SALGA
South African Local Government Association

# SOUTH AFRICAN LOCAL GOVERNMENT ASSOCIATION (SALGA)

## FRAMEWORK FOR WATER CONSERVATION AND DEMAND MANAGEMENT

**VERSION 1.4.**

**MAY 2008**

South African Local Government Association
For the South African Local Government Association

------------------------------ ------------------------------
Ms I Mkoka Date
Project Manager

------------------------------ ------------------------------
William Moraka Date

Manager: Water Services Unit

Matji and Associates Africa (Pty) Ltd

For Matji and Associates (Pty) Ltd:

------------------------------ ------------------------------
MP Matji Date

## PUBLICATION SPECIFICATIONS

**Published by**

**South African Local Government Association (SALGA)**

**REPUBLIC OF SOUTH AFRICA**

| | |
|---|---|
| **Tel** | **: 012 369 8000** |
| **Fax** | **: 012 369 8001** |
| **Cell No** | **: 082 308 5519** |
| **Email** | **: wmoraka@salga.org.za** |



**This report should be cited as:**

South African Local Government Association (SALGA). May 2008.Strategic Framework for Water Conservation and Water Demand Management. Final Report Versio1.4 compiled by Matji & Associates (Pty) Ltd

**ACKNOWLEDGEMENTS**

This document would not have been successful without the commitment and contribution of the following individuals and organization:

- Mr William Moraka, Manager: Water Services Unit of SALGA for prioritizing the project and make funds available
- Ms Ina Mkoka, Water Services Unit of SALGA, for coordinating the project on behalf of SALGA
- The Technical Team of Matji & Associates (Pty) Ltd led by MP Matji, more especially Mr Hugh Allan, Technical Team specialist for compiling the document and providing technical direction
- All other individuals and organizations who provided input either directly or indirectly to this document

## ABBREVIATIONS

| | |
|---|---|
| ASL | Above Sea Level |
| CMA | Catchment Management Agency |
| d | day |
| dia. | Diameter |
| DMA | District Meter Area |
| DWAF | Department of Water Affairs and Forestry |
| hr | hour |
| ILI | Infrastructure Leakage Index |
| IWA | International Water Association |
| kl | kilolitre = 1 cubic metre |
| KPI | key performance indicator |
| l | Litres |
| LA | Local Authority |
| m | Metres |
| $m^3$ | Cubic Metres |
| mm | Millimetres |
| MDAP | Missing Data Action Plan |
| NRW | Non Revenue Water |
| PS | Pumping Station |
| PWTP | Potable Water Treatment Plant |
| s | second |
| SR | Service Reservoir |
| TWL | Top Water Level |
| UARL | Unavoidable Real Losses |
| WWTP | Wastewater Treatment Plant |
| SALGA | South African Local Government Association |

## DEFINITIONS

**Real losses** can be defined as losses that comprise evaporative and leakage losses from conveyance systems and storage facilities, process losses at treatment plants and overflows from storage tanks.

**Apparent losses** comprise unauthorised consumption and measurement and administrative inaccuracies.

**Water conservation** refers to the minimisation of loss or waste, the preservation, care and protection of water resources and efficient and effective use of water.

**Demand management** refers to the adaptation and implementation of a strategy by a water institution to influence the water demand and usage of water in order to meet any of the following objectives: ***economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, and political acceptability***.

**TABLE OF CONTENTS**

**LIST OF TABLES**

# 1. INTRODUCTION

## 1.1. Key Challenges Related to Water Conservation and Water Demand Management (WC/WDM)

The Water Services Unit (WSU) of South African Local Government Association (SALGA) has identified and prioritised the need to provide technical support including advising municipalities on issues related to water conservation and demand management. Some of these issues emanated from research and studies which have showed that water losses in some of the Municipalities are very high (refer to Table 1.1).

Various studies were commissioned by DWAF to gain an understanding on the extent of water losses in Municipalities (DWAF, 2006). A survey on water losses was conducted by DWAF's Water Services Unit in a number of Municipalities (refer to **Table 1.1. in Annexure A**). The study has shown that the average water losses in Municipalities which were surveyed is between 18% and 58.6%, with annual losses of up to 69% recorded in Emfuleni Municipality. DWAF has commissioned a follow-up study to understand the factors leading to such high water losses. At the time of compiling this report the findings of such a study a study were not available.

On the 17th March 2008, The South African Minister of Water Affairs and Forestry send a strong message on the need to conserve water. She further emphasized that Water Conservation and Water Demand Management (WC/WDM) are gaining increasing importance in DWAF. The DWAF's commitment to WC/WDM is supported by the initiatives rolling-out a pilot programme in 2007 in eight Municipalities. The Pilot Programme was aimed at reducing water losses, estimated at 29%, to 15% .

## 1.2. The Need for a Strategic Framework for WC/WDM

The National Department of Water Affairs and Forestry has developed a multi-sectoral WC/WDM strategy. One of the sectors that the strategy focuses on is Local Authorities (Domestic Use). South Africa has about 284 Local Authorities which were created through the Municipal Demarcation Act No.27 of 1998 (DWAF, 2007). This includes six (6) metropolitan municipalities, forty-seven (47) District Municipalities and two hundred and thirty-one (231) Local Municipalities. All these Municipalities have to formulate WC/WDM strategy that could assist them in addressing water losses/wastages and also ensure efficient management of their water services infrastructure. To ensure consistency in the approach to WC/WDM, a common and standardised approach had to be developed. In view of this, SALGA has commissioned this specific project to address the issue.

### 1.3. Regulations to Conserve Water

Regulations relating to compulsory national standards and measures to conserve water were published in Government Gazette of 8th June 2001. These regulations include, amongst others,

- Water services audit as a component of the WSDP
- Water and effluent balance analysis and determination of water losses
- Repair of leaks
- Pressure in reticulation systems
- Measurement/control of water supplied
- Consumer installations other than meters

In addition to the above, DWAF's Directorate: Water Use Efficiency is in the process of finalising regulations related to WC/WDM for Municipalities. This is a clear indication of the DWAF's determination to promote water use efficiency. Local Authorities should therefore prioritise on issues related to WC/WDM.

## 2. FRAMEWORK FOR THE DEVELOPMENT OF WC/WDM STRATEGY

### 2.1. Introduction

Despite numerous initiatives by various national bodies and several local authorities in the years since the passing of the National Water and Water Services Acts, much of local authority water supply management is characterised by under-performance in terms of:

- the levels of service provided to consumers (continuity and pressure of supply)
- reduction of water losses to an optimum economic level
- control of water demand
- maximum utilisation of the available infrastructure assets
- efficiency in use of human and financial resources

Of course exceptions to such a generalisation do exist, but this framework is intended to provide a road map for those local authority managers that recognise that there are shortcomings within their organisation and who have the motivation and responsibility to make changes in organisational structure, operational management procedures, staff skills and responsibilities, monitoring and reporting regimes, as well as some modest investment in instrumentation, rehabilitation and repairs.

A check list table to assess relevance of the framework document has been designed (**refer to Annexure B**). If the answer to any of the check list items is **No**, then there is room for improvement and this framework should be of interest.

### 2.2 Basic Principles

***Integration of WC/WDM to the water services function***

Whilst it is obvious that the introduction of new water conservation and water demand management initiatives will require additional resources, such initiatives should not be seen as separate from the water services planning and operational functions. A primary objective of WC/WDM is to contribute in a cost effective manner to the provision of a reliable supply of water to the community, including facilitating the extension and improvement of services to the sections of the community that presently experience poor or effectively no service.

***The importance of data***

The development of a strategy for water conservation and demand management needs to be based on a thorough review of the extent, performance and operation of the water supply infrastructure, the utilisation of water by consumers, and an analysis of physical and administrative losses, including the financial consequences of such losses. It requires reliable data on:

- the configuration of the main infrastructure components, from source to consumer, their hydraulic characteristics / capacities, and correct understanding of their inter-relation and mode of operation
- the extent of metering within the system infrastructure and at consumer connections, and their accuracy
- the quantities of raw water available at the requisite assurance of supply, taking into account the effect of changes in catchment characteristics with time (eg land use, invasive alien plant species, diffuse and point sources of pollution)
- the quantities of raw water abstracted, treated water produced and supplied to districts and sub-districts – annual average, monthly, and daily peaks
- pressures within the reticulation system and the durations when the system is not pressurised due to shortage of water, if applicable
- the numbers of residential consumers and populations, subdivided by socio-economic classification / housing type, and future projections
- the numbers of non residential consumers and future projections

- quantities of water taken by or delivered to authorised consumers, subdivided by socio economic classification / type
- unauthorised use of water, to the extent that this can be quantified
- the short run marginal cost of water production and delivery (ie the direct financial benefit to the municipality of eliminating physical loss of water within the infrastructure, per litre / kilolitre)
- the tariff structure and short run marginal income of billed water consumed (ie the direct financial benefit to the municipality of eliminating unauthorised use or correcting under registration of consumer flow meters, per litre / kilolitre)

All of these data sets are of relevance both to the planning and operation of water services generally, and to the WC/WDM function.

Without these data we can never be sure that the right mix of WC/WDM initiatives are selected, or that we are targeting our efforts and committing human and financial resources in the most effective way. We owe it to the community to tackle WC/WDM with a maximum result for least cost philosophy and to apply the same degree of professional rigour as we would expect when implementing and operating new dams or water treatment plants.

***Level of service objectives***

Armed with the above data, a strategy can then be devised which has the purpose of ensuring that the authority is able to provide a continuous supply of water to its consumers in a "normal" year, at minimum cost, without imposing special restrictions, having regard to increases in the numbers of consumers connected and/or improvements in the levels of service in the future.

***Simplified short term strategy may be appropriate***

In the first instance, the strategy can be simplified by considering only the existing situation, especially if it is evident that there is considerable scope for water savings that can be justified either by their contribution to the rectification of current level of service deficiencies, or by the financial benefits to be realised.

***Types of water loss and the benefits of reducing them***

Water losses are of two types: "real" (or "physical") losses, and "apparent" (or "administrative") losses. **Real losses** comprise evaporative and leakage losses from conveyance systems and storage facilities, process losses at treatment plants and overflows from storage tanks. **Apparent losses** comprise unauthorised consumption and measurement and administrative inaccuracies. Both types of loss are likely to be found on all systems.

If water shortages are not a problem, then the justification for reducing losses is primarily financial, but more often water shortages, either presently or in the foreseeable future, provide the primary motivation for water loss reduction, with the added benefit of a financial gain. Such financial gains in fact provide the some of the funding needed for the WC/WDM initiatives and must be utilised accordingly and not be lost to the water service function.

### *Phased approach*

When preparing a strategy for the first time, it is likely that not all of the data which is necessary for a fully comprehensive analysis will be available or reliable. A first WC/WDM strategy should therefore comprise two elements:

1. the identification of priority WC/WDM measures which can be initiated with confidence of a positive result, on the basis of the information available
2. recommendations on further investigations and data capture, including additional instrumentation, together with changes to management information and reporting systems, so that the strategy can be reviewed and updated in a few years time with the benefit of better and more reliable information, including the results of the priority WC/WDM measures.

### 2.3 Procedure

The procedure envisaged by this framework document comprises the following key pillars of WC/WDM:-

a. Legislative/Institutional Requirements
b. Technical
c. Financial, and
d. Social

Each of the pillars is discussed in detail in the next Chapters.

## 3 LEGISLATIVE/INSTITUTIONAL REQUIREMENTS

This Section of the document focuses on legislative instruments and institutional capacity to support the implementation and enforcement of WC/WDM measures.

### 3.1. Legislative Requirements

Municipalities need to ensure that all activities undertaken as part of the overall WC/WDM comply with relevant pieces of legislation such as Municipal Systems Act, Public Finance Management Act, etc. In order to achieve this, an understanding WC/WDM activities, coupled with Water Acts is required.

At the national level, the National Water Act and Water Services Act make various provisions and requirements for the implementation of WC/WDM principles and measures. At the Municipal level, the Municipality needs to have appropriate legal instruments that could assist in implementing and enforcing WC/WDM measures. This legal instrument is the bylaws.

According to Chapter III of the Water Services Act, Act No.108 of 1997, every Water Services Authority (WSA) must compile bylaws which contain conditions for the provision of water services. The first step should be to ensure that the bylaws incorporate conditions for promoting/encouraging water use efficiency. If the bylaws do not make this provision, then it will be difficult for any Municipality/Local Authority to successfully implement WC/WDM measures.

### 3.2. Institutional Requirements

The Municipality needs to build institutional capacity that would ensure successful implementation of aspects/components of WC/WDM. The first priority is that the water services manager or chief engineer or whoever who has overall responsibility, understands the integrated concept and what he/she is trying to achieve by way of optimising water operations and efficiency. The key change is from passive to active system management. That "buy in" is essential for that person having the authority to make the necessary changes to department, section and individual job responsibilities, then sets about ensuring that all of the tasks that were not performed in the past but are now recognised to be necessary, are actually carried out. He / she may of course need to rely upon advice from others and delegate individuals to get trained up, and one can certainly envisage in a larger Municipality having specialist teams with team leaders, e.g. a leakage reduction unit or a consumer use monitoring and minimisation unit. Of course promote WC/WDM as a vital component of water service delivery, but it must be integrated into the organisation in its various parts.

In Municipalities where Water Services Providers (WSP) has been appointed, there must be service level agreement between the WSP and the Municipality (Water Services Authority). The Service level agreement must clearly outline the roles and responsibilities of both institutions. The Water Services Provider must be appointed in terms of Chapter IV of the Water Services Act Act No.108 of 1997.

In some of the Municipalities, there will be a need for the establishment of institutions such as the Water Committees to facilitate service delivery. These committees should be established in terms of Chapter VII, Section 51, of the Water Services Act, Act No. 108 of 1997.

# 4 TECHNICAL

The technical pillar is the core of all the other three pillars of WC/WDM. The outcome of this pillar informs the approach to Economic, Social and Legislative/Institutional pillars. To ensure that all pillars have a backbone, resources need to be invested in the understanding of water and sanitation infrastructure and challenges related to the status of such an infrastructure.

This Chapter focuses on all technical issues related to WC/WDM. It focuses on portable water and wastewater components. The key topics of focus in the Chapter are:

- Understanding of the Water/Wastewater Infrastructure System
- Undertaking information and data check
- Assessment of :-
  - ✓ raw water sources and infrastructure
  - ✓ portable water treatment plants
  - ✓ bulk water imports/purchases
  - ✓ treated water storage facilities
  - ✓ treated water transmission mains
  - ✓ bulk system metering
  - ✓ water and sewerage networks
  - ✓ pumping stations (water and wastewater)
  - ✓ Consumer metering
  - ✓ Water consumption
  - ✓ Infrastructure competence summary
  - ✓ Existing water conservation and water demand management practices
  - ✓ Water mass balance and performance indicators

## 4.1. Understand the System(s) – Fixed Assets

Ensure that there is a proper understanding of the configuration of the whole of the water supply infrastructure and how it operates. Produce a simple schematic diagram, ideally showing hydraulic capacities, levels, sizes of transmission mains, positions of flow meters, etc. Each distribution area should be identified (typically as fed from a service reservoir). Refer example as Fig 1 and the schedule of key data in **Table 1 in Annexure C**.

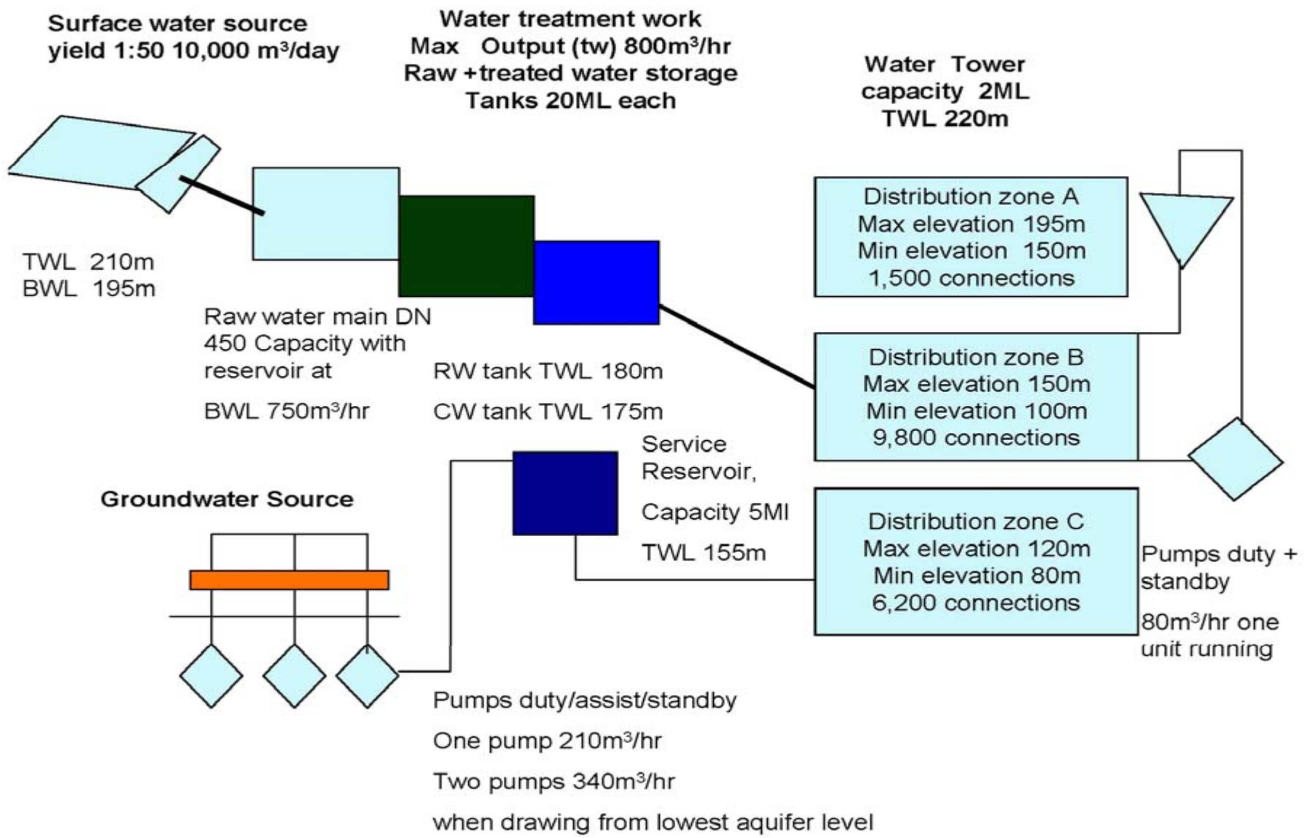


**Fig 1: Schematic Diagram with Key Water Infrastructure Data**

## 4.2. Information and Data Check

Table 2 in **Annexure C** was designed to assist the Municipality in establishing what information and data exist and assign degrees of confidence. Many of these data should already exist, as required by the Water Services Act and its accompanying regulations. Where there are no data, e.g. absence of flow meter, develop a **Missing Data Acquisition Plan** [MDAP], which becomes part of the Implementation Plan (refer Section 6). If the LA has already made a commitment in principle to encompass WC/WD in its water services operation and planning processes, then the MDAP should be drawn up, costed, funding allocated and implemented without waiting for the development of the Strategic Plan.

## 4.3 Raw Water Sources and Infrastructure

Tables 3A to 3C **in Annexure C** were designed to assist the Municipality with the compilation of a situation assessment for each raw water source.

## 4.4 Potable Water Treatment Plants

Table 4 in **Annexure C** was designed to assist the Municipality in compiling a situation assessment for each water treatment plant.

## 4.5 Bulk Water Imports / Purchases

Table 5 in **Annexure C** was designed to assist the Municipality in compiling a situation assessment for bulk water import / purchase.

## 4.6 Treated Water Storage Facilities

Table 6 in **Annexure C** was designed to assist the Municipality in compiling a situation assessment for each treatment water storage facility, including the clear water tank at a treatment plant.

## 4.7 Treated Water Transmission Mains

Table 7 in **Annexure C** was designed to assist the Municipality in compiling a situation assessment for the treated water transmission mains (trunk mains that typically connect treatment plants to service reservoirs and do not have any service connections)**.**

## 4.8 Bulk (System) Metering

Table 8 in **Annexure C** was designed to assist the Municipality in compiling a situation assessment for the bulk or system metering. If there is no meter on one of the key measurement points (ref to Table 2, items 2.4 to 2.8), include the measurement point in Table 8 but enter note “meter missing”.

### 4.9 Water and Sewerage Networks

Tables 9A and 9B [from items 1.10, 1.12, 2.10 & 2.11 in Table 2] in **Annexure C** have been designed to assist Municipalities in compiling a situation assessment for each discrete supply system and sewerage catchment, and for each sub system or distribution area or zone within a discrete supply system. The situation with regard to the provision of a continuous supply of water to consumers is simply recorded in this Table, even though the causes and remedies are likely to be multi faceted, including addressing issues of consumer demand. This assessment is dealt with later in Section 6.

### 4.10 Pumping Stations (Water or Wastewater)

Table 10 in **Annexure C** was designed to assist Municipalities in compiling a situation assessment for pumping station.

### 4.11 Wastewater Treatment Plants

**Table 11** in **Annexure C** was designed to assist Municipalities in compiling a situation assessment for each water treatment plant, compile a Situation Assessment.

### 4.12 Consumer Metering

Table 12 [from items 1.11, 2.15 in Table 2] in **Annexure C** was designed to assist Municipalities in compiling a Situation Assessment for consumer metering.

### 4.13. Water Consumption

Tables 14A [from items 2.16 to 2.20 and 2.24 to 2.26 in Table 2] in **Annexure C** was designed to assist the Municipality in compiling a situation assessment for each distribution and catchment area if possible, but for the whole municipality as a minimum.

### 4.14. Infrastructure Competence Summary

Tables 3 to 12, were designed to assist the Municipality in compiling an infrastructure competence Situation Assessment summary as it is shown in Table 15 which is also in **Annexure C.**

### 4.15. Existing Water Conservation and Water Demand Management Practices

**Table 16** in **Annexure C** was designed to assist the Municipality in designing a situation assessment for WC/WDM practices.

### 4.16. Water Mass Balance and Performance Indicators

#### 4.16.1 Fundamental Principles in Accounting for Water

In the water mass balance, we shall observe the basic scientific principle of **conservation of mass**, namely that matter cannot be created or destroyed, but it may be changed to a different form, e.g. from liquid to gaseous state through evaporation.

A mass balance block diagram is a useful aid to ensuring that (a), we do not overlook possible sources of loss, and (b) we account for every drop in simple arithmetic terms, i.e the sum of the parts (the outputs) = the whole (the input). This may be obvious as a statement, but in many water audits that do not apply this discipline, because different parts of the system are analysed independently, the numbers just do not add up and the validity of the output results and conclusions are called into question.

A common error is to use different time frames for different parts of the system, possibly because of absences of data. The starting point should be to compile an annual mass balance using data on system inputs and outputs for the same 12 month period, so that seasonal variances in demand are smoothed out. The results from the mass balance over a year give the annual average inflows, losses and demands, although these are more commonly expressed in terms of cubic metres or kilolitres per day.

It can be of assistance when considering water shortages that may occur only, or are more severe, in the summer season, to compile a mass balance for the peak month demand, but it is recommended to establish a competent annual mass balance in the first instance. As far as the water supply side is concerned it is recommended to split the water mass balance into two parts:

1. From the raw water source(s) through to the point(s) of input of treated water into distribution
2. From the point(s) of treated water input, through the reticulation, to the consumer.

A third water supply mass balance could be developed from the point that the consumer draws water from the reticulation, but this is only useful in micro management of consumer demand and is outside of the scope of this framework, however the fact that some sub components of consumer use offer more potential for water conservation than others, is recognised in developing consumer demand management programmes. In the subsequent sections and the illustrative examples, the mass balance for a single system is presented, as a discrete technical entity. As an administrative body, however, a local authority may have more than one system.

Understanding the basic configuration of the infrastructure, as described in Section 3.1, so as to define the boundaries of each system, is crucial. Being able to split the register of consumers and billing data and allocate them to the appropriate system, is also a pre-requisite. Finally, it should be obvious, but it can never be over emphasised, that a complete and competent metering regime from raw water abstraction through to the consumer connections is an essential feature of water accounting and therefore of water conservation and demand management.

#### 4.16.2. Source to Supply Input Mass Balance

##### 4.16.2.1. Content and compilation of balance

Figure 2 below is an example of a source to supply input mass balance for a single system.

<table>
<tr><td rowspan="2">Raw water abstracted<br>30,000 Ml/yr</td><td>Net water into own supply<br>26,335 Ml/yr</td><td>Input to Fig 3<br>Mass Balance</td></tr>
<tr><td rowspan="5">Losses in infrastructure up to the point of supply<br>3,590 Ml/yr</td><td>L1 treatment process losses</td></tr>
<tr><td rowspan="5">Treated water imported<br>2,000</td><td>L2 leakage and overflows from tanks</td></tr>
<tr><td>L3 leakage from conveyance systems</td></tr>
<tr><td>L4 evaporation from open systems</td></tr>
<tr><td>L5 apparent losses</td></tr>
<tr><td>Water exported to others<br>2,075 Ml/yr</td><td></td></tr>
</table>

**Fig 2: Annual Mass Balance: Source to Supply Input**

The losses are calculated by subtraction. In the example:

$$30,000 + 2,000 - 26,325 - 2,075 = 3,590$$

In the sub-division of losses, note that the apparent losses could be negative, eg if the raw water was under-recording the true quantity and/or the meters measuring the water put into supply or exported were over-recording the true quantity.

It will be appreciated from this example, that if, say, the raw water meter was under measuring the true amount by about 10%, then the actual losses would be about twice the estimate. Thus in the original balance, if it was found that water treatment process losses were 5% of raw water input, there is about 2,000 Ml/year of other real and apparent losses to be found. However if the true amount of raw water abstraction was 35,000 Ml/year, then there is about 5,000 Ml/year to be found. This example serves to emphasis the importance of accurate metering when computing losses by subtraction (losses cannot be measured in themselves), possibly making the difference to the decision on whether or not to further investigate, locate and minimise the losses within this part of the water balance.

Treated water that is exported in bulk to others may either be accounted for in this mass balance or in the Fig 3 mass balance as a major consumer, but it is preferable in **Fig 2** so that **Fig 3** is more representative of the local authority's own consumer base.

#### 4.16.2.2. Analysis of the balance and indicators

The ratio of losses to the amount of raw water abstracted expressed as a percentage provides a baseline - 3,590/32,000 = 11.2% in the above example.

***L1 Treatment plant process losses***

A water treatment plant should have metering of both raw water inlet and treated water outlet, or of the dirty water that goes to waste, so as to be able to determine the process losses, L1 in Fig 2. If there is a washwater recovery system, then L1 should be negligible. If filter backwash and clarifier sludge is simply discharged to sewer, then 5% or more of the raw water abstracted could be accounted for by L1. If more than 5% or the figure quoted in the design or operation manual, then it is worthy of closer investigation.

***L2 Leakage and overflow from tanks***

This can only be determined by site inspection. Leakage from tank structures may not always be readily visible, but can be determined accurately by conducting a "drop test" on a full tank whilst the inflow and outflow are closed temporarily. Reduction of such leakage could be costly, depending on the nature and location of defects. Overflow losses are caused by faulty inlet control valves or level control systems in the case of a pumped inflow. Complete elimination of overflow losses, which can be substantial, should be the aim, and should be technically possible at low cost.

***L3 Leakage from conveyance systems***

The conveyance systems may include both open channels for raw water, as well as pipes. Leakage from open channels is usually evident by inspection, but the cost of rectification may be significant, depending on the nature of the channel lining. It is generally difficult to determine transmission main leakage accurately, since it relies on accurate metering. If it appears from the annual mass balance to be excessive, it needs to be checked on site.

It is worthwhile "walking the line" to check for visible evidence of leakage, such as wet ground or patches of lush vegetation. However it has been known for large trunk main leaks to be invisible, by finding leakage paths into drainage systems. A suitable benchmark for acceptable pipeline leakage is the value used for testing of new mains, as given in SABS 1200L, but obviously any visible leaks must be repaired, irrespective of any benchmark value.

*L4 Evaporation losses*

If there are open raw water storage reservoirs downstream of the point of abstraction, or long conveyance channels, then evaporation losses can be significant. These can readily be calculated from determination of the water surface areas and standard evaporation rates for the location as published by the Water research Commission (2001)..

*L5 Apparent losses*

Also with open raw water storage or conveyance systems, then the possibility of theft of water for irrigation or other use cannot be ruled out. Otherwise the only other apparent losses are due to meter error, which can be determined, and minimised, by meter calibration or renewal.

### 4.16.3. Treated Water Supply Input Mass Balance

#### 4.16.3.1. Content and compilation of balance

Figure 3 below is an example of a supply input to consumer mass balance. The concept of revenue and non revenue water, originally proposed by the International Water Association and adopted by DWAF, is enshrined in the computation.

<table>
<tr><td rowspan="10">Water into supply (system input volume)<br>26,335 Ml/yr</td><td rowspan="5">Authorised consumption<br>20,310 Ml/yr</td><td rowspan="3">Billed consumption<br>20,260 Ml/yr</td><td>C1 Metered consumption<br>17,910 Ml/yr</td><td rowspan="2">Revenue water<br>18,910 Ml/yr</td></tr>
<tr><td>C2 Non metered consumption<br>1,000 Ml/yr</td></tr>
<tr><td>C3 Consumption billed but not paid for 1,350 Ml/yr</td><td rowspan="8">Non revenue water<br>7,425 Ml/yr<br>[28.2%]</td></tr>
<tr><td rowspan="2">Unbilled consumption[1]<br>50 Ml/yr</td><td>C4 Metered unbilled consumption<br>0 Ml/yr</td></tr>
<tr><td>C5 Non metered unbilled consumption<br>50</td></tr>
<tr><td rowspan="5">Losses<br>6,025 Ml/yr</td><td rowspan="3">Apparent losses<br>1,015 Ml/yr</td><td>C6/L1 Unauthorised consumption – unregistered connections / theft<br>100</td></tr>
<tr><td>L2 Billing errors & adjustments[2]<br>100</td></tr>
<tr><td>L3 Metering inaccuracies<br>815 Ml/yr</td></tr>
<tr><td rowspan="2">Real losses<br>5,010 Ml/yr</td><td>L4 Leakage & overflows in service reservoirs & tanks<br>100 Ml/yr</td></tr>
<tr><td>L5 Leakage from water mains & service connections<br>4,910 Ml/yr</td></tr>
</table>

**Fig 3: Annual Mass Balance: System Input to Consumer**

*Notes:*

1. *Unbilled but authorised consumption generally comprises water that is used by the municipality itself. Examples are: fire fighting (including hydrant testing), flushing of mains for quality purposes.*
2. *As emphasised in Note 3 of Table 2, the consumption data used in the mass balance must be the summation of actual meter readings and technical estimates of unmetered consumption, before any billing adjustments are made for financial reasons. Such billing adjustments are a component of apparent losses, and can be negative as well as positive.*

The percentage of non revenue water in Fig 3 comes to 28.2%, but an alternative calculations starting with Fig 2 and based on the quantity of raw water abstracted could be:

NRW = (3,590+7,425)/32,000 = 34.4%

The amount of loss component L5, leakage from the reticulation, can be cross-checked by undertaking a **night flow analysis**. The night flow analysis relies on there being only a small amount of consumption during the hours 02.00 to 04.00. The theory is that, after deduction of that small consumption, as well as any industrial consumption from 24 hour processes, the balance of the **minimum night flow** is leakage. However this leakage comprises both leakage in the reticulation and leakage within consumer's premises. Reconciling night flow data with the annual mass balance result requires a good level of technical understanding, as well as accurate metering.

Night flow analysis is not effective if, due to high demand / supply deficiency during the day time, consumer storage tanks are being filled during the night.

#### 4.16.3.2. Analysis of the balance and indicators

***Consumption C1 to C6***

Consumption components C1 to C3 should be analysed by reference to Tables 13A and 14A, the resulting output for the whole municipality being shown in Table 17 below. These results can be compared with benchmark values such as those given in Table 6A of Vol 2 of the DWAF WC/WDM Guideline Manual (IWRM) and an estimate of any excess consumption can be made to derive a potential water saving from WDM initiatives.

The same exercise can be conducted for individual supply areas within the municipality and comparisons can be made, which may help to reveal either anomalies in the data, worthy of further investigation, or target priority areas within the municipality.

In South Africa the aim should be to eliminate unmetered consumption (C2 and C5), and any estimate used for the purposes of compiling the mass balance should be considered to have a low confidence factor, unless there has been a rigorous process to arrive at the estimate. Clearly, if components C3 (billed but unpaid consumption) and C6 (unauthorised consumption) are significant, these need to be highlighted and included in any action plan for loss reduction.

***L2 Billing errors and adjustments***

These simply need to be understood for what they are, the main aim being to ensure that they are visible so as to avoid a false picture being given of true consumption or apparent losses.

***L3 Metering inaccuracies***

Inaccuracies in bulk (system) metering can be determined by calibration or meter renewal and in any WC/WDM programme should be minimised. Inaccuracies in consumer meters can be estimated, firstly by establishing the meter profile of types, manufacturers and ages, and then by representative testing. As a general rule, the greater the average age of the meter stock, the greater the degree of under-recording. A consumer meter management programme must be a core component of any WC/WDM programme.

***L4 Leakage and overflows from service reservoirs and tanks***

Refer remarks under L2 above.

***L5 Leakage from water mains and service connections***

In most systems, this is likely to comprise the largest volume of loss. If there are any trunk mains without service connections within the Fig 3 balance, then ideally these should be considered separately as in L3 above. However this may not be practicable and it is acceptable to include them with the rest of the reticulation.

It should be well enough understood by now that percentage of system input is an incorrect indicator for reticulation leakage, simply because any changes in consumer use have a corresponding change in the percentage of leakage (demonstrable by simple arithmetic) without there being any actual change in leakage. Furthermore, reticulation leakage is a function of pipe length, numbers of connections and system pressure and no two networks have the same characteristics. So they should not be compared in percentage terms.

The recommended indicator for reticulation leakage is the IWA indicator Infrastructure Leakage Index (ILI), which is now generally accepted in South Africa. It does involve some careful calculation however, and knowledge both of system pressure and periods of pressurisation.

The first step is to calculate the value of "unavoidable real losses" (UARL):

UARL = 18 l/day per km of water main per m of adjusted pressure*

+ 0.8 l/day per connection per m of adjusted pressure*

+ 25 l/d per km of underground pipe up to the consumer meter beyond the street boundary

** Refer Table 9 note 3*

The second step is to calculate the value for ILI which is:

ILI = annual leakage losses (L5)/365/UARL

It is generally accepted that, for a network in average structural condition, ILI should be less than 2.5. With rehabilitation, values of ILI < 2.0 should be achievable. A new network that has been laid and supervised to a good technical standard should have an ILI of less than 1.0.

When calculating ILI, it is important to appreciate that it permits a higher unavoidable loss according to system pressure. If an acceptable ILI is calculated but with a high system pressure (above 5 bar say), it is important not to overlook the opportunity to reduce losses by pressure reduction.

Table 5B in the Vol 2 of the DWAF WC/WDM Guideline Manual (IWRM) shows the benefits to be gained by pressure reduction. For example, a reduction from 60 m to 40 m average pressure should achieve a reduction of 43% in leakage.

***Consumer internal plumbing leakage***

Consumer internal plumbing leakage is not identified separately within Fig 3, although it can be significant and should be estimated. It is likely to be found as a component of C2 (unmetered consumption), C3 (consumption billed but not paid for) and C6 (unauthorised consumption / theft). In all three cases it constitutes non revenue water.

### 4.16.4. Return Flow Mass Balance

#### 4.16.4.1. Content and compilation of balance

Fig 4 below shows the components of a complete return flow mass balance. It is much more difficult to estimate all of these components and for the purposes of most water conservation initiatives that are within the sphere of local authority responsibility, the mass balance when considered at the wastewater treatment plant, which is where we have the ability to measure inflows, can be simplified as shown in

Fig 5.

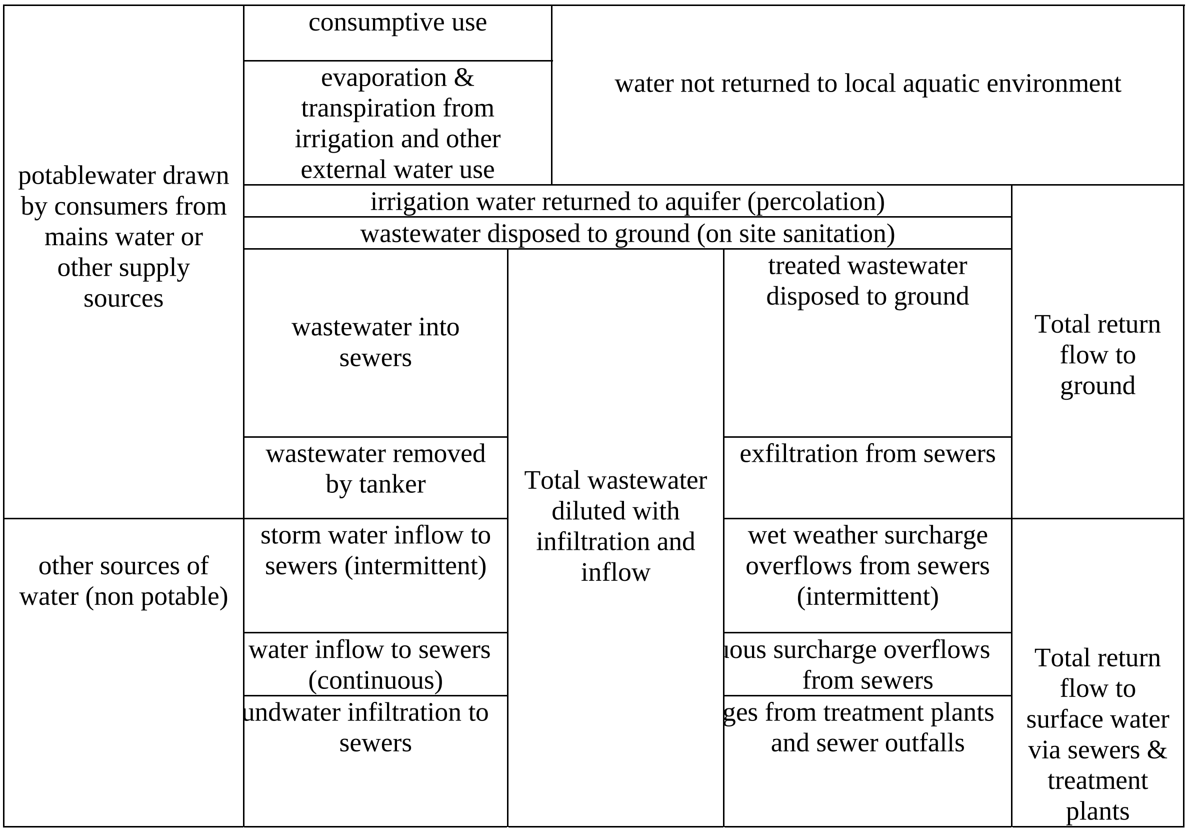


**Fig 4: Wastewater Return Flow Mass Balance**

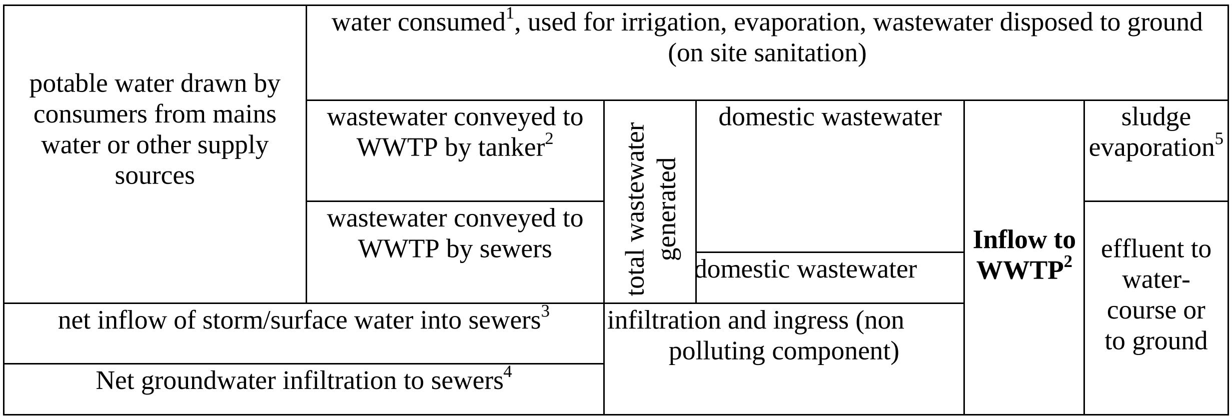


**Fig 5: Simplified Return Flow Mass Balance at Wastewater Treatment Plant**

*Notes:*

1. *"Consumed" in this context means not being returned to local aquatic environment, eg converted to product.*
2. *Whether tanker waste is discharged upstream or downstream of the WWTP inflow measurement device should be noted. Ideally, tanker waste should be measured separately at reception.*
3. *Inflow less outflow under surcharge conditions*
4. *Infiltration into defective sewers & manholes which are below groundwater table, less exfiltration from defective sewers & manhole which are above ground water table.*
5. *Shown for completeness and can easily be estimated if wet sludge is dried atmospherically on open drying beds, otherwise, ie mechanical dewatering, the amount is insignificant and can be ignored.*

The only point of measurement on Fig 5 is at the inlet to, or possibly the outlet from the WWTP, but, like a flow meter on a water distribution system, it measures only the total flow and the sub-division into parts must be estimated by other methods.

In many countries the “return to sewer” portion of the water supplied to consumers is known and fairly consistent, typically 90-95%. Therefore on a mass balance calculation, the infiltration and surface water inflow is the difference between the total flow measured at the inlet to the WWTP and the return to sewer amount calculated from the water supplied. The problem with this method is that (a), the portion of return to flow can vary significantly in South Africa, both seasonally and according to socio economic household category, and (b) inaccuracies in metering can easily distort the answer significantly.

The preferred method of estimating the quantity of infiltration and surface water inflow is by examination of the diurnal variation in inflow to the WWTP over a 24 hour period. Using the same principle of minimum night flow as referred to in section 4.16.3.1, an estimate can be made of this component.

#### 4.16.5. Water Loss and Consumption Summary

Before moving on the development of a WC/WDM strategy, it is useful to summarise the findings of the water balance and performance audits. Table 18 provides a suggested format. The results are classified in terms of their severity as high / medium /low, which provides a pointer towards the strategy, but what is “high” may nevertheless be excluded from the WC/WDM action plan in some circumstances and, equally, there may be justification for reducing further what is already “low”. Such judgements are the purpose of the strategy development in Section 7 and to some extent will be influenced by the financial consequence of losses, as described in Section 5.

## 5. FINANCIAL

Some of the Municipalities are facing challenges related to cost recovery related to the provision of water and sanitation services. The Municipalities need to monitor the change in the cost recovery rate. It must also be noted that the costs recovered from the provision of water services can be utilized to improve the status of the existing infrastructure in terms of operation and maintenance and/or even replacing the old/non-functional infrastructure. Water use charges can be used as a means of encouraging reduction in water wastages/losses and/or inefficient water use. Both real and apparent water system losses, as well as conveyance of ground water and surface water inflows to sewer systems, represent a financial loss to the municipality.

The recovery of these losses within a WC/WDM programme can provide a significant contribution to its funding.  Indeed some WC/WDM measures are likely to be wholly self-financing.

If the optimisation of WC/WDM with future asset planning is envisaged then a relatively sophisticated approach is required, typically incorporating net present cost accounting, such as the concept of integrated water resource management as set out in Chapter 9 of Vol 2 the DWAF WC/WDM Guideline Manual. The unit costs which must be determined for the immediate evaluation of WC/WDM measures are:

1. The short run marginal unit costs of water abstraction, production, bulk purchase and pumping, which are represent the immediate benefit of reducing real water losses, as derived in Tables 3B, 4 and 5
2. The relevant unit selling cost of water to consumers, ie at the appropriate variable component of the current water tariff
3. The short run marginal cost of conveying wastewater in sewerage networks, which represent the immediate benefit of reducing infiltration and inflow to sewers.

The marginal cost in (1) will always be much less than the unit selling cost in (2).
A typical financial loss statement based on the previous example is illustrated in Table 19.

In the above example, the marginal cost for raw water pumping is 0.075 R/kl, and for water treatment is 0.025 R/kl, thus all real losses downstream of the treatment plant have a marginal cost of R0.1/kl. No further pumping within the reticulation is assumed, but if there was a booster pumping station for delivery to higher elevations, then the marginal cost of this water would be greater and the financial benefits for each kilolitre of water saved greater than for the rest of the network. The metering inaccuracies within the apparent losses in Fig 3 are assumed to be due 100% to consumer meter under-registration and no over-registration of the system input meter.

## 6. SOCIAL

Municipalities need to develop appropriate WC/WDM awareness and education materials. They also need to implement various educational and awareness programmes to promote water use efficiency and also encourage water saving practices. The situation in each Municipality will be different, so even the approach to the development and implementation of the programmes may vary from one Municipality to another. In order to ensure effective awareness and educational programmes, a comprehensive situation assessment to understand consumers needs to be undertaken.

## 6.1. Consumer Profiles

Compile Situation Assessments as Table 13A and 13B [from items 2.13, 2.14, 2.22, 2.23, 2.25 to 2.27 in Table 2], for each water distribution and sewerage catchment area if possible, but for the whole municipality as a minimum.

## 6.2. Consumer Behaviour/Practices

Consumer behaviour and/or current best management practices related to WC/WDM should be understood. A survey to understand consumer/customer's knowledge, attitude, and perception/practices (KAP) needs to be undertaken prior to developing any awareness/educational programmes. This would assist the Municipality in monitoring and evaluating the success and challenges related to the programme.

# 7. DEVELOPMENT OF WC/WDM STRATEGIC PLAN

The development of the WC/WDM strategic plan depends to a greater extent on the technical and economic data/information available. However, other two pillars (i.e. social and legislative/institutional) of WC/WDM should also form part of the strategic plan.

## 7.1. LEGISLATIVE/INSTITUTIONAL

In formulating the strategic plan, it is crucial for the Municipality to ensure that there are supporting statements in the Municipality's bylaws. If there are no supporting statements, the Municipality will not have legal muscles to enforce WC/WDM measures. The Municipality also needs to ensure that institutional structures with delegated powers have been put in place to champion the implementation of identified WC/WDM measures/programmes. This should be clearly outlined in the strategic plan.

## 7.2. TECHNICAL

The selection of water conservation and demand management measures is governed by:

- The supply - demand balance and the contribution of WC/WDM measures in alleviating water shortages, now and/or in the foreseeable future

***Clear statement on water supply –demand balance***

In the first step, the relationship between available supply and consumer demand is evaluated. The past trend as well as the current year needs to be considered, and a projection for the future made. Peak day rather than annual average demands are considered in this evaluation. A clear statement of the supply – demand balance position needs to be made, and quantified, so that the amount of water "to be found" is derived, whether in the form of new or upgraded infrastructure to increase the supply, and/or in savings to be made by demand reduction measures.

*Identification of supply side bottlenecks*

Most infrastructure that has been developed piecemeal over many decades results in imbalances and certain “bottlenecks” in the system, rather than every major component having the same effective capacity. From the Table 15 Infrastructure Summary, the availability of treated water can be reviewed, considering all of the links in the chain of supply from raw water source through to the consumer. For each bottleneck, a cost can be put against its elimination, so that a pattern of progressive increase in infrastructure development cost corresponding to rising demand is seen, as illustrated by the example in Table 20 below. The final two columns in the table can be repeated for X = 5, 10, 15, 20 as considered appropriate.

***Demand side***

On the demand side of the equation, the focus will be on household consumption, illegal connections and reticulation losses, and the potential for demand reduction by WC/WDM measures. A systematic approach needs to be adopted that ensures that no options are overlooked. Such an approach is conceptualised in Table 21 below.

***Selection of package of primary measures***

Review of the content of Tables 20 and 21 is likely to confirm the need for certain actions that have been appreciated at the outset, but now with proper justification to support a business case. The discipline of adopting a systematic approach may well highlight other measures that could otherwise have been overlooked. The selected package of measures is almost always likely to comprise a combination of supply and demand side measures. Supporting measures are considered within the scope of the Implementation Plan. For further details of the technical content of the measures listed in Table 18, reference may be made to Vol 3 of the DWAF WC/WDM Guideline Manual (IWRM).

## 7.3. FINANCIAL

In formulating the WC/WDM strategic plan, some of the financial components that must be taken into account includes the:-

- Cost recovery status – the Municipality needs to establish its cost recovery status and determine out factors affecting non-payment for services. The relationship between non-payment for services and level of service should be established. The strategic plan should then address factors that are the root cause of non-payment for services.
- Tariff structure *(billing types (i.e. fixed charge, volume charge, and block charge pre-paid)).* The tariffs can be used as deterrents for addressing water wastages and losses. The Municipality should revisit the current tariff structure

- Operation and maintenance costs – performance of the existing infrastructure depends on the extent of operation and maintenance of the system. Water losses can be avoided if the water infrastructure is well maintained.

### 7.4. SOCIAL

The strategic plan should focus on developing appropriate educational and awareness programmes informed by the outcome of technical and economic interventions/programmes.

## 8 IMPLEMENTATION PLAN

The implementation plan should focus on addressing issues emanating from the four pillars of WC/WDM.

### 8.1 LEGISLATIVE/INSTITUTIONAL

Many WC/WDM initiatives fail to deliver their potential, simply because they are not adequately managed and resourced, and the organisational changes needed are not made. The Implementation Plan must address this. The selection of WC/WDM measures will dictate how the organisation needs to be adapted and responsibilities assigned, to achieve a successful implementation. This will entail an assessment of the impact of WC/WDM measures on departments and individuals, the identification of skills and human resource gaps and the mechanisms by which such gaps will be filled.

***Consumer metering***

Typically in South Africa, consumer metering is a function within the financial department whereas operating the infrastructure is a technical function. This is not a viable model for integrated WC/WDM, which should be self evident from this framework. The core data is a shared resource and must meet the needs of both functions. The management of the meter stock is essentially a technical function, so the preferred model is for meter management and, logically, for meter reading, including quality control of meter reading data, also to be the responsibility of the technical services department. Meter readers are a key municipality interface with the consumer. They are “eyes and ears” and can participate in leak identification, for example.

***Outsourcing***

The outsourcing of some activities will be necessary, at least in the short term. Planning and implementing the bulk meter improvements and part 1 of the consumer meter management regime are obvious examples. Whether the additional long term operational activities are to be implemented in whole or in part by external organisations will be a matter for the LA to determine according to its circumstances, but what is essential is the identification of internal management responsibility for delivery of the programme, although can be an advantage in appointing an external project manager in the short term to kick start the programme.

## 8.2 TECHNICAL

### 8.2.1. Missing Data Acquisition Plan (MDAP)

The MDAP is developed from Table 2, the original data and information check list. The MDAP can be expected to comprise specific actions of three types:

1) Capture and collation of data that do not require any new infrastructure or instrumentation, only internal organisational action being needed. An example of this would be improvement to meter reading (system and consumer).
2) Filling gaps in the records of infrastructure, generally involving surveys, but could include performance testing, for example checking the actual output of pumps against the nominal design value.
3) Improvements to system instrumentation, particularly metering but could also include measurement of pressures within the reticulation, water levels in reservoirs, wells and storage tanks.

### 8.2.2. Metering

#### 8.2.2.1. Bulk (System) Metering

The first step is to carry out a full technical audit on the existing meters to check them for accuracy. The format of the meter recording and archiving arrangements should also be reviewed. Some existing meters may need to be replaced because they are obsolete or beyond economic repair. It is acceptable to rely upon taking readings manually and transferring the data to a register, but providing it is actually done and it is the responsibility of someone to collate the data so that there is meaningful output that can be used for regular monitoring of water use.

The installation of additional meters to enable complete water accounting is a key component of the MDAP. As well as proper sizing of meters (dimensioned according to expected flow range and meter accuracy and not simply matching the size of the pipeline), decisions need to be made on the methods for recording, transferring and archiving the data and incorporated in the specification for the meters.

#### 8.2.2.2. Consumer Metering

If no meter management regime is in place, then the first step is to estimate the extent of measurement deficiency, together with filling any gaps in the meter stock profile (ie age, type, manufacturer profile). This will entail representative testing of consumer meters, which can either be done in-situ or by replacement with new and bench testing the old meter (which if salvageable could be refurbished and put back into service). A parallel part of this exercise is to review the format of the meter database.

If it does not incorporate: manufacturer, type, serial number, size, age (installation date); then the database should be modified accordingly. On the basis of the consumer meter appraisal, a **meter management regime plan** can be prepared. It is recommended that this should comprise two parts:

1) Backlog elimination – 5 year plan to achieve target level of meter accuracy, including installation of meters on unmetered connections (whether or not they are billed).
2) Long term meter management regime – ongoing programme of annual checks and renewals, rapid response to faulty meter identification.

The representative testing can be used to prioritise meter renewals, if a particular type of meter is found to have poor accuracy. The long term meter management plan should include an age component. For example, a target could be set that there should be no meters greater than 20 years of age that have not been checked. Particular attention should be paid to the meters on large consumers. If the cost of a new meter installation is R5000, say, but the meter generates an income of, say, R200,000 per year, and if meter is under-recording by, say 5%, then over 5 years its replacement will finance R50,000 of WC/WDM measures. When a meter is replaced, the meter database must be edited accordingly.

## 8.3 FINANCIAL

If the process outlined in this framework is followed, then the basis for the Financial Plan will be in place. The Financial Plan will have both income and expenditure components and it is fundamental that there is “ring fencing” of the water services budget since it is a key feature of integrated WC/WDM that there will be a shift in the balance of capital to operating expenditure. To this must be overlaid the allocation of budgets over, say, a 5 year time frame and the costing of external professional services and works contracts, according to the decisions on outsourcing.

## 8.4 SOCIAL

In order to ensure sustainability, the education and awareness programmes should be implemented using local resources. Internal capacity required for implementing the programmes should be built within the Municipality.

### 8.5. SUMMARY OF IMPLEMENTATION PLAN

A suggested format for summarising the Implementation Plan and how the municipality will deliver it is given in Tables 22 and 23. It is important to make the distinction between one-off start up and ongoing activities. In terms of financial impact, completion of these tables will enable net present cost financial and economic calculations to be done, if required.

## 9 MONITORING AND REPORTING PLAN

Fundamentally, the objective of WC/WDM is to contribute to a substantive degree in improving levels of service to the community in the most cost effective manner. Other infrastructure investment measures may also be implemented over the same time frame and therefore the monitoring and reporting regime is visualised in two parts:

1) Level of service report
2) WC/WDM measures report

Annual reporting is recommended. The annual report should relate to the Implementation Plan, with progress and financial statements accordingly. A key feature of monitoring and reporting should be key input and output indicators (output indicators also key performance indicators, KPIs). Some indicators, such as some KPIs, will be standard, others should be tailored according to the content of the Strategic Plan and Implementation Plan. It is important to have a clear picture of the trend, and it is recommended that 5 years of data are presented. An example format for an Annual Report is included as **Annexure G**.

## 10. SUMMARY AND CONCLUSIONS

The difficulties in planning and successfully implementing water conservation and water demand management measures within a local authority should not be underestimated. Whilst a simple problem analysis can lead to the identification of what may be a number of obvious initiatives, this approach has its limitations in terms of achievement and sustainability. The following conclusions have been arrived at in relation to each of the four pillars:-

### 10.1. LEGISLATIVE/INSTITUTIONAL

WC/WDM measures cannot be enforced with success if there are no legal instruments in place to support such the enforcement. Prior to engaging in enforcing WC/WDM measures, Municipalities need to ensure that legal tools have been incorporated into the Municipal Bylaws. The Municipality needs to ensure that institutional structures with sufficient human resources capacity including a champion for WC/WDM have been put in place. Failure to have a champion will lead to none of the measures being implemented.

### 10.2. TECHNICAL

The amount of data capture, collation and appraisal needed for the structured approach to planning WC/WDM that is presented in this Framework may seem to be onerous to some, but in an efficiently run water and sewerage undertaking, if these data are not available, then the managers responsible for delivering good quality water and sanitation services efficiently to the community cannot realise that aim.

Conducting this appraisal should assist not just in devising a better package of WC/WDM measures than would be developed using a more simplistic approach, but also will lead to a better understanding of system operation and efficiency.

### 10.3. FINANCIAL

The value of a local authority's assets are substantial and the need for water conservation and demand management measures is in fact an indicator that the best use is not being made of those investments. Introduction of WC/WDM provides an opportunity for improving operational practices and getting a greater return on the investment in infrastructure.

### 10.4. SOCIAL

Education and awareness programmes should involve local community to ensure sustainability, continuity and buy-in from consumers. Materials developed should be based on the specific situation within the Municipality.

## 11. REFERENCES


a. Water Services Act, Act No. 108 of 1997
b. National Water Summit, 17th March 2008, Speech by Minister LB Hendricks, National Minister of Water Affairs and Forestry, Gallager Estate, Midrand, Gauteng.
c. DWAF, June 2006, Data Collected as part of the study entitled 'Towards Water Conservation and Water Demand Management'
d. Government Gazette 22355 of 8th June 2001.
e. DWAF, December 2007, Water Services Authority Legislative Handbook.
f. DWAF, August 2004. Water Conservation and Demand Management Strategy for the Water Services Sector.
g. DWAF / Danida, April 2004. Guidelines for Water Conservation and Demand Management, Volume 2, Undertaking a WC & WDM Situation Assessment and Development of a Business Plan within the Water Services Sector.
h. DWAF / Danida, April 2004.Guidelines for Water Conservation and Demand Management, Volume 3, Implementation of WC & WDM Measures within the Water Services Sector.

i. International Water Association, 2000. Performance Indicators for Water Services, IWA Series 2000 Manuals of Best Practice, ISBN 1-900222-272, Washington, USA (Authors: Alegre, H., Hirner, W., Baptista, J. and Parena, R.).

j. SABS report no 0306, 1999. The Management of Potable Water in Distribution Systems.

k. Water Research Commission, 2001. Development of a Simple and Pragmatic Approach to Benchmark Real Losses in Potable Water Distribution Systems in South Africa. WRC report number TT 159/01, ISBN 1-86845-773-7, Pretoria, RSA (Authors : McKenzie, R.S. and Lambert, A.O.),

l. SABS 1200L 1983. Medium Pressure Pipelines.

m. International Water Association, 2007. Integrated Water Meter Management. ISBN 978 184339 0343,

n. Water SA Vol 25 no 2 (author E H Johnson), April 1999. In Situ Calibration of Large Water Meters.

**ANNEXURE A : TABLE 1.1. QUICK SURVEY ON LOSSES DONE BY WATER SERVICES UNIT AT DWAF (SOURCE : DATA GATHERED AS PART OF THE STUDY: TOWARDS WC/WDM REGULATIONS, 2006)**

| | | Water bought | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **No.** | **Municipality** | **2001** | **2002** | **2003** | **2003 StatsSA** | **2004** | **2004 StatsSA** | **2005** |
| 1 | City of Tshwane Metropolitan Municipality | 183,640,204 | 193,443,115 | 214,284,254 | *217,250,284* | 235,099,314 | *244,768,954* | 249,795,110 |
| 2 | City of Johannesburg Metropolitan Municipality | | 434,223,469 | 458,115,082 | *458,000,000* | 469,758,273 | *472,948,780* | 471,560,410 |
| 3 | City of Cape Town Metropolitan Municipality | 295,049,454 | 287,635,361 | 301,362,349 | ***345,063,114*** | 310,270,000 | *256,074,000* | 269,078,000 |
| 4 | Ekurhuleni Metropolitan Municipality | 244,342,344 | 250,438,248 | 258,910,005 | ***240,980,904*** | 272,246,888 | ***260,259,376*** | 300,531,488 |
| 5 | eThekwini Metropolitan Municipality | | | 291,000,000 | *291,000,000* | 282,506,337 | *282,506,337* | 288,400,000 |
| 6 | Nelson Mandela Bay Metropolitan Municipality | | 72,584,000 | 75,742,000 | *76,070,000* | 78,239,000 | ***131,898,000*** | 78,917,000 |
| 7 | Buffalo City Local Municipality | | 59,369,647 | 59,293,388 | *60,367,783* | 57,466,405 | *57,342,023* | 57,091,752 |
| 8 | Manguang Local Municipality | 47,034,330 | 48,558,230 | 57,246,440 | ***48,858,187*** | 59,650,943 | *59,650,943* | 61,763,972 |
| 9 | Mogale City Local Municipality | 19,058,822 | 20,329,471 | 21,611,921 | ***4,982,716*** | 22,538,202 | *0* | 22,280,700 |
| 10 | Sol Plaatjie Local Municipality | | | 23,907,754 | *23,907,754* | 24,889,329 | *24,339,691* | 26,875,882 |
| 11 | Polokwane Local Municipality | 15,547,057 | 16,417,466 | 19,874,000 | ***19,874,000*** | 17,668,917 | *17,668,917* | 17,670,000 |
| 12 | Mbombela Local Municipality | | | | ***2,884,700*** | | ***2,782,030*** | 10,030,000 |
| 13 | Rustenburg Local Municipality | | | 22,179,379 | *22,179,379* | 23,460,000 | ***40,370,000*** | 26,573,000 |
| 14 | Steve Tshwete Local Municipality | | | 13,090,524 | *13,090,524* | 12,905,988 | *12,905,988* | 13,000,000 |
| 15 | Emalahleni Local Municipality | 27,325,784 | 30,663,614 | 31,820,058 | *31,820,058* | 31,620,905 | ***18,960,333*** | 31,799,450 |
| 16 | Mafikeng Local Municipality | 13,112,234 | 12,851,285 | 13,293,202 | *13,293,202* | 12,535,460 | *12,535,460* | 11,310,199 |
| 17 | The Msunduzi Local Municipality | | 39,568,009 | 41,120,633 | *40,687,955* | 42,677,244 | *42,677,244* | 43,930,168 |
| 18 | City of Matlosana Local Municipality | | | 22,431,560 | *22,431,560* | 22,791,783 | *22,791,783* | 24,620,000 |
| 19 | Emfuleni Local Municipality | 66,158,064 | 68,559,144 | 72,232,865 | *72,035,116* | 73,789,926 | ***66,000,000*** | 79,098,348 |
| 20 | Matjhabeng Local Municipality | | | 26,159,220 | ***26,159,220*** | 25,850,979 | ***25,850,979*** | 26,000,000 |
| | | 616,218,839 | 1,247,005,698 | 1,981,621,255 | 2,030,936,456 | 2,075,965,893 | 2,052,330,838 | 2,110,325,479 |

| No. | Municipality | Water sold | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **2001** | **2002** | **2003** | **2003 StatsSA** | **2004** | **2004 StatsSA** | **2005** |
| 1 | City of Tshwane Metropolitan Municipality | 128,629,371 | 135,653,128 | 150,953,301 | ***177,238,204*** | 167,803,959 | ***187,560,746*** | 176,819,800 |
| 2 | City of Johannesburg Metropolitan Municipality | | 263,195,511 | 257,819,727 | *255,000,000* | 285,278,223 | ***360,019,785*** | 316,898,864 |
| 3 | City of Cape Town Metropolitan Municipality | | | 240,637,549 | ***291,951,813*** | 196,980,680 | *196,980,680* | 224,990,357 |
| 4 | Ekurhuleni Metropolitan Municipality | 190,604,000 | 216,499,612 | 223,705,372 | ***21,634,788*** | 235,314,146 | ***172,890,119*** | 216,261,216 |
| 5 | eThekwini Metropolitan Municipality | | | 197,000,000 | *197,000,000* | 194,289,161 | *194,289,161* | 204,510,000 |
| 6 | Nelson Mandela Bay Metropolitan Municipality | | 53,664,000 | 55,114,000 | ***61,570,000*** | 57,069,000 | *57,069,000* | 55,912,000 |
| 7 | Buffalo City Local Municipality | | 34,682,431 | 34,650,472 | *32,665,925* | 33,303,468 | *32,042,186* | 30,585,106 |
| 8 | Manguang Local Municipality | 32,411,171 | 39,320,632 | 36,037,614 | ***48,553,089*** | 37,256,917 | *37,256,917* | 39,159,053 |
| 9 | Mogale City Local Municipality | 16,485,844 | 16,721,561 | 16,152,703 | ***3,373,832*** | 16,857,882 | ***0*** | 17,444,462 |
| 10 | Sol Plaatjie Local Municipality | | | 13,561,855 | *13,561,855* | 15,831,066 | *15,832,066* | 16,284,410 |
| 11 | Polokwane Local Municipality | 12,698,349 | 13,567,966 | | ***19,826,760*** | 12,226,711 | *11,658,307* | 12,230,000 |
| 12 | Mbombela Local Municipality | | | | ***2,136,442*** | | ***0*** | 8,820,000 |
| 13 | Rustenburg Local Municipality | | | | ***19,415,499*** | 16,765,000 | ***0*** | 18,396,000 |
| 14 | Steve Tshwete Local Municipality | | | 10,884,207 | *10,884,207* | 10,691,454 | *10,691,454* | 11,000,000 |
| 15 | Emalahleni Local Municipality | 19,682,535 | 19,521,013 | 19,299,538 | *19,299,000* | 18,760,333 | ***12,860,572*** | 18,523,465 |
| 16 | Mafikeng Local Municipality | | 6,525,720 | 8,508,088 | *8,510,179* | 8,274,665 | ***13,041,128*** | 7,500,000 |
| 17 | The Msunduzi Local Municipality | | 22,961,423 | 23,689,552 | *23,771,056* | 24,280,319 | *24,280,319* | 22,558,042 |
| 18 | City of Matlosana Local Municipality | | | 16,195,104 | *16,195,104* | 15,309,460 | *15,309,460* | 15,310,000 |
| 19 | Emfuleni Local Municipality | 29,019,922 | 29,231,387 | 32,022,850 | ***66,048,552*** | 33,519,479 | ***43,900,000*** | 24,494,000 |
| 20 | Matjhabeng Local Municipality | | | 16,527,615 | *16,527,615* | 19,414,154 | *19,414,154* | 19,500,000 |
| | | 429,531,193 | 851,544,383 | 1,352,759,547 | 1,305,163,920 | 1,399,226,076 | 1,405,096,054 | 1,457,196,775 |

| No. | Municipality | Difference 2001 | 2002 | 2003 | 2004 | 2005 | Average | 2005-group average |
|---|---|---|---|---|---|---|---|---|
| 1 | City of Tshwane Metropolitan Municipality | 30.0% | 29.9% | 29.6% | 28.6% | 29.2% | 29.4% | -1.7% |
| 2 | City of Johannesburg Metropolitan Municipality | | 39.4% | 43.7% | 39.3% | 32.8% | 38.8% | 1.8% |
| 3 | City of Cape Town Metropolitan Municipality | | | 20.2% | 36.5% | 16.4% | 24.3% | -14.6% |
| 4 | Ekurhuleni Metropolitan Municipality | 22.0% | 13.6% | 13.6% | 13.6% | 28.0% | 18.1% | -2.9% |
| 5 | eThekwini Metropolitan Municipality | | | 32.3% | 31.2% | 29.1% | 30.9% | -1.9% |
| 6 | Nelson Mandela Bay Metropolitan Municipality | | 26.1% | 27.2% | 27.1% | 29.2% | 27.4% | -1.8% |
| 7 | Buffalo City Local Municipality | | 41.6% | 41.6% | 42.0% | 46.4% | 42.9% | 15.5% |
| 8 | Manguang Local Municipality | 31.1% | 19.0% | 37.0% | 37.5% | 36.6% | 32.3% | 5.6% |
| 9 | Mogale City Local Municipality | 13.5% | 17.7% | 25.3% | 25.2% | 21.7% | 20.7% | -9.2% |
| 10 | Sol Plaatjie Local Municipality | | | 43.3% | 36.4% | 39.4% | 39.7% | 8.5% |
| 11 | Polokwane Local Municipality | 18.3% | 17.4% | | 30.8% | 30.8% | 24.3% | -0.2% |
| 12 | Mbombela Local Municipality | | | | | 12.1% | 12.1% | -18.9% |
| 13 | Rustenburg Local Municipality | | | | 28.5% | 30.8% | 29.7% | -0.2% |
| 14 | Steve Tshwete Local Municipality | | | 16.9% | 17.2% | 15.4% | 16.5% | -15.6% |
| 15 | Emalahleni Local Municipality | 28.0% | 36.3% | 39.3% | 40.7% | 41.7% | 37.2% | 10.8% |
| 16 | Mafikeng Local Municipality | | 49.2% | 36.0% | 34.0% | 33.7% | 38.2% | 2.7% |
| 17 | The Msunduzi Local Municipality | | 42.0% | 42.4% | 43.1% | 48.7% | 44.0% | 17.7% |
| 18 | City of Matlosana Local Municipality | | | 27.8% | 32.8% | 37.8% | 32.8% | 6.9% |
| 19 | Emfuleni Local Municipality | 56.1% | 57.4% | 55.7% | 54.6% | 69.0% | 58.6% | 38.1% |
| 20 | Matjhabeng Local Municipality | | | 36.8% | 24.9% | 25.0% | 28.9% | -5.9% |
| | Average % loss for the group | 30.3% | 31.7% | 31.7% | 32.6% | 30.9% | | |

## ANNEXURE B CHECKLIST TO ASSESS RELEVANCE OF FRAMEWORK DOCUMENT

| **Check List to Assess Relevance of Framework Document** | Yes ✓<br>No ✕ |
|---|---|
| 1 Are all consumers able to draw water at 1 bar pressure 24 / 365, except in breakdown circumstances? *[see note 1]* | |
| 2 Do you know how many km of water main your organisation owns / is responsible for, and is there a reliable record of their locations, sizes, materials and ages? *[see note 2]* | |
| 3 Are there working and reliable flow meters:<br>(a) on all raw water abstractions (if applicable)?<br>(b) on outlets of all treatment plants (if applicable)?<br>(c) on transfer connections from adjacent authorities or water boards?<br>(d) on outlets of all service reservoirs?<br>(e) on inlets to all wastewater treatment plants? | |
| 4 Are there working and reliable flow meters on most consumer connections? *[see note 3]* | |
| 5 Is the mean pressure in the network(s) known and has it been optimised? | |
| 6 If the organisation has its own raw water source, does is it participate in catchment or aquifer management planning and protection? | |
| 7 Is the term "passive leakage control" understood and is it practised? *[see note 4]* | |
| 8 Is the term "active leakage control" understood *[see note 5]* and is it practised? | |
| 9 Is there a system for recording bursts and repairs on the network(s) and / collating them in a meaningful format? | |
| 10 Is there a quality control regime applied to the reading of customer meters? | |
| 11 Is there someone who is responsible (ie is included in his/her job description) for regular water accounting and reporting? | |
| 12 Is the short run marginal cost of water production /purchase known? | |
| 13 Are the basic principles of relevant water conservation and demand management measures understood and their approximate costs known? | |
| 14 Does the Council receive an annual technical and financial report on the performance of the water service operations? | |

*Notes:*

1. *Answer **Yes** if there are pockets of non compliance but there a technically viable corrective action plan and the finance is committed to implement it. Answer **No** if there is no system of monitoring or reporting or other reliable evidence of compliance exists.*
2. *Answer **No** if there is no systematic regime for updating the records database after new works or repair or rehabilitation is carries out.*
3. *Answer **No** if there is no systematic programme of meter repair / replacement.*
4. *Answer **No** if there is no system of reporting visible leaks and monitoring follow up repair (closure of loop).*
5. *Answer **No** if the answer does not include a time component*

## ANNEXURE C TABLES RELATED TO TECHNICAL DATA

### Table 1: Infrastructure Information (Fixed Assets) Needed for System Understanding

| Infrastructure Component | | Information Needed | Units |
|---|---|---|---|
| 1,1 | Raw water source | Reliable yields (by assurance level)<br>Maximum permitted abstraction | $m^3$/year<br>kl or $m^3$/d |
| 1.2 | Raw water abstraction facility (e.g. pump, transmission main) | Maximum capacity *see notes 1, 2* | l/s or $m^3$/hr |
| 1.3 | Raw water storage (e.g. reservoir, tank) | Capacity when full<br>Top water level (TWL) | kl or $m^3$<br>mASL |
| 1.4 | Treated water production facility | Input capacity (of raw water)<br>Production capacity (of treated water) *see notes 3 & 4* | kl or $m^3$/d or hr |
| 1.5 | Bulk imports of raw or treated water | Where they are on the system and their function | - |
| 1.6 | Treated water storage (e.g. service reservoir, water tower) | Capacity when full<br>Top water level (TWL) | kl or $m^3$<br>mASL |
| 1.7 | Water pumping stations | Where they are on the system<br>Maximum capacity (in case of pumps all duty pumps operating) | -<br>l/s or kl or $m^3$/hr |
| 1.8 | Transmission mains | Length, diameter, capacity | km, mm, l/s or kl or $m^3$/hr |
| 1.9 | System flow meters | Where they are on the system and their function<br>Diameter<br>Manufacturer and serial number<br>Type<br>Age | -<br>mm<br>-<br>-<br>years |
| 1.10 | Water supply distribution areas (typically the area fed from a service reservoir or water tower) | Length of reticulation<br>Approximate age and material profile<br>Highest and lowest ground elevations supplied<br>Numbers of service connections *see note 5* | km<br>-<br>mASL<br>no. |
| 1.11 | Consumer meters | Number<br>Age profile<br>Types / manufacturers | no.<br>years<br>- |
| 1.12 | Sewerage catchment areas | Length of sewer<br>Approximate age and material profile<br>Numbers of service connections | |
| 1.13 | Sewage pumping stations | As water PS 1.7 | |
| 1.14 | Wastewater treatment plants | Daily dry weather flow treatment capacity<br>Equivalent in pollution load<br>Maximum hydraulic capacity | kl or $m^3$/d<br>kg BOD/d<br>l/s or kl or $m^3$/hr |

Notes:

1. *In case of pumps, the capacity is with all duty pumps operating. The design figure can be taken, but after some years of operation the actual output may be different and if critical should be checked.*
2. *In case of gravity pipeline, the capacity should be determined from the lowest operating level at the source to the top water level at the inlet to treatment plant or raw water storage tank as applicable.*
3. *Difference between raw water input and treated water output may be significant if there is no sludge supernatant / backwash recovery.*
4. *Existing water treatment capacity may be limited by normal hours of operation, potential for increase in daily output without additional infrastructure may be noted.*
5. *Number of service connections off the network may be less than the number of consumers, e.g. one connection to a manifold of consumer meters at an apartment block.*

**Table 2: Data Check**

| Information / Data Set | | Complete-ness of Data | Confidence Level | Importance / Priority within MDAP | Specific Actions for MDAP |
|---|---|---|---|---|---|
| *Infrastructure Assets:* | | | | | |
| 2.1 | Configuration and dimensioning of the water and wastewater infrastructure (as Table 1) | | | 1 | |
| 2.2 | Capacities of the major components (as Table 1) | | | 1 | |
| *Operational data on water supply:* | | | | | |
| 2.3 | Condition of the raw water source *see note 1* | | | 1 | |
| 2.4 | Records of daily raw water abstractions last 5 years | | | 1 | |
| 2.5 | Records of daily treated water production last 5 years | | | 1 | |
| 2.6 | Records of daily bulk water imports and exports last 5 years *see note 2* | | | 1 | |
| 2.7 | Records of water pumped at other water pumping stations last 5 years *see note 3* | | | 2 | |
| 2.8 | Records of daily input to each distribution area, last full year | | | 1 | |
| 2.9 | Records of 24 hour diurnal flow variation into water distribution areas, last full year | | | 2 | |
| 2.10 | Records of times that reticulation system is not pressurised (no water to consumers) and numbers of consumers or proportion of network affected, last full year | | | 1 | |
| 2.11 | Numbers of pipeline and service pipe bursts repaired and their locations | | | 2 | |
| 2.12 | Total numbers of registered consumers, water supply | | | 1 | |
| 2.13 | Number of domestic consumers | | | 1 | |
| 2.14 | Number of non domestic consumers | | | 1 | |
| 2.15 | Percentage of consumers not metered | | | 1 | |
| 2.16 | Records of meter readings of domestic households, last 5 years *see note 4* | | | 1 | |
| 2.17 | Estimation of annual unmetered domestic consumption | | | 1 | |
| 2.18 | Records of meter readings of non domestic consumers, last 5 years *see note 4* | | | 1 | |
| 2.19 | Estimation of annual unmetered non domestic consumption | | | 1 | |
| 2.20 | Estimation of annual illegal consumption | | | 1 | |
| 2.21 | Sub division of 2.12 to 2.19 data by distribution area | | | 2 | |
| 2.22 | Breakdown of households and population by socio-economic category | | | 1 | |
| 2.23 | Sub division of 2.22 by distribution area | | | 2 | |
| *Operational data on wastewater* | | | | | |

| Information / Data Set | | Complete-ness of Data | Confidence Level | Importance / Priority within MDAP | Specific Actions for MDAP |
|---|---|---|---|---|---|
| 2.24 | Number of households connected to sewerage systems | | | 1 | |
| 2.25 | Number of non domestic premises connected to sewers | | | 1 | |
| 2.26 | Total number of registered sewer connections | | | 1 | |
| 2.27 | Breakdown of households connected to sewers by socio-economic category | | | 1 | |
| 2.28 | Records of water pumped at other sewerage pumping stations last 5 years *see note 3* | | | 2 | |
| 2.29 | Records of waste from on site sanitation systems tankered to WWTP | | | 2 | |
| 2.30 | Records of daily inflow to and/or outflow from WWTPs last 5 years | | | 1 | |
| 2.31 | Records of 24 hour diurnal flow variation into WWTP, last full year | | | 2 | |
| *Financial data:* | | | | | |
| 2.32 | Cost of electricity at PWTPs, last year | | | 1 | |
| 2.33 | Cost of chemicals at PWTPs, last year | | | 1 | |
| 2.34 | Cost of electricity for pumping, water at each station, last year *see note 5* | | | 2 | |
| 2.35 | Cost of bulk water purchases, last year | | | 1 | |
| 2.36 | Tariff structure for bulk water purchases | | | 1 | |
| 2.37 | Cost of electricity for pumping wastewater, last year *see note 6* | | | 2 | |

Notes:

1. *The quality and quantitative reliability of the raw water source should be known. Are the catchment / hydrogeological conditions which applied when the facility was originally designed still prevailing? Are there are any threats to quality which render the existing potable water treatment process unsuitable? Are land use changes or other abstractions from the same source affecting the reliable yield of the source?*
2. *Bulk (treated) water exported to others is usually identified separately, but it can also be regarded simply as a major non domestic consumer and could be included in 2.17.*
3. *Applicable to other pumping stations that are within the system. Pumping stations that function as the means of abstraction of raw water or are integral with treatment plants are included with*
4. *This figure must be the raw data taken from the meter readings and not the billing records, in case of adjustments made for financial purposes.*
5. *Cost of water treatment can include pumping into supply or raw water abstraction if integral with the plant and not separately metered.*
6. *For financial impact of water conservation measures, only the cost of electricity for pumping is of interest. At a WWTP an estimate needs to be made of the proportion of electrical power that is used for pumping the main flow, which may be zero if WWTP operates by gravity from inlet to outlet. The cost of treatment chemicals at a WWTP is generally a function of pollution load and not hydraulic load, so can be ignored.*

**Table 3A: Situation Assessment - Raw Water Source**

| Item | Situation Assessment |
|---|---|
| Reliable yields (by assurance level) [from 1.1] | |
| Maximum permitted abstraction [from 1.1] | |
| Analysis of raw water abstractions last 5 years [from 2.4]:<br>(i.) maximum day<br>(ii.) maximum month<br>(iii.) annual averages<br>(iv.) 5 year trend | |
| Condition of source, qualitative and quantitative [from 2.3] | |

**Table 3B: Situation Assessment - Raw Water Abstraction Facility (pump, gravity main)**

| Item | Situation Assessment |
|---|---|
| Maximum capacity of abstraction facility [from 1.2] | |
| Hydraulic reserve (difference between maximum capacity of facility and maximum rate of abstraction) [from 1.1 and 1.2] | |
| Administrative reserve (difference between maximum capacity of facility and maximum permitted abstraction) [from 1.2 and 2.4/Table 3A] | |
| Marginal cost of pumping (cost of electricity ÷ amount of water pumped over the same period) [from 2.4/Table 3A and 2.34] | |
| Statement of the condition of the infrastructure | |

**Table 3C: Situation Assessment - Raw Water Storage**

| Item | Situation Assessment |
|---|---|
| Capacity when full and Top water level (TWL) [from 1.3] | |
| Capacity expressed as hours of storage at average and maximum day abstraction [from 1.3 and 2.4/Table 3A] | |
| Statement of the condition of the infrastructure | |

**Table 4: Situation Assessment - Water Treatment**

| Item | Situation Assessment |
|---|---|
| Input capacity (of raw water) and production capacity (of treated water) [from 1.4] | |
| Analysis of treated water production last 5 years [from 2.5]:<br>(i.) maximum day<br>(ii.) maximum month<br>(iii.) annual averages<br>(iv.) 5 year trend | |
| Treatment reserve (difference between maximum capacity of plant and maximum day production [from 1.4 and 2.5], as % | |
| Marginal cost of treatment (cost of electricity + chemicals ÷ amount of treated water produced over the same period) [from 2.5, 2.32 & 2.33], R/kl | |
| Statement of the quality of water:<br>(i.) raw water - comparison with basis for plant design and note if catchment / aquifer conditions are having adverse effect on treatment efficiency<br>(ii.) treated water - compliance with regulatory standard | |
| Statement of the condition of the infrastructure | |

### Table 5: Situation Assessment - Bulk Water Imports / Purchases

| Item | Situation Assessment |
|---|---|
| Analysis of imports last 5 years [from 2.6]:<br>(iii.) maximum day<br>(iv.) maximum month<br>(v.) annual averages<br>(vi.) 5 year trend | |
| Average cost of water purchases (total cost ÷ amount of water purchased over the same period) [from 2.6 and 2.35] | |
| Marginal cost of water purchased - if stepped tariff the highest applicable step, or the variable component of a fixed charge plus cost per kl tariff [from 2.36] | |

### Table 6: Situation Assessment - Treated Water Storage

| Item | Situation Assessment |
|---|---|
| Capacity when full, top water level (TWL) [from 1.6] | |
| Capacity expressed as hours of storage at average and maximum day throughput [from 1.6, 2.5 & 2.8] | |
| Statement of the condition of the infrastructure | |

### Table 7: Situation Assessment - Treated Water Transmission Mains

| Transmission Main / Function | Dia. | Length | Material | Age | Working pressure | Hydraulic capacity | Condition* |
|---|---|---|---|---|---|---|---|
| WTP to SR1 | | | | | | | |
| WTP to SR2 | | | | | | | |
| Etc | | | | | | | |
| Etc | | | | | | | |

**Especially by reference to numbers of bursts - calculate the indicator: no. of bursts per year per kilometre of pipe. Good condition if less than 2 bursts per 100 km per year; poor condition if more than 6 bursts per 100 km per year*

### Table 8: Situation Assessment - Bulk (System) Metering

| Function | Dia. of meter / pipe* | Manufacturer | Type | Age | Availability of historic data | Condition / accuracy / calibration status |
|---|---|---|---|---|---|---|
| Raw water abstraction | | | | | | |
| Raw water inlet to PWTP | | | | | | |
| PWTP wastewater to sewer | | | | | | |
| Treated water into supply | | | | | | |
| Outlet from SR1 | | | | | | |
| Outlet from SR2 | | | | | | |
| Outlet from water tower A | | | | | | |
| Etc | | | | | | |

** If meter is same diameter as pipe it may be over-sized and inaccurate in low flow range, over-sized mechanical meters may stop and fail to record low flows*

**Table 9A: Situation Assessment – Water Reticulation Network**

| Distribution Area | Length of pipe | Age profile | Material profile | Pressure range[1] | No. of service connects | Supply continu-ity[2] | Condition[3] |
|---|---|---|---|---|---|---|---|
| SR1 / DA1 | | | | | | | |
| SR 2/ DA2 | | | | | | | |
| Tower A / DA3 | | | | | | | |
| Total from WTP (Supply system 1) | | | | | | | |
| WB import / DA4 (Supply system 2) | | | | | | | |
| Whole Municipality | | | | | | | |

1. *If there are no measurements, estimate from TWL of service reservoir and ground levels at lowest and highest points of service*
2. *Supply continuity as a percentage of the time that water is available at pressure in the network, without technical restriction on demand from consumers, 100% representing a system that is pressurised continuously without interruption throughout the year. If supply shortages affect only part of networks, adjust the percentages in proportion to the numbers of consumers or length of reticulation.*
3. *Especially by reference to numbers of bursts - calculate the indicator: no. of bursts per year per kilometre of pipe. Good condition if less than 20 bursts per 100 km per year; poor condition if more than 40 bursts per 100 km per year.*

**Table 9B: Situation Assessment – Sewerage Network**

| Distribution Area | Length of pipe | Age profile | Material profile | No. of service connects | Condition |
|---|---|---|---|---|---|
| Catchment area 1 | | | | | |
| Catchment area 2 | | | | | |
| Whole Municipality | | | | | |

**Table 10: Situation Assessment – Pumping Station**

| Item | Situation Assessment |
|---|---|
| Station design capacity [from 1.7 & 1.13] | |
| Estimated maximum inflow | |
| Station reserve difference between maximum capacity and maximum inflow, as % | |
| Marginal cost of pumping (cost of electricity ÷ amount of water or wastewater pumped over the same period) [from 2.7, 2.28, & 2.34], R/kl | |
| Statement of the condition of the infrastructure | |

**Table 11: Situation Assessment – Wastewater Treatment**

| Item | Situation Assessment |
|---|---|
| Daily dry weather flow and maximum hydraulic capacity (of treated water) [from 1.14] | |
| Analysis of plant inflow last 5 years [from 2.30]:<br>(i.) maximum day<br>(ii.) maximum month<br>(iii.) annual averages<br>(iv.) 5 year trend | |
| Treatment reserve (difference between maximum capacity of plant and maximum day inflow [from 1.14 and 2.30], as % | |
| Statement of the quality of treated effluent. | |

**Table 12: Situation Assessment - Consumer Metering**

| Item | Situation Assessment |
|---|---|
| Number of meters | |
| Age profile | |
| Proportion of consumers not metered | |
| Statement on meter types and manufacturers | |
| Condition assessment:<br>• details of any meter management programme, testing etc.<br>• estimated number / proportion of defective meters<br>• summary on accuracy / possible degree of under-recording | |

**Table 14A: Situation Assessment – Water Consumption**

| Distribution Area | Domestic metered | Domestic un-metered | Non domestic metered | Non domestic un-metered | Estimate of illegal consumption | Total water consumption |
|---|---|---|---|---|---|---|
| DA1 | | | | | | |
| DA2 | | | | | | |
| DA3 | | | | | | |
| Total Supply system 1 | | | | | | |
| DA4 / Supply system 2 | | | | | | |
| Whole Municipality | | | | | | |

**Table 14B: Situation Assessment – Water Consumption, Sewered Areas**

| Distribution Area | Domestic metered | Domestic un-metered | Non domestic metered | Non domestic un-metered | Estimate of illegal consumption | Total water consumption |
|---|---|---|---|---|---|---|
| Catchment area 1 | | | | | | |
| Catchment area 2 | | | | | | |
| Whole system | | | | | | |

**Table 15: Situation Assessment – Infrastructure Competence Summary**

| Item | Competence Criteria | Assessment |
|---|---|---|
| *Water supply infrastructure:* | | |
| Raw Water Sources | Available quantity of raw water, trend<br>Raw water quality, trend | |
| Raw Water Abstraction Facilities | Capacity<br>Physical condition / reliability | |
| Raw Water Storage Facilities | Capacity<br>Physical condition | |
| Treated (Potable) Water Production Facilities | Capacity<br>Treated water quality<br>Physical condition / reliability | |
| Treated Water Storage Facilities | Capacity<br>Physical condition | |
| Treated Water pumping Stations | Capacity<br>Physical condition | |
| Treated Water Transmission Mains | Capacity<br>Physical condition | |
| Bulk (system) Metering | Provision<br>Accuracy | |
| Water Reticulation Networks | Supply continuity<br>Physical condition | |
| Consumer Metering | Provision<br>Physical condition / accuracy | |
| *Wastewater infrastructure:* | | |
| Sewerage Networks | Physical condition | |
| Wastewater Pumping Stations | Capacity<br>Physical condition | |
| Wastewater Treatment Plants | Capacity<br>Effluent quality<br>Physical condition | |

**Table 16: Situation Assessment – WC/WDM Practices**

| Type of WC/WDM Practised | **Scope and Cost** | **Measurable Results** |
|---|---|---|
| *Raw water resource conservation - catchment /aquifer management:* | | |
| Alien plant removal (surface water catchment) | | |
| Other measures to arrest deterioration / improve water quantity | | |
| Other measures to arrest deterioration / improve water quality | | |
| Optimisation of reservoir storage | | |
| *Supply and distribution management:* | | |
| Reduction of physical losses in raw water conveyance infrastructure (evaporation, leakage) | | |
| Reduction of backwash and overflow losses at water treatment plants | | |
| Reduction of physical losses in treated water conveyance and storage infrastructure (leakage, overflows) | | |
| Reduction of physical losses in reticulation networks – passive leakage control | | |
| Reduction of physical losses in reticulation networks – active leakage control | | |
| Network sectorisation to assist with active leakage control (and consumer demand management) | | |
| Reduction of physical losses in reticulation (and consumer demand) by reducing pressures in reticulation network | | |
| Reduction of physical losses by selective rehabilitation of reticulation network | | |
| Installation of "leak free" new reticulation | | |
| Consumer meter management programme | | |
| *Consumer use reduction:* | | |
| Social awareness and education | | |
| Retrofitting water efficient fittings | | |
| Waste minimisation | | |
| Water re-use | | |
| Rainwater harvesting | | |
| Repair consumer leaks | | |
| Delivery point water management | | |
| Tariff management | | |
| *Return flow management:* | | |
| Minimisation of infiltration and inflow | | |
| Minimisation of exfiltration | | |
| Re-use of wastewater | | |
| Tariff management ("polluter pays" principle) | | |

**Table 17: Consumption Analysis**

| | Households high income | Households med income | Households low income | All Households | Non domestic consumers |
|---|---|---|---|---|---|
| Population | | | | | |
| Number of households | | | | | |
| Persons per household | | | | | |
| Annual water consumption | | | | | |
| Consumption per unit | | | | | |
| Consumption per person | | | | | |
| Consumption per non domestic consumer | | | | | |

**Table 18: Summary of Water Losses, Consumption and Excess Sewer Inflow**

| Item | Amount of Loss / Consumption / Inflow Ml/yr | High / Medium / Low |
|---|---|---|
| *Fig 2:* | | |
| Leakage losses in raw water conveyance and storage | | |
| Evaporation losses in raw water conveyance and storage | | |
| Water treatment process losses | | |
| Leakage and over flow losses in treated water storage tanks | | |
| Leakage losses in treated water storage | | |
| Apparent losses from raw water source to supply input | | |
| *Fig 3:* | | |
| Domestic household consumption | | |
| Non domestic consumption | | See note |
| Unbilled consumption | | |
| Unauthorised consumption | | |
| Billing errors and adjustments | | |
| Metering inaccuracies | | |
| Leakage and overflows from storage tanks | | |
| Leakage from reticulation and service connections | | |
| *Fig 5:* | | |
| Ground water infiltration | | |
| Surface water inflow | | |

*Note: Unless a specific study of non domestic water use is undertaken, it will not be possible to judge whether the amount of consumption exceeds normal or target values.*

## ANNEXURE D TABLES RELATED TO FINANCIAL DATA

**Table 19: Financial Loss Statement, Annual Account**

| | **Amount of loss Ml/yr** | **Unit cost R/kl** | **Annual financial loss R** |
|---|---|---|---|
| *Fig 2:* | | | |
| Real losses, raw water (pumping) | 3,000 | 0.075 | 225,000 |
| Real losses, treated water (treatment) | 2,000 | 0.025 | 50,000 |
| Apparent losses (export) | 200 | 3.0 | 60,000 |
| Apparent losses (internal) | 390 | 0 | 0 |
| *Fig 3:* | | | |
| Non payment of billed consumption | 1,350 | 4.0 | 5,400,000 |
| Unbilled consumption (internal cost) | 50 | 0.10 | 5,000 |
| Real losses | 5,010 | 0.10 | 501,000 |
| Apparent losses | 1,015 | 4.0 | 4,060,000 |
| *Fig 5:* | | | |
| Pumping of sewer infiltration and inflow | 5,000 | 0.05 | 250,000 |
| **Total Financial Loss** | **10,551,000** | | |

## ANNEXURE E TABLES RELATED TO SOCIAL DATA

### Table 13A: Situation Assessment - Consumer Profile, Water

| Distribution Area | Population/ Households high income* | Population/ Households med income* | Population/ Households low income* | Total population/ Households | Non domestic consumers | Total no. of water consumers |
|---|---|---|---|---|---|---|
| DA1 | | | | | | |
| DA2 | | | | | | |
| DA3 | | | | | | |
| Total Supply system 1 | | | | | | |
| DA4 / Supply system 2 | | | | | | |
| Not served by municipal water supply | | | | | | |
| Whole Municipality | | | | | | |

### Table 13B: Situation Assessment - Consumer Profile, Sewerage

| Distribution Area | Population/ Households high income* | Population/ Households med income* | Population/ Households low income* | Total population/ Households | Non domestic consumers | Total no. of sewerage consumers |
|---|---|---|---|---|---|---|
| Catchment area 1 | | | | | | |
| Catchment area 2 | | | | | | |
| Not served by sewerage | | | | | | |
| Whole Municipality | | | | | | |

* Breakdown according to local practice, may have more categories or could be based on erf size

**Table 20: Infrastructure Bottleneck Analysis, Example**

| Infrastructure Component | Existing max capacity Ml/d | Present peak day demand[1] Ml/d | Works to meet current demand | Cost of works to meet current demand | Works to meet X year horizon demand, without WC/WDM actions | Costs of works to meet future demand |
|---|---|---|---|---|---|---|
| Source reliable yield | 110 | 100 | - | | Establish additional source | |
| Max.permitted abstraction | 120 | 100 | - | | Negotiate increase | |
| Abstraction pump/main | 90 | 100 | Refurbish existing pumps | | Replace pumps with higher capacity units | |
| Water treatment plant[2] | 100 | 110 | Chemical dosing | | Construct extra clarifier, filter | |
| Treated water storage[3] | 100 | 110 | None, accept <24 hour storage | | Construct additional tank | |
| Treated water trunk mains | 120 | 110 | - | | Duplicate affected mains | |
| Water reticulation network[4] | 90 | 110 | Reinforce network, 2 km | | Reinforce network, 10 km | |
| Wastewater treatment plant | 70 | 80 | Hydraulic reinforcement in conveyance systems | | Conveyance reinforcement + additional settlement tanks | |

Notes:

1. *Peak day demand raw water will be greater than peak day demand treated water by the amount of losses in raw water infrastructure and treatment process losses.*
2. *Capacity based on process (achievement of treated water quality standard) as well as hydraulic capacity*
3. *Capacity as Ml/d based on requirement for 24 hours storage at maximum daily demand*
4. *Capacity of reticulation network based on meeting consumer demand at all points on the network, whilst maintaining the declared minimum service pressure (eg 200 kPa). Not easy to determine without hydraulic model, but possible.*

## Table 21: Problem Analysis - WC/WDM Solutions

| **Problem** | **Possible WC/WDM Solution** | **Potential water saving Ml/d** | **Potential cost saving R/yr** | **Start up Cost** | **Annual Cost** |
|---|---|---|---|---|---|
| Deteriorating raw water resource (quantity or quality) | Alien plant control | | | | |
| | Pollution control | | | | |
| | LA active participation with CMA in catchment / aquifer management (range of possibilities) | | | | |
| | Re-use of wastewater | | | | |
| Leakage losses in transmission mains | Locate and repair leaks | | | | |
| Leakage losses in storage tanks | Locate and repair leaks | | | | |
| Overflow losses in storage tanks | Replace / repair mechanical and/or electrical control devices | | | | |
| Leakage losses in reticulation | Pressure reduction | | | | |
| | Passive leakage control | | | | |
| | Active leakage control | | | | |
| | Sectorisation | | | | |
| | Rehabilitation of network | | | | |
| | Extensions to network – leak free | | | | |
| Unpaid billed consumption | Credit control plan | | | | |
| Illegal connections | Inspection and control plan | | | | |
| High metering losses | Meter management programme | | | | |
| High consumer demand | Social awareness & education | | | | |
| | Retrofit water efficient appliances | | | | |
| | Waste minimisation | | | | |
| | Water re-use | | | | |
| | Rainwater harvesting | | | | |
| | Repair consumer leaks | | | | |
| | Delivery point water management | | | | |
| | Tariff management | | | | |
| Sewer infiltration & inflow | Sewer rehabilitation | | | | |

## ANNEXURE G: SUMMARY OF THE IMPLEMENTATION PLAN

**Table 22: Summary of Implementation Plan – Start - up**

| WC/WDM Measure | Start up activities | Management Responsibility | In house Resources | External Resources | Procurement | Cost | Organisational Changes, Responsibilities, Procedures | Assumptions, Risks, Constraints |
|---|---|---|---|---|---|---|---|---|
| Overall programme management and reporting | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**Table 23: Summary of Implementation Plan – Long Term Ongoing Activities**

| WC/WDM Measure | Ongoing activities | Management Responsibility | In house Resources | External Resources | Additional Annual Cost[1] | Savings in Operating Cost[2] | Change in Annual Income[3] | Net Financial Impact on Annual Water Services Budget[4] | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Overall programme management and reporting | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

<u>Notes</u>:

1. *Annual cost of maintaining the WC/WDM measure.*
2. *Planned savings in electricity, chemicals and bulk water purchases.*
3. *Increase in income due to consumer meter management, decrease in income due to reduction in consumer use (may be offset by adoption of stepped tariff).*

## ANNEXURE H: EXAMPLE FORMAT OF ANNUAL REPORT ON WATER CONSERVATION AND WATER DEMAND MANAGEMENT WATER

| Subject | Current year | Year -1 | Year -2 | Year -3 | Year -4 | 5 Year Trend | Remarks[1] |
|---|---|---|---|---|---|---|---|
| **1. LEGISLATIVE/INSTITUTIONAL** | | | | | | | |
| Are the bylaws incorporating WC/WDM conditions? | | | | | | | |
| What is the total staff compliment responsible for WC/WDM? | | | | | | | |
| Is there a champion for the implementation of WC/WDM measures in the Municipality? | | | | | | | |
| Is there a call center for reporting queries | | | | | | | |
| | | | | | | | |
| **2. TECHNICAL** | | | | | | | |
| Infrastructure | | | | | | | |
| Permitted raw water abstraction (Ml/d) | | | | | | | |
| Raw water abstraction capacity (Ml/d) | | | | | | | |
| Raw water storage capacity (after abstraction) (Ml) | | | | | | | |
| Treated water production capacity (Ml/d) | | | | | | | |
| Treated water storage capacity (Ml) | | | | | | | |
| Length of raw water mains (km) | | | | | | | |
| Length of treated water transmission mains (km) | | | | | | | |
| Length of reticulation (km) | | | | | | | |
| Number of bulk (system) meters | | | | | | | |
| Number of consumer meters | | | | | | | |
| Number of consumer meters calibrated / renewed | | | | | | | |
| Water balance [Figs 2 and 3] | | | | | | | |
| Amount of raw water abstracted (Ml) | | | | | | | |
| Amount of treated water produced (Ml)[3] | | | | | | | |
| Total raw water, process and other losses (Ml) | | | | | | | |
| Treated water bulk purchases (Ml) | | | | | | | |
| Treated water exported (Ml) | | | | | | | |
| Total treated water put into LA area supply (Ml) | | | | | | | |
| Authorised household consumption (Ml) | | | | | | | |
| Authorised non domestic consumption (Ml) | | | | | | | |
| Authorised consumption, total (Ml) | | | | | | | |

| Subject | Current year | Year -1 | Year -2 | Year -3 | Year -4 | 5 Year Trend | Remarks[1] |
|---|---|---|---|---|---|---|---|
| Total losses in supply and distribution [Fig 3] (Ml) | | | | | | | |
| Revenue water (Ml) | | | | | | | |
| Non revenue water (Ml) | | | | | | | |
| Water loss indicators | | | | | | | |
| Raw water losses as percent of abstraction (%) | | | | | | | |
| Non revenue water / treated water into supply (%) | | | | | | | |
| Apparent losses / treated water into supply (%) | | | | | | | |
| Reticulation leakage (ILI) | | | | | | | |
| Number of mains bursts | | | | | | | |
| Number of bursts per km of main | | | | | | | |
| Consumption indicators | | | | | | | |
| Water consumption per household | | | | | | | |
| Water consumption per person | | | | | | | |
| Water consumption per non domestic connection[4] | | | | | | | |
| WC/WDM initiative indicators[5] | | | | | | | |
| *Resource conservation measures:* | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| *Fig 2 water loss reduction:* | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| *Fig 3 water loss reduction (infrastructure):* | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| *Fig 3 consumption reduction:* | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **3. FINANCIAL** | | | | | | | |
| Cost recovery rate | | | | | | | |
| Annual expenditure on resource conservation | | | | | | | |
| Annual expenditure on Fig 2 water loss reduction | | | | | | | |
| Annual expenditure on Fig 3 water loss reduction 1 | | | | | | | |
| Annual expenditure on Fig 3 water loss reduction 2 | | | | | | | |
| Annual expenditure on Fig 3 water loss reduction 3 | | | | | | | |
| Annual expenditure on consumer use reduction | | | | | | | |

| Subject | Current year | Year -1 | Year -2 | Year -3 | Year -4 | 5 Year Trend | Remarks[1] |
|---|---|---|---|---|---|---|---|
| Etc | | | | | | | |
| Total annual expenditure on WC/WDM measures[6] | | | | | | | |
| Cost savings in water production and bulk purchase | | | | | | | |
| Increased income from consumer meter management | | | | | | | |
| Change in income from consumer use reduction[7] | | | | | | | |
| Net change in water services annual balance[8] | | | | | | | |
| **4. SOCIAL** | | | | | | | |
| Consumer awareness programmes | | | | | | | |
| Water use efficiency education programmes | | | | | | | |
| Media (e.g. printed/electronic/radio/play) for communicating water use efficiency | | | | | | | |
| Levels of Service | | | | | | | |
| Numbers of domestic households | | | | | | | |
| Numbers of non domestic consumers | | | | | | | |
| Total number of consumers | | | | | | | |
| Service continuity (%)[2] | | | | | | | |

Notes:

1. *The targets for levels of service, infrastructure capacity and indicators should be included.*
2. *Service continuity = 100*(total number of consumers – no of consumers experiencing water shortage x percent of time)/total number of consumers*
3. *The amount of treated water produced from the raw water abstracted, excluding bulk purchases of treated water*
4. *Excluding bulk exports to adjacent authorities*
5. *Indicators need to be set according to the nature of the initiative. Should include both input indicators, e.g number of consumer leak repairs (input), reduction in consumer leakage / household demand (output).*
6. *Arguably these measures should be considered to be part of good, economically optimised operation practice and should in due course become normal.*
7. *If no change in tariff, then will be a reduction. Introduction of steeped (or steeper stepped) tariff may be income neutral or show an increase.*
8. *Consideration needs to be given as to how to deal with financing of capital investment on an annual basis, eg new meters*

## WASTEWATER

| Subject | Current year | Year -1 | Year -2 | Year -3 | Year -4 | 5 Year Trend | Remarks[1] |
|---|---|---|---|---|---|---|---|
| Levels of Service | | | | | | | |
| Numbers of domestic households with sewerage | | | | | | | |
| Numbers of non domestic consumers with sewerage | | | | | | | |
| Total number of consumers with sewerage | | | | | | | |
| Infrastructure | | | | | | | |
| Wastewater treatment capacity (Ml/d) | | | | | | | |
| Ditto kgBOD/d | | | | | | | |
| Length of sewers (km) | | | | | | | |
| Wastewater balance (inflow to WWTP) [Fig 5] | | | | | | | |
| Amount of domestic wastewater (Ml) | | | | | | | |
| Amount of non domestic wastewater (Ml)[3] | | | | | | | |
| Amount of infiltration / surface water inflow (Ml) | | | | | | | |
| Reticulation indicators | | | | | | | |
| Sewer infiltration / inflow per km per m dia of sewer. | | | | | | | |
| Wastewater quantitative indicators | | | | | | | |
| Wastewater per household | | | | | | | |
| Wastewater per person | | | | | | | |
| Wastewater per non domestic connection | | | | | | | |
| WC/WDM initiative indicators | | | | | | | |
| Sewer rehabilitation | | | | | | | |
| Re-use of wastewater | | | | | | | |
| Non domestic pollution load (kgBOD/d) | | | | | | | |
| Financial | | | | | | | |
| Annual expenditure on sewer rehabilitation | | | | | | | |
| Annual expenditure on wastewater re-use | | | | | | | |
| Etc | | | | | | | |
| Total annual expenditure on WC/WDM measures | | | | | | | |
| Cost savings in pumping non polluted wastewater | | | | | | | |
| Cost savings in treating lower non domestic pollution load | | | | | | | |
| Change in income from “polluter pays” tariff | | | | | | | |
| Net change in water services annual balance | | | | | | | |