


CITY WATER AUDIT

Methodology and Outcome

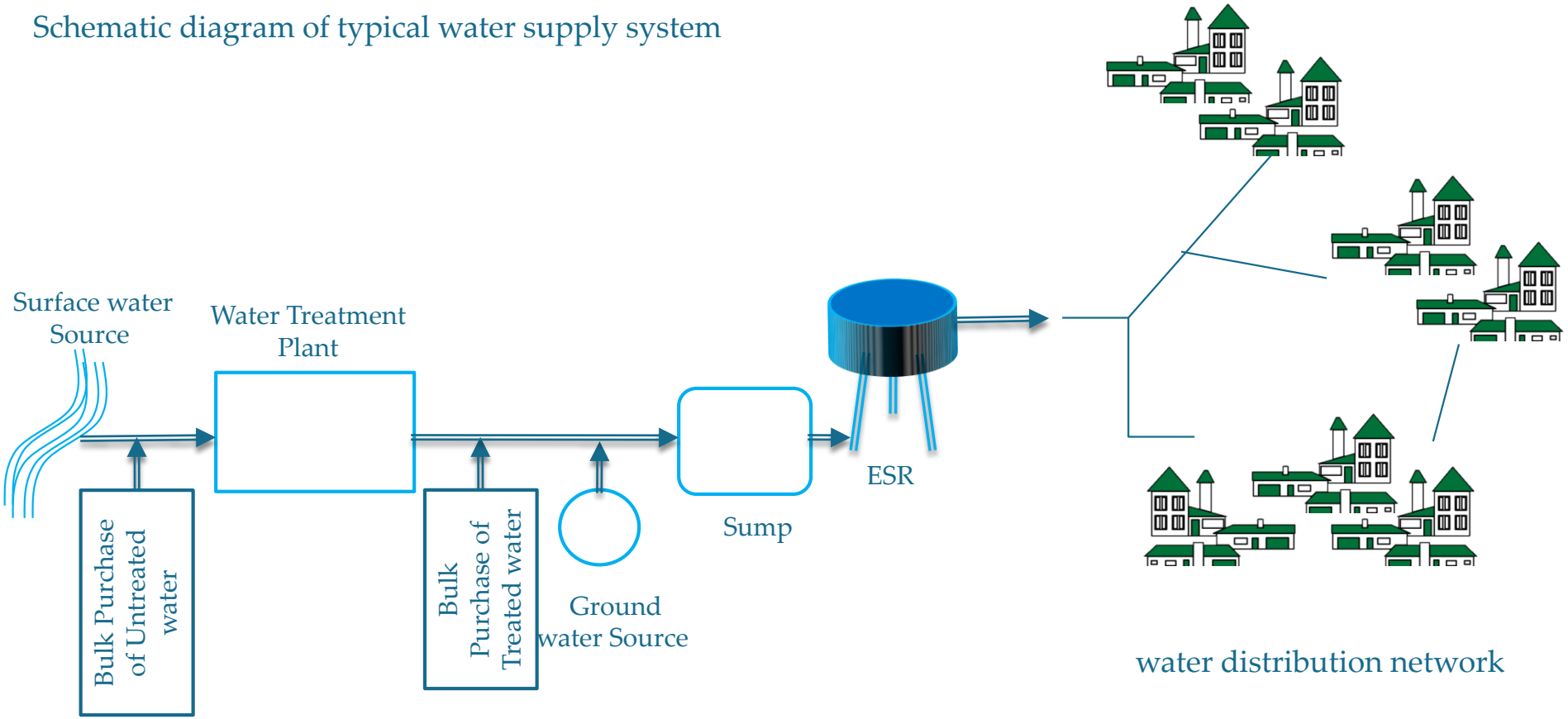
pas performance assessment system

PAS Project, CEPT University, India

Introduction

Schematic diagram of water supply system

Schematic diagram of typical water supply system



- Lack of metering
- Pipelines within the distribution network are interlinked
- Control of leakage on a routine, planned basis is impossible
- Routinely measure or assess adequacy of system pressure is impossible

Source: Water and Sanitation Program of the World Bank

To plug the leak

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

Water Audit Methodology

Before the Audit

- Establish a worksheet
- Set up a study period
- Define the study boundary

IWA standard water balance chart

<table>
<tr><td rowspan="9">System Input Volume (A)</td><td rowspan="3">Authorised consumption (B1)</td><td rowspan="2">Billed authorised consumption (C1)</td><td>Billed meter consumption (D1)</td><td rowspan="2">Revenue water (E1)</td></tr>
<tr><td>Billed un metered consumption (D2)</td></tr>
<tr><td>Unbilled authorised consumption (C2)</td><td>Unbilled metered consumption (D3)</td><td rowspan="7">Non-Revenue Water (NRW) (E2)</td></tr>
<tr><td rowspan="6">Water losses (B2)</td><td>Unbilled unmetered consumption (D4)</td></tr>
<tr><td rowspan="2">Apparent losses (C3)</td><td>Unauthorised consumption (D5)</td></tr>
<tr><td>Metering inaccuracy (D6)</td></tr>
<tr><td rowspan="4">Real losses (C4)</td><td>Leakages on transmission and/ or distribution mains (D7)</td></tr>
<tr><td>Leakages and overflows at Utility's storage tanks (D8)</td></tr>
<tr><td>Leakage on services connections up to point of customer metering (D9)</td></tr>
</table>

Steps for water audit

Task 1: System Input Volume (A)

Volume of water entered into a transmission system and/or purchased water from concerned agency

- Identify various sources of water production
  - Surface water: Intake of dam, river, lake or reservoir
  - Groundwater: Tube/bore wells
  - Bulk raw and/or treated purchase
- Measure the quantity from each sources
  - Quantity of water at various points need to be measured by flow meters. If flow meters are absent, measurements are done with portable ultrasonic flow meter
  - Quantity of bulk purchase water is generally available from water bill received by ULB

Installation of portable flow meter

- While installing or using portable flow meter
  - It must be ensured that the minimum length of straight pipeline at upstream is 5 times the diameter of pipe and at downstream is 3 times the diameter of pipe without any bend, valves or joints
  - This is required to attain proper estimates of water flow in pipeline

Steps for water audit

Task 2: Billed Authorised Consumption (C1 = D1+D2)

Volume of metered and non-metered water taken by billed consumers

- **Billed metered consumption (D1)**
  - Identify metered connections
  - Measure quantum of metered use
    - Zone/ward-wise billed metered water connections to be obtained from ULB's billing system and volume of metered water to be extracted from ULB records

Steps for water audit

Task 2: Billed Authorised Consumption

- **Billed unmetered consumption (D2)**
  - Identify unmetered connection
  - Estimate quantum of unmetered use
    - Billed unmetered consumption can be calculated by:
      - Test zone flow measurement [like District Metered Area (DMA)] or
      - Representative sample survey method
    - Measurement can be done by installing water meter during measurement period

Zone flow measurement

- Billed quantity is measured in various test zones and subsequently, extrapolated at city level
- Selection of test zone should be based on the following criteria:
  - It should cover all the housing category like HIG, MIG, LIG and Slums
  - Availability of detailed distribution maps
  - Availability of consumer data like number of consumers, size of connections, existing water meter details etc.
  - Preferably, smaller zones with about 50 to 60 house service connections
- If meters are already installed then check its accuracy and replaced inaccurate meters. If meters are not installed then installed meters in all connections
- Everyday take readings and calculate the losses in the test zone. Pressure is recorded on a predetermined location
- This exercise should be carry out for few days, mainly one week.

Representative sample survey

- Sampling according to water distribution zones:
  - Number of connections in each zone should be arrived at according to their sizes using the base map and record of house connections
  - Samples should be taken from each water zone at an average pressure level by considering the topography and distance from the elevated reservoir and supply timings
  - Survey in each zone can be conducted using selected representative house connections for sample measurements. It must be ensured that samples should cover all the inhabited area and also slum households within city
  - Total quantum of water received can be calculated by multiplying number of connections with average quantity of water received at consumer ends for each water zone

Representative sample survey

- Sampling according to wards
  - If the distribution system cannot be divided into water zones then samples should be taken at ward level
  - Number of connections in each ward can be multiplied with the average quantity of water received per connection to get the city level quantity of water received at consumer end

Steps for water audit

Task 3: Calculate the volume of Non-Revenue Water (NRW)(E2)

NRW is the difference between System Input Volume and Billed Authorised Consumption. NRW consists of Unbilled Authorised Consumption and Water Losses.

- Non-Revenue Water = System Input Volume – Revenue Water

Steps for water audit

Task 4: Calculate the Unbilled Authorised Consumption ($C2 = D3 + D4$)

Unbilled authorised consumption covers metered and unmetered free supply

- **Unbilled metered consumption (D3)**
  - Identify unbilled metered authorised connection
  - Measure quantum of meter use
    - Zone/ward wise metered unbilled water connections and consumption details can be obtained from ULB

Steps for water audit

Task 4: Calculate the Unbilled Authorised Consumption

- **Unbilled unmetered consumption (D4)**
  - Identify the unmetered authorised connections
    - This component typically includes items such as public stand post, tanker supply, government offices, schools, hospitals, gardens, public toilets etc.
  - Measure quantum of unmetered authorised use
    - Water consumption in municipal property (municipal schools, offices, gardens etc.) is measured or calculated as per prescribed norms mentioned in Central Public Health and Environmental Engineering Organisation (CPHEEO) manual for specific use
    - Estimation of water supply from public stand post: volumetric flow measurement can be deployed for sample stand post
    - Water supply through tankers to unserved areas is calculated by estimating trips, capacity of tankers and estimating increase in tanker supply in summer seasons

Steps for water audit

Task 5: Calculate Authorised consumption (B1)

Authorised consumption includes billed and unbilled consumption

- Authorised consumption = Billed authorised consumption (C1) + Unbilled authorised consumption (C2)

Task 6: Calculate water losses (B2)

Water losses includes apparent losses and real losses

- Water losses = System input volume – Authorised consumption

Steps for water audit

Task 7: Calculate the apparent losses ($C_3 = D_5 + D_6$)

Apparent losses also known as commercial losses which includes unauthorised consumption and all types of meter inaccuracy and data handling error

- **Unauthorised consumption (D_5)**
  - Identify unauthorised connection and then estimate quantum of unauthorised use

  From detailed consumer survey of selected test zone or by doing through sample survey, estimate percentage of illegal connections and from that estimate the unauthorised consumption
- **Metering inaccuracy (D_6)**
  - Estimate the inaccuracy of meters (D_6)

  Metering inaccuracy can be calculated through a sample survey across various meter installations at end users. The composition of the sample shall reflect the various brands and age groups of domestic meters. Based on the results of the accuracy tests, average meter inaccuracy values (as percentage of metered consumption) will be established for different user groups

Steps for water audit

Task 8: Calculate real losses (C4)

Real losses also known as physical losses. Volumes lost through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering

- Real losses = Water losses (B2) – Apparent losses(C3)

Steps for water audit

Task 9: Assessment of Real Losses

- Identify potential water losses like
  - Leaks at raw water transmission lines
  - Evaporation losses
  - Water treatment losses
  - Leaks/seepage of reservoirs
  - Overflows of reservoirs
  - Leaks at distribution mains
  - Leakages from valves and air valves
  - Leakages from services connections up to meter
- Measure or estimate quantum of losses by type (D7, D8,D9)

Methods for real losses assessment

The following methods has been used for measuring and estimating losses from identified leaks

- Bucket and stop watch methods
- Portable Ultrasonic Flow Meter
- Volumetric measurement
- Measurements by partially filled pipe, V-Notch etc.

Assessment of real losses

- Leaks at raw/treated water transmission lines: Measure inlet and outlet of pipelines; leakage from valves and air valves should be surveyed and subtracted
- Evaporation losses: Evaporation rate should be measured and with the help of capacity curve, losses should be calculated
- Water treatment losses: Inlet and outlet of treatment plant should be measured
- Leaks/seepage of reservoirs: Drop test should be carried out
- Overflows of reservoirs: Calculated based on frequency and flow rates
- Leaks of distribution mains: Measure inlet and outlet of pipelines
- Leakages from valves and air valves: Can be calculated using bucket and stop watch method
- Leakages from services connections up to meter: By deducting the mains leakage and storage tank leakage from the total volume of physical losses

Template for water audit

Sr. no.	Item	Water Volume		
		Subtotal (MLD)	Total Consumption (MLD)	Percentage of Total Supply
1	At Head works		14.21	100
2	At Storage Reservoir		13.43	
3	At consumer end			
4	-Domestic -Non-Domestic Total	5.66 0.36	6.02	
5	Corrections- Low flow rate not recorded on meter		1.96	
A	Total corrected water use		7.98	56.16
6	Free water use	1.25		
B	Total authorised water use		1.25	8.80
7	Unauthorised consumption from illegal connections	0.15		
C	Total apparent loss		0.15	1.06
8	Loss of water from Source to GSR (Transmission Loss)	0.78		
9	Loss of water at storage tanks	0.12		
10	Loss of water in distribution system	3.88		
D	Total real loss		4.78	33.64

Performance indicator for NRW

Water Resources related indicators

- **% Authorised and Unbilled Consumption to Total Supply:**
  - Authorised and unbilled consumption is expressed as percentage of total water supply
  - This indicator is used for policy level decisions. For example, government offices also have to pay water bill, which is a policy level decision to curtail free supply
- **% Losses from Source to WTP:**
  - Amount of water losses from source to WTP is expressed as percentage of total water losses
  - This indicator is used for deciding the strategies for reduction of water losses
- **% Losses from WTP to WDS:**
  - Amount of water losses from WTP to WDS is expressed as percentage of total water losses
  - This indicator is used for deciding the strategies for reduction of water losses
- **% Losses from WDS to Final Consumption:**
  - Amount of water losses from WDS to final consumption is expressed as percentage of total water losses
  - This indicator is used for deciding the strategies for reduction of water losses

Performance Indicator for NRW

Indicators related to system operation

- **Water Losses per Connection**
  - Usually water losses are presented as "Percentage by Volume" but this indicator is unsuitable for assessing the efficiency of operational management of water losses. So water loss in litres per service connection per day is the preferred basic operational Performance Indicator
  - This indicator is useful for target settling and also use for comparisons between systems
- **Real Losses per Service Connection per month per meter Pressure**
  - Real losses expressed in terms of annual volume lost per connection per average meter of pressure
  - More useful indicator for comparing different utilities with systems operating at different pressures
- **Water Losses per Mains Length**
  - Total losses expressed in terms of annual volume lost per length of mains
  - This indicator is more useful to know the condition of Network. It does not include the affect of pressure relations in the pressure zone

Performance indicator for NRW

Indicators related to system operation

- **Unavoidable Annual Real Losses (UARL)**
  - This indicator is used to estimate the lowest technically achievable real loss for well managed and maintained system with more than 5,000 service connections, connection density (Nc/Lm) more than 20 per km, and average pressure more than 25 meters. The general equation for UARL is: (18 x Lm + 0.8 x Nc + 25 x Lp) x P

    Where, Lm – Length of Main (km); Nc – No of Connections; Lp - Total length of private pipe, property boundary to customer meter (km); P – Average pressure in meter
  - This equation is based on the component analysis of real losses. The unit of this indicator is liters/day
- **Infrastructure Leakage Index**
  - Ratio between the actual real losses and an estimate of the minimum real losses that could be technically achieved for the system operating pressure, average service connection length and service connection density
  - It is an indicator of water supply system expressing the technical condition of the system from point of view of water losses. It also measures how effectively a utility is managing real losses under the current operating pressure regime
- **Economical Level Leakage (ELL)**
  - The concept of ELL describes the equilibrium between the costs of leakage control and their benefits below which it is not cost effective to make further investments or to use additional resources to drive leakage down any further

Performance indicator for NRW

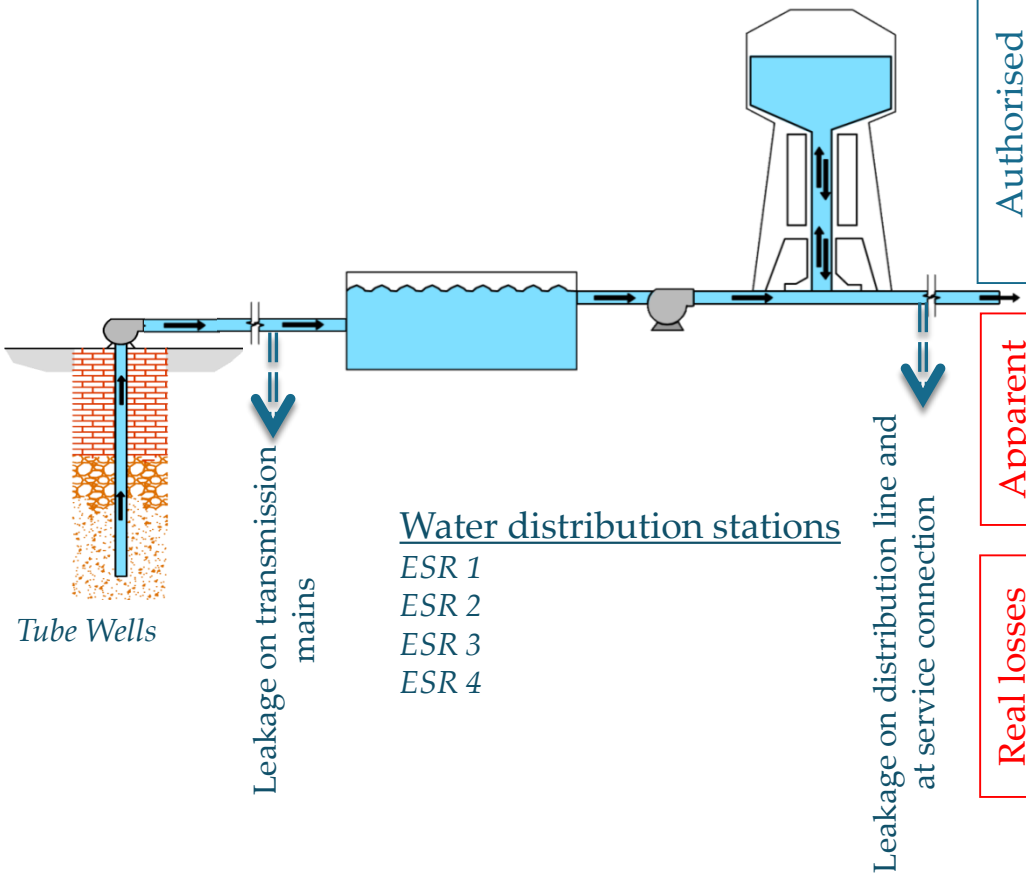
Financial Water Losses Performance Indicators

- **Annual Cost of Real Losses**
  - Real losses expressed in terms of production cost
  - This indicator gives the money loss due real losses
- **Annual Potential Saving from Reducing Water Loss**
  - This indicator gives the amount of rupees saved due to reduction of water losses

Strategies to Reduce NRW

NRW reduction

Reduction of these components will increase revenue



Authorised consumption

Meter ₹ Billed metered consumption

Meter ₹ Billed unmetered consumption

Apparent losses

Unbilled authorised consumption

Unauthorised use:

Metering inaccuracy

Real losses

Leakage on transmission and distribution mains

Leakage and overflow at storage tank

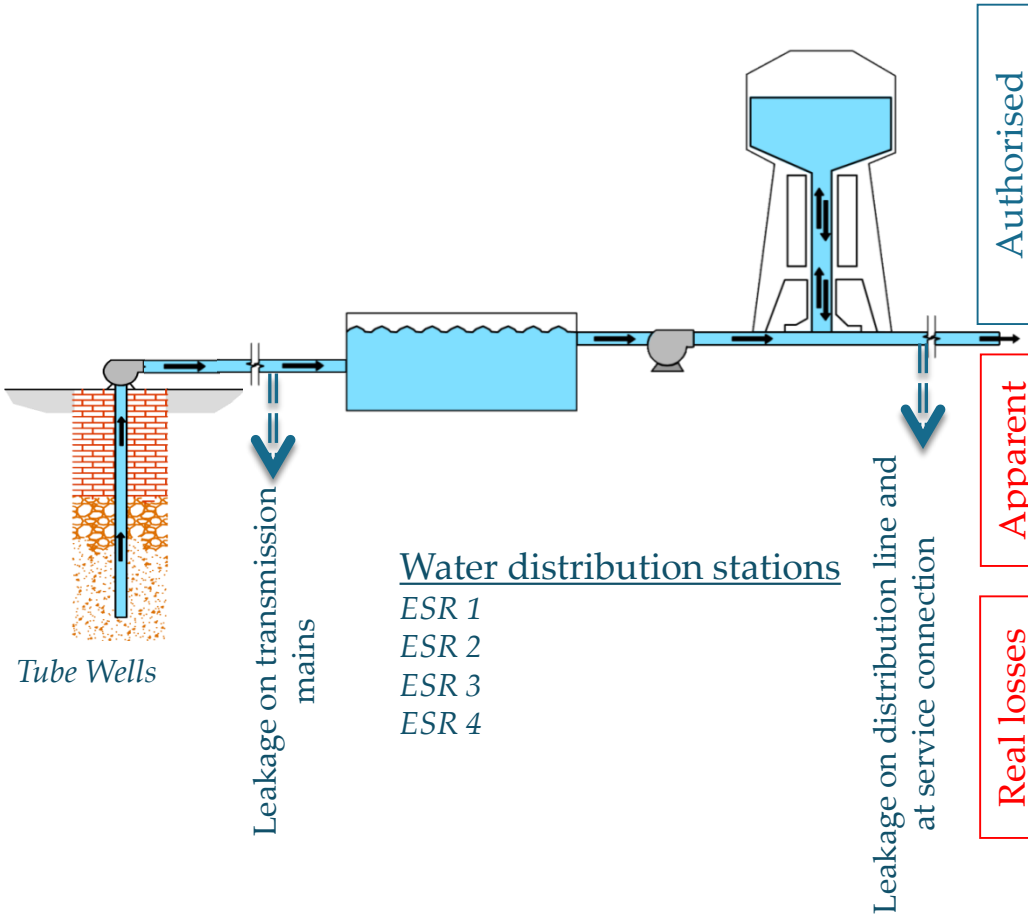
Leakage at service connection

Revenue water

Non revenue water

NRW reduction

Reduction of these components will reduce expenditure and increase revenue (volumetric tariff)



Authorised consumption

Meter ₹ Billed metered consumption

Meter ₹ Billed unmetered consumption

AUTHORIZED ₹ Unbilled authorized consumption

Apparent losses

AUTHORIZED ₹ Unauthorized use:

Metering inaccuracy

Real losses

Leakage on transmission and distribution mains

Leakage & overflow at storage tank

Leakage at service connection

Revenue water

Non revenue water

Measures to reduce NRW –Unbilled Authorised and Apparent Losses

Losses	Improvement measures
Unbilled authorised consumption	Start charging free supply
Illegal consumption	Identify and then regularise illegal connection
Meter inaccuracy	Prepare meter replacement plan

Measures to reduce NRW – Real Losses

Losses	Improvement measures
Leakage in transmission and distribution main	Repair leaking valves Repair or replace leaking pipelines
Leakage and overflow at storage tank	Create awareness in staff Repair or rehabilitate storage tank
Leakage at service connection	Replace service connection Pressure management

Cost of NRW reduction measures

	Low cost	Medium cost	High cost
Short term	Reduction in free supply		
	Regularisation of illegal connection		
	Repair valves and storage tank		
Medium term		Reduce customer meter inaccuracy	
Long term			Replacement of pipelines
			Replacement of service connection
			Pressure management

Thank You