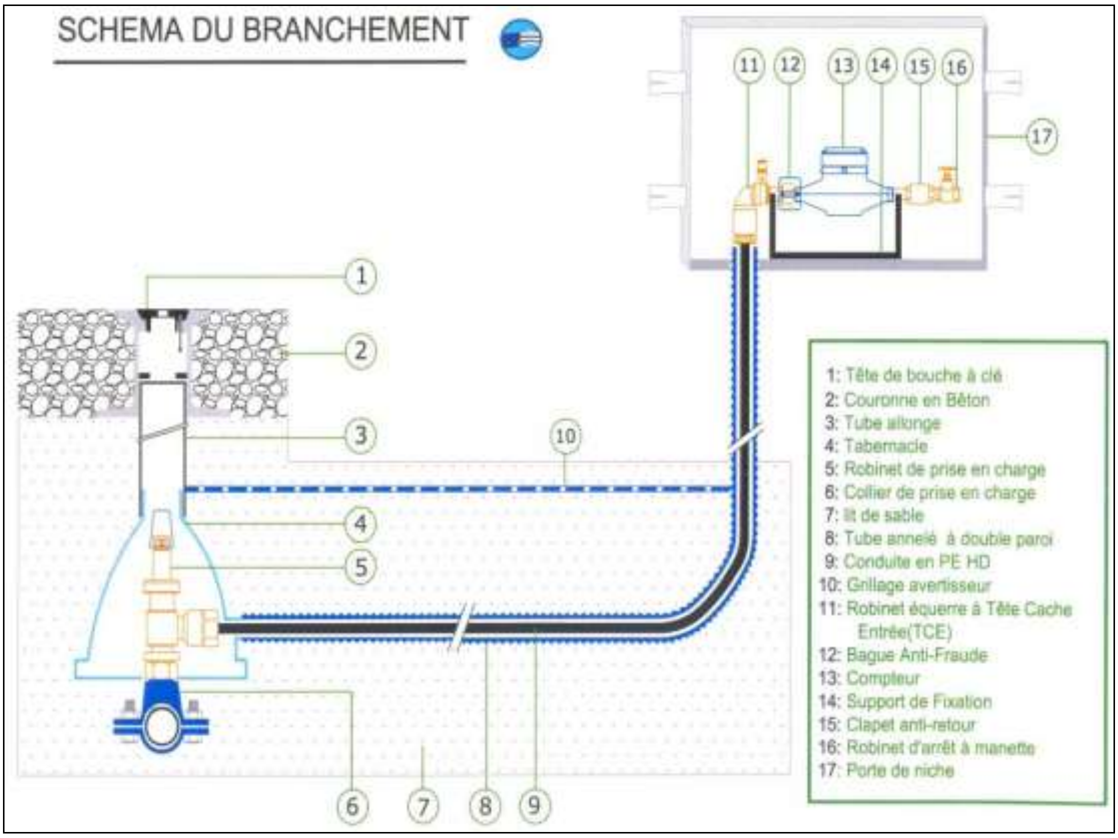
The implementation of the improved version of the connection guide, which incorporates new materials and new technologies including connection parts and items.

Implementation of the above strategy is bearing fruit over the years. The connection policy conducted contributes significantly to achieving the overall goal of a distribution yield of 80% by 2015. However, it is difficult to quantify this part, given that performance shown for ONEP distribution centers reflects the efforts made both in the detection and repair of leaks and in management and improvement of connections, and generally in the optimization of network management (storage, pressure, etc.).

Besides the technical advantages, the proposed improvements have had an impact on reducing the average cost of connection by around 30% compared to the initial cost.

In terms of performance evaluation, during the year 2012, ONEP established the "Data Management operations" application, GDE, which will provide the database and build performance indicators that will guide future decisions on all aspects (technology and standards, improved connection guide, purchasing and inventory, etc.).

Figure 11: CONNECTION DIAGRAM



References:

6. Technical report on drinking water 2011, VEOLIA ENVIRONMENT
7. ONEP drinking water connections guide
8. Presentation of activities of the Standardization Directorate (ONEE presentation 3 December 2013)

9. Presentation of management system for operation data (GDE) (ONEE Presentation 3 December 2013)
10. Operational procedures for distribution networks ONEE, DPA-P-04-06, May 2006
11. ONEE website - Water Branch; www.onep.ma

4.5 CONCLUSIONS AND RECOMMENDATIONS

The national development strategy in the water sector has raised water savings as a priority of government policy in this area. In this context, the development of a new national plan to improve the yields of drinking water distribution networks is primarily intended to give new impetus to efforts by public operators in the matter of NRW reduction. The fixed goal of various operators is to achieve an overall efficiency of distribution networks of 80% by 2020.

Morocco is distinct in the field of management of drinking water systems owing to a diversity of operators that grants the NRW management scheme a real wealth of experience and relevance in terms of good practices.

The approach taken by the consultant, through discussions with various stakeholders (mapping), has thus aimed to cover the different types of operators to get an idea of the different approaches and best practices for reducing NRW. Three operators were selected, for each of whom a series of interviews was conducted on the basis of a questionnaire, sent in advance. Exchanges undertaken show that loss reduction is a central challenge for all operators, and best practices are essentially quite similar. The differences reflect the specificities of each operator:

- The National Office for Drinking Water, recently merged with the National Office for Electricity to establish the National Office for Electricity and Drinking Water (ONEE), representing the national level, both urban and rural.
- An operator representing the private sector, namely REDAL, a subsidiary of Veolia Environnement, contract holder at Rabat-Salé,
- A local public operator, namely the Water and Electricity Distribution state owned company for the city of Fez.

The meetings with operators identified mainly three (3) cornerstones of good practice, including:

- Metrology and measuring (ONEE example)
- Leak detection and repair (RADEEF example)
- Connection policy (ONEE example)

The analysis of documents collected and the various interviews with operators revealed the following:

- NRW appears as a strategic objective for the various operators. The achievement of national and / or contractual objectives is clearly defined in the annual and multi-year action plans. Performance indicators are clearly defined and are monitored regularly.
- Different funders support this approach and participate in the financing of actions to reduce NRW. The various assessments undertaken show that actions taken have very good profitability (return on investment, internal rate of return (IRR)).

The Standards and Procedures section has experienced very strong growth in all the operators in terms of best practices. National operators develop national practices, arising from their experience, while the private operator is based on the experience of the group and its adaptation to local conditions. Strengthening the exchange between operators on the respective approaches could be an asset to encourage (leverage). Let us mention, for example, the following achievements (ONEE Water Branch):

- Connection implementation and monitoring guides
- SS Types
- Standardization of purchasing of connecting hardware
- Monitoring of standards for small and large-gauge measuring
- Operating procedures

Skills-building is a high priority for operators. The ONEE Water Branch, through the International Institute for Water and Sanitation (IEA), meets all of its needs for skills-building. IEA provides an international reputation in the field of skills-building across the region (Africa and Arab countries). The Institute, with the support of operators in developed countries (Waternet, la Société Wallonne des Eaux (S.W.D.E-Belgium) (Marseilles Water Company-SEM, etc.) within the framework of twining assumes the role of a platform for sharing expertise with other African operators, particularly in the field of NRW, which is a major problem in the southern countries (Support to the National Water Company of Mauritania (NELS), Cape Verde, etc.).

REDAL also has a training center that provides training for staff, especially with the support of experts from the Veolia Group. Membership of the Veolia Group allows it to benefit from the tools developed within the group, particularly in terms of working procedures, technological tools and the information system (see presentation of the LERNE tool for customer management)

At the end of the mission carried out, it is important to note the growing awareness of NRW management at the level of institutions and especially Moroccan operators. The necessary investments are considered profitable in the medium term. NRW management is taken into account in an integrated manner by implementing action plans for all components (ref IWA). Operators are aware of the importance of the sustainability of the action. Operators are aware of the richness of their experience and would like platforms for exchange and sharing of experience at national and international level to be established.

Following this review of good practices, the following key **recommendations** may be put forward:

1. Operators should better integrate NRW management into their investment policy, considering the capital gains generated by the improved yields and performance of facilities in general.

2. Experiments conducted (ONEP) show that the adoption of programs to improve performance with management in project mode (with a system of monitoring and evaluation) is a guarantee for the achievement of operator goals related to management and maintenance of facilities.

3. Standardization: The above examples demonstrate the need for drinking water operators to implement a suitable standardization strategy. ONEP has established a

dedicated structure within the Heritage Directorate, but has also put in place the necessary structures at regional level.

4. However, standardization in NRW should be a national matter. National standards organizations (e.g. in Morocco) must be heavily involved and encouraged by the operators to put in place the necessary regulations. The procurement policy of the operators must be reported and coordinated with suppliers in a transparent partnership.

5. On the other hand, standardization also requires effort in terms of control methods. The acquisition of test benches, and training of staff is a sign of good management of the standardization policy.

6. Information Management: Efforts are to be undertaken in the management of information, including the implementation of geographic information management systems introducing real-time management components.

7. Skills-building: Good practices listed highlight the potential of knowledge and experience of Moroccan operators in the field. ONEP, through the International Institute of Water and Sanitation, is a platform that already provides a regional role (MENA-Africa) in this area. Programs dedicated to NRW management must be established by the IEA on the basis of needs for skills-building of beneficiary operators, with the support of the European Union. IEA support could also involve support for project design and completion of financing requests.

Better benchmarking should be institutionalized, particularly through the dissemination of project deliverables. SWIM-SM should organize a meeting between the operators of the countries concerned to enable them to share experiences and develop mutual support projects in the field of NRW.

Annex 1: List of Contacts by Country

1. Algeria

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Annex 2: List of Documents by Country

1. Algeria

BP	No. of Document	Reference	Source	Project	Contact
BP1	1	AGGREGATE BUSINESS OF SECTOR 4. (2008)	Hattyou06@gmail.com	/	Mr. Youcef HATTOUM, ADE Zone Director, ADE Zone of Tizi-Ouzou, Tizi-Ouzou, 15 Algeria, Fax: +213-26-229 463, Mobile +213-66-350-068, Email: Hattyou06@gmail.com, Web: www.ade.dz
BP1	2	HATTOUM.Y & BOUAYAD.A. (2010) : CITY OF TIZI OUZOU SEGMENTATION	Hattyou06@gmail.com	/	Mr. Youcef HATTOUM
BP2	3	ABH-CZ. (2013) : MANAGEMENT BOARD	Abh-cz@wissal.dz	/	MR. Belkacem MARAF, DirectOr GEnEral of ABH-CZ68, rue Frère CHAIB EDDOUR, BP 664, Chlef, Chlef, 2 Algérie, Fax +213-27-790 68800, Tel: +213-27-771 35700, Mobile +213-770 -258364, email: Abh-cz@wissal.dz, Web: www.abh-cz.com.dz
BP2	4	ABH-CZ. (2013) : ABH PRESENTATION.	Abh-cz@wissal.dz	/	Mr. Belkacem MARAF
BP2	5a. & 5b.	ABH-CZ. (2011). : ACTIVITY REPORT.	Abh-cz@wissal.dz	/	Mr. Belkacem MARAF

2. Israel

BP	No.	Reference/Document	Source	Project	Contact
BP1, BP2&BP3	1a and 1b	Enlarging water availability in Israel by reducing water loss and sewage leaking, Dr. Ofira Ayalon, Shmuel Ne'eman Institute in the Technion, Haifa 2009 (With annex)	Shmuel Ne'eman Institute HTTP://WWW.NEAMAN.ORG.IL/NEAMAN2011/TEMPLATES/SHOWPAGE.ASP?DBID=1&LNGID=2&TMID=5 81&FID=646&IID=8065		
BP1, BP2&BP3	2	Minimization of water loss in urban water supply systems – Instructions for systematic implementation in Israel, Water Authority 2010	Water Authority		The Governmental Authority for Water and Sewage, 14 Hamasger Street, Tel – Aviv, 61203, P.O.B 20365, Israel Tel: 972-3-6369600, Fax: 972-3-6369750
BP1&BP2	3	Mey Lod, preliminary water loss survey, DHV MED 2010	DHV project	Mey Lod water loss project	Mey Lod, 18 Aba Hillel st. Lod Tel.08-9543000 , Fax. 08-9543001
BP1	4	Performance based contracts for NRW management, Water 21, April 2009	Water 21 magazine		
BP1, BP2&BP3	5	National water and sewage authority activity report 2011	Water Authority		The Governmental Authority for Water and Sewage, 14 Hamasger Street, Tel – Aviv, 61203, P.O.B 20365, Israel Tel: 972-3-6369600, Fax: 972-3-6369750
BP1, BP2&BP3	6	Water supply data of municipalities and water corporations at 2010,Water	Water Authority		The Governmental Authority for Water and Sewage, 14 Hamasger Street, Tel – Aviv, 61203, P.O.B

BP	No.	Reference/Document	Source	Project	Contact
		Authority 2011			20365, Israel Tel: 972-3-6369600, Fax: 972-3-6369750
BP1&BP3	7	Assessing non-revenue water and its components: a practical approach, Water21 2003	Water 21 magazine		
BP3	8	Mey-Lod, Operational Master Plan for water supply system, DHV MED, April 2011	DHV project	Mey Lod water loss project	Mey Lod, 18 Aba Hillel st. Lod Tel.08-9543000 , Fax. 08-9543001
BP3	9	Managing leakage by District Metered Areas: a practical approach, Water21, April 2004	Water 21 magazine		
BP3	10	WaterCAD® Water Distribution Modeling and Management, Bentley 2012	Bentley Systems software product brochure		
BP3	11	Pressure Management – hydraulic control valves, Bermad 2007	Bermad	Technical bulletin	Bermad, Kibutz Evron, Israel Tel. 04-9855311, Fax. 04-9855380
	12	MANAGEMENT OF THE URBAN WATER SECTOR: ORGANIZATIONAL STRUCTURE, MANAGEMENT TOOLS AND INTERACTIONS WITH OTHER SECTORS, PROF. NAVA HARUVI 2009	Water Authority http://www.water.gov.il/hebrew/professionalinfoanddata/studies/20071/haruvi-b-.pdf	Water Authority Research	

3. Jordan

BP NO.	DOC. NO.	REFERENCE/DOCUMENT	SOURCE	PROJECT	CONTACT DETAILS
BP 1	1	Final Report: Water & Wastewater Billing & Revenue Collection Service Contract for Madaba Governorate	Engicon O&M	Water & Wastewater Billing & Revenue Collection Service Contract for Madaba Governorate Project	Eng. Firas Matar, Acting C.E.O. P. O. Box 926963 - Amman 11190 Jordan Tel. +962 6 4602120 (ext. 310), Mob. +962 7 97031673, Fax. +962 6 4602130, Email: fmatar@engicon.com, www.engicon-om.com
BP 1	2	Micro - Private Sector Participation PSP To Reduce NRW by Improving Billing and Collection, Madaba, Jordan	Water Authority of Jordan/Ministry of Water and Irrigation	Micro-PSP Experience in Jordan-The Case of WAJ Madaba Project	Eng. Iyad Dahiyat Director/ Program Management Unit Ministry of water & Irrigation, Salem Hindawi st. 41, Amman 11181 Jordan, Fax: +962 65652278, Tel: +962 65652261, Mobile: +962796860000, Email: idahiyat@gmail.com www.waj.gov.jo
BP2	3	Guidelines For Service Connections Installation 2011 (English)	Water Authority of Jordan/Ministry of Water and Irrigation	JICA-Project	Mrs. Hanan Khouri Director of Training at WAJ Ministry of water & Irrigation Jaber Ibn Hayyan street, Amman 11181 Jordan Fax: +962 65665871, Tel: +962 65680100 Ex;1222, Mobile: +962795646564 Email: Hanan_jk2002@yahoo.com www.waj.gov.jo
BP2	4	Guidelines For Service Connections Installation 2011 (Arabic)	Water Authority of Jordan/Ministry of Water and Irrigation	JICA-Project	Mrs. Hanan Khouri See address under 3 above.
BP2	5	SYABAS' Standard Specification for Pipe Laying Works (English)	Water Authority of Jordan/Ministry of Water and Irrigation	JICA-Project	Mr. Waleed Sukkar Senior Advisor Ministry of water & Irrigation, Jaber Ibn Hayyan street, Amman 11181 Jordan

BP NO.	DOC. NO.	REFERENCE/DOCUMENT	SOURCE	PROJECT	CONTACT DETAILS
					Fax: +962 65683516 Tel: +962 65683516 Mob: +962796611858 Email: waleedsukkar@gmail.com www.waj.gov.jo
BP3	6	Pressure Management Effects on Intermittent Water Supply Pilot Projects 2011	Water Authority of Jordan/Ministry of Water and Irrigation	Pressure Management Pilot Projects 2011	Mr. Waleed Sukkar See Address under 5 above
BP3	7	Guidelines for water loss reduction: Focus on pressure management (Arabic)	Arab Countries Water Utilities Association (ACWUA)		Eng. Mustafa S. Nasereddin (M.Sc), Director of Programs and Technical Services, Arab Countries Water Utilities Association (ACWUA) P.O. Box: 962449 Amman-11196 Jordan E-mail: Mustafa_Nasereddin@acwua.org Cell: +962-79-5820-434 Office: +962-6-5161-700 Fax: +962-6-5161-800 URL: www.acwua.org

4. Morocco

BP	Document No.	Title	Author	Document Type	Submitted by
General	1	Véolia Environnement-Morocco - Organizational Structure	Veolia Environnement	PPT	Ms Anne LEGUENNEC
General	2	Véolia Maroc-Business lines directorate - internal memo	Veolia Environnement	Pdf	Ms Anne LEGUENNEC
General	3	2011 Technical report on drinking water	REDAL	Pdf	Ms Anne LEGUENNEC
General	4	LERNE Management System, general presentation, 2010	Veolia Environnement	PPT	Ms Anne LEGUENNEC
BP2	5	Action plan for improving the efficiency of the distribution network, November 2012	RADEEF	Pdf	Ms Safae Amarti
BP1	6	Improved hydraulic efficiency of the AEP systems of ONEE (Presentation meeting of 3 December)	ONEE-Water Branch	PPT	Mr Boubkeur lahoucine
BP3	7	Presentation of activities of the Standardization Directorate (Presentation meeting of 3 December)	ONEE-Water Branch	PPT	Mr Madani Mohamed
BP1& BP3	8	Presentation of management system for operation data (GDE) (Presentation meeting of 3 December)	ONEE-Water Branch	PPT	Mr NAZZA Abdellatif