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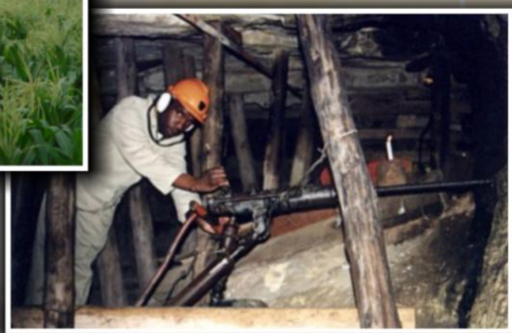
Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA
Directorates: Water Use efficiency
and
National Water Resource Planning


# Vaal River System: Large Bulk Water Supply Reconciliation Strategy

## POTENTIAL SAVINGS THROUGH WC/WDM IN THE UPPER AND MIDDLE VAAL WATER MANAGEMENT AREAS



MAY 2007

PREPARED BY:


DMM
PDNA
PD NAIDOO & ASSOCIATES
wrp
A Miya Group Company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# POTENTIAL SAVINGS THROUGH WC/WDM IN THE UPPER AND MIDDLE VAAL WATER MANAGEMENT AREAS

**REFERENCE**

*This report is to be referred to in bibliographies as:*

Department of Water Affairs and Forestry, South Africa, May 2007

**POTENTIAL SAVINGS THROUGH WC/WDM IN THE UPPER**

**AND MIDDLE VAAL WATER MANAGEMENT AREAS**

***Project Team:***

WRP Consulting Engineers (Pty) Ltd, DMM Development Consultants, and PD Naidoo & Associates in association.

***This Report Prepared by:***

WRP Consulting Engineers (Pty) Ltd and PD Naidoo & Associates

**Report No.** P RSA C000/00/4406/02

# VAAL RIVER SYSTEM: LARGE BULK WATER SUPPLY RECONCILIATION STRATEGIES

# LIST OF REPORTS

| Report No: | Title |
|---|---|
| P RSA C000/00/4406/01 | Urban water requirements and return flows |
| P RSA C000/00/4406/02 | Potential savings through WC/WDM in the Upper and Middle Vaal water management areas |
| P RSA C000/00/440603 | Re-use options |
| P RSA C000/00/4406/04 | Irrigation water use and return flows |
| P RSA C000/00/4406/05 | Water resource analysis |
| P RSA C000/00/4406/06 | Groundwater Assessment: Dolomite Aquifers |
| P RSA C000/00/4406/07 | First stage reconciliation strategy |

*Above list of reports effective as at December 2006*

| | |
|---|---|
| **Title:** | *Potential Savings through WC/WDM in the Upper and Middle Vaal Water Management Areas* |
| ***Authors:*** | *R Mckenzie and Willem Wegelin: WRP Pty Ltd and K Haumann: PD Naidoo & Associates* |
| ***Project Name:*** | *WATER CONSERVATION AND DEMAND MANAGEMENT POTENTIAL ASSESSMENT: BUSINESS PLAN FOR IMPLEMENTATION – DEVELOPMENT IN THE UPPER AND MIDDLE VAAL WATER MANAGEMENT AREAS* |
| ***DWAF Report No:*** | *P RSA C000/00/4405/02* |
| ***Status of Report:*** | *Final Draft* |
| ***First Issue:*** | *May 2007* |

***Project Team: WRP, DMM and PDNA in association***

***Approved for the Consultants by:***

.........................................................

*RS McKenzie*

*Study Leader Water Conservation and*

*Demand Management Study*

***DEPARTMENT OF WATER AFFAIRS & FORESTRY***

*Directorate National Water Resource Planning and Directorate Water Use Efficiency*

***Approved for DWAF by:***

| | |
|---|---|
| ......................................................... | ......................................................... |
| *C Chunda* | *JI Rademeyer* |
| *Study leader : Directorate Water Use Efficiency* | *Study leader : Directorate National Water Resource Planning* |

# POTENTIAL SAVINGS THROUGH WC/WDM IN THE UPPER AND MIDDLE VAAL WATER MANAGEMENT AREAS

## *Executive Summary*

### INTRODUCTION

Following completion of the study to investigate the Internal Strategic Perspectives (ISPs) for the Vaal River Water Management Areas (WMAa), which was completed in 2004, the Department of Water Affairs and Forestry (DWAF) identified and prioritised several studies to further support Integrated Water Resource Management in the Vaal River System. Although the original ISP Study's water balance assessments indicated that augmentation of the Vaal River System is only required by the year 2025, several factors were identified that could influence this date and required further investigations.

Firstly, it was acknowledged that the water requirement projection scenarios used in the ISP study did not include the influence of potential water conservation and demand management initiatives. As a result, the Directorates National Water Resource Planning and Water Use Efficiency commissioned the Water Conservation and Demand Management Potential Assessment: Business Plan Development for the Upper and Middle Vaal River Water management Areas. The results from this study are documented in the remainder of this report.

Secondly it was recognised that the time required to implement a large water resource augmentation scheme could be as long as fifteen years and coupled with the fact that the future water requirement scenarios exhibit low rates of increase makes the timing of intervention critical.

Finally, a comprehensive Reserve Determination had not been undertaken for the Vaal River System and will have to be incorporated into the balance between the available supply and the projected water requirements.

Given the above factors as well as various other uncertainties identified in the assumptions used in the ISP study, the Directorate: National Water Resource Planning commissioned another major study to reconcile the demand and supply situation in the Vaal River System. Since the water demand projections form one component of the reconciliation between supply and demand, it was agreed that the two studies would be integrated to ensure consistency and to avoid duplication of effort. The remainder of this report documents the objectives and results from the Water Conservation and Demand Management study.

**MAIN OBJECTIVES OF THE WC/WDM STUDY**

The main objectives of the Water Conservation and Water Demand Management study were to:

- investigate the potential influence on future water requirements in the Vaal River System of WC/WDM activities based on reliable information derived from real case studies;
- identify and develop strategies to improve the effective and efficient use of existing and available water resources in all water sectors (urban, industrial and agricultural);
- assess the likely costs associated with the possible WC/WDM activities to enable the savings to be compared with alternative augmentation schemes;
- assess the current and planned WC/WDM measures within the Vaal River Basin in order to provide realistic future demand scenarios to the study team responsible for the reconciliation of demand and supply.

The core of the study area consists of the Upper, Middle and Lower Vaal River Water Management Areas. Due to the numerous inter-basin transfers that link this core area with other WMA's, however, reconciliation planning has to be undertaken in the context of the full Integrated Vaal River System which also includes portions of the Komati, Usutu, Thukela and Senqu River (Located in Lesotho) catchments. In addition, significant water transfers occur to water users in the Olifants and Crocodile (West) River catchments, many of which are totally dependant on the water resources of the Integrated Vaal River System.

In order to assess the potential savings that can be achieved through the various possible WC/WDM interventions, it is first important to establish the existing water demand distribution in the study area. In this regard, the water demand distribution for the Vaal River System is shown in **Figure 1** from which it can be seen that the Rand Water demand is clearly the largest component. It should also be noted, that the Rand Water demand is used almost entirely for urban and industrial purposes. It is also important to note that the bulk of the irrigation demands are supplied with low quality water made up primarily from effluent return flows where the salt concentrations have increased to the level whereby the water cannot be used again for urban purposes. The bulk of this report therefore concentrates on the Rand Water demands which can be distributed among the various municipalities as shown in **Figure 2.**

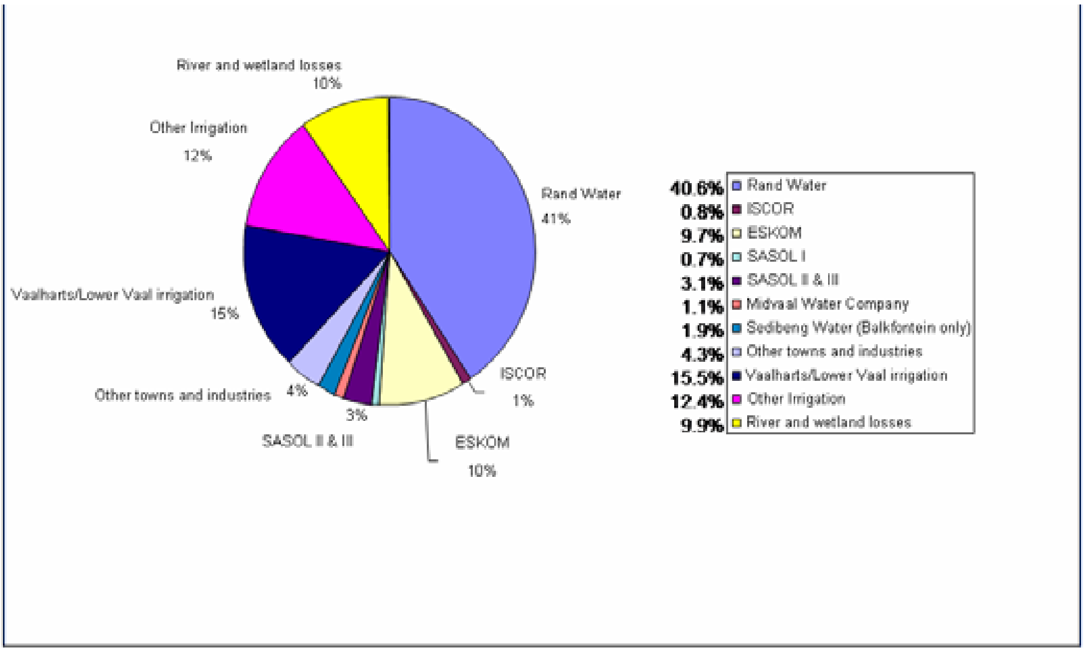



**Figure 1: Breakdown of Water Demands in the Vaal River System**

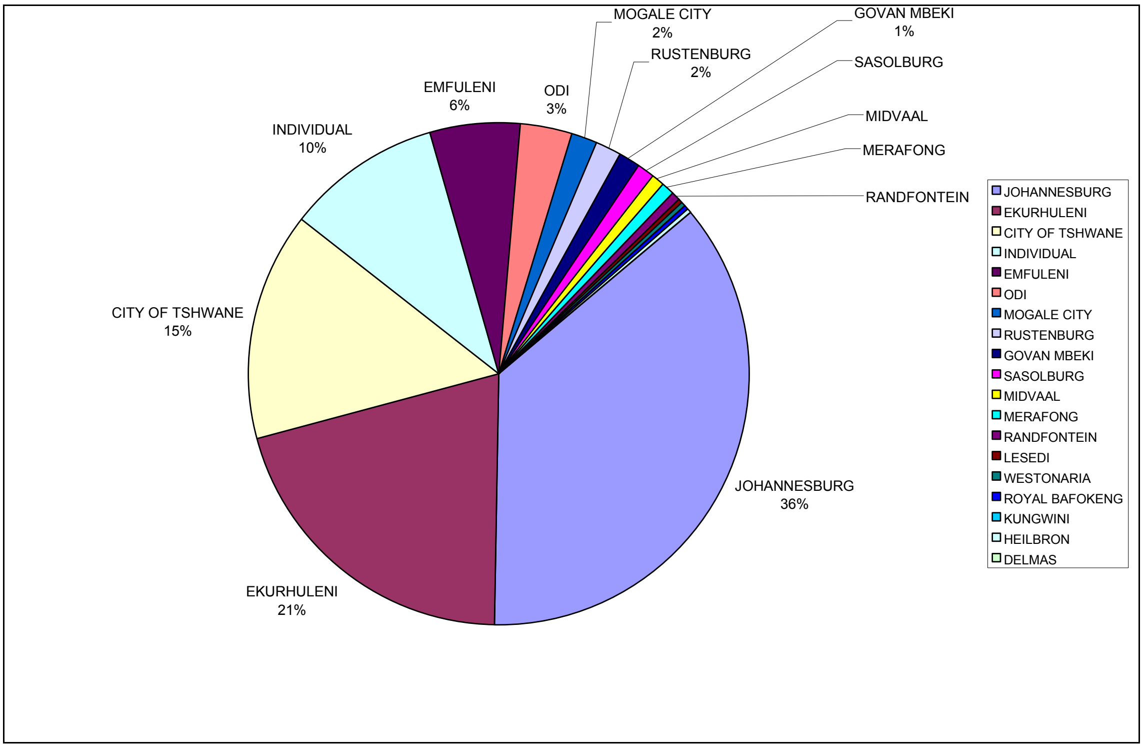



**Figure 2: Breakdown of Rand Water's demands**

## INDUSTRIAL, MINING AND POWER SECTOR

### Industrial sector

The major motivational factors for water demand management and water conservation prevalent in the Industrial sector include:

- Sustainability Standards Set by Clients (Regular Inspections - Food, Pharmaceutical & Beverage)
- "Specific Water Consumption" per product is monitored and comparisons with international benchmarks generally compare favourably
- Obtaining relevant ISO accreditation is a priority for a number of consumers
- Part of Large International Organisation (Benchmarked)
- High operating Costs (Water and Energy)
- Quality of Abstracted Raw Water (Steel)
- Quality of Effluent Discharged (National Water Act - DWAF) / Discharge Tax

The stumbling blocks to implementing water demand management and water conservation are:

- Cost of implementing projects prohibitive (pay-back 2 years or less)
- Energy costs significantly higher that water, therefore main focus for improved efficiencies

Potential measures for water demand management and water conservation for the industrial sector include:

- Most large companies are implementing Sustainability / Environmental Policies regarding water
- Water Audits/ Water balance – Although prevalent amongst most large consumers, many medium sized and smaller consumers due not have adequate systems in place. There is subsequently significant potential through improved monitoring and control of water used for various industrial processes. Monitoring of processes and equipment ensures that they are operating within optimum water usage limits.
- Organisations targeted by the study stated that retrofitting/ replacement of existing dated equipment with more efficient equipment would results in a reduction in consumption.
- "Specific Water Consumption" per product is not monitored in all industrial sectors. Industries should be encourage to do so as part of water audits (even if only internal benckmarks are established). Comparisons with international benchmarks are often not considered applicable as type of product and process may vary.

- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage. Limited uptake of water efficient devices for domestic usage was found.
- Recycling of effluent through treatment. Discharge of waste water with little or no recycling was found to be common practice amongst industrial consumers.
- Retrofit or eliminate once through cooling systems. Options include: re-circulation of cooling water, air cooled systems, discharge to other applications.
- Proper operation and maintenance of hot water and steam systems. Options include: Active leak detection and maintenance, return steam condensate to boiler, discharge blow down through expansion tanks, insulate steam, condensate, hot water pipes and storage tanks.
- Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the industrial sector.
- Major drivers moving forward are legislation and the cost of water. The most common reason for organisations not implementing water demand measures is financial. Most organisations will only consider capital project with a return on investment period of two years or less.
- A major concern amongst large consumers is growth in demand due to deterioration in water quality.

**Mining**

The major motivational factors for water demand management and water conservation prevalent in the mining sector include:

- Quality of Effluent Discharged (National Water Act - DWAF)
- International Standards – ISO 14 001
- Part of Large International Organisation – Annual SHE targets set (Benchmarked against other operations)
- Security of supply – Alternatives to potable water are used due to supply limits
- Operating Costs (Water and Energy)

Potential measures for water demand management and water conservation for the mining sector include:

- Current legislation (National Water Act - DWAF) is likely to have an ongoing impact on use within the mining sector.
- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage (including retrofitting of water saving devices)
- Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the industrial sector.
- Operating Costs (Water and Energy).
- Non-potable use including partially treated effluent. Additional scope exists for suitably situated mines to make use of partially treated effluent from municipalities for process water.
- Improved efficiency of Effluent Treatment Plants (Reverse Osmosis).
- New technology/ retrofitting. New mining techniques that are specifically suited to water scarce regions are being developed. Upgrading of older workings and equipment will result in a reduction in water consumption.
- Co-operation with other local users (Current legislation/ By-laws may be an obstacle). Mines are investigating the viability of recycling of process and decant water through treatment for supply to other mines/ industrial users as well as municipalities. The use of dual reticulation systems by towns in municipal areas has been implemented on a limited scale to date.

**Power sector**

Motivation to Implement WDM/ WC

- Operating Costs
- Target of Zero Effluent Discharge
- Current legislation (National Water Act - DWAF)

Potential measures for water demand management and water conservation for the power sector include:

- Significant improvements in efficiency achieved 1980 – 2001 through implementation of Dry Cooling.
- Future improvements in efficiency dependant on technology breakthrough.
- Demand Side Management (DSM) Program implemented in 1994 has continued potential (Currently Working with Dept Energy and Minerals).

**IRRIGATION SECTOR**

Efforts have been made to identify the causes of water losses in the six schemes in the Vaal catchment in the irrigation sector, and hence to propose achievable water conservation and demand management initiatives. The study reviews the extent of data gaps in the catchment, which, at this stage, presents a stumbling block in water use auditing in the catchment. Analysis of the water balance data obtained from DWAF indicated significant conveyance loss in the catchment. Most of the conveyance losses in the catchment are attributed to operational losses, which can be easily alleviated by equipping water bailiffs with tools which can assist them to release the right amount of water at the right time. The conveyance loss in the Vaalharts scheme, unlike the other schemes, is mainly attributed to canal evaporation and seepage from canals. The high evaporation is reckoned to be due to the length of the channel. The high seepage loss, as people from the area indicated, especially from the North Canal, is due to improper construction.

The potential for water saving by implementing latest technologies has been investigated based on theoretical irrigation application efficiency values. A 2% improvement in each of the six selected schemes would provide a 7.3 million $m^3$/a saving. This can irrigate an area of 948 ha assuming 7700 $m^3$/ha/a water requirement. Similarly if the irrigation application is improved by 5% in each of the schemes, 18.0 million $m^3$/a water, which can irrigate 2 340 ha, which is equivalent to the entire Schoonspruit government water scheme. There are savings in operational costs which can offset the capital costs of improving efficiencies. These are however, closely linked to the types of crops that are being farmed.

As mentioned, while a quota allocation system is in place and while farmers are not using their full allocation, there is little incentive for farmers to implement more efficient irrigation systems, despite the fact that it can be shown that there are sufficient offsets in operational cost savings . It should, of course, be borne in mind that under utilization also serves as a buffer for the risk to farmers of impending drought periods. It would appear reasonable to link the water tariff to assurance of supply, as this is likely to provide the kind of incentive to encourage farmers to balance their risks of supply against using more efficient irrigation systems.

A four-year project titled " Standards and Guidelines for improved irrigation efficiency from dam wall release to root zone application" is running by a consortium of ten people funded by WRC. The objective of this project is to develop benchmarks for all aspects of irrigation. These benchmarks are imperative to assess irrigation efficiency and hence to quantify the benefits of different water conservation and demand management efficiencies.

There is also huge potential for saving by improving the water management. However, the existing water monitoring system in the whole catchment has to be improved in order to give reliable information, to assist in identifying management problems and to quantify the benefits.

The success of water conservation and demand management initiatives mainly depends on the awareness and, responsibility and accountability of water control officers and the end users. As in Australia, a shift from thinking of productivity in the traditional way, from yield per hectare to yield per $m^3$ can bring about a substantial improvement in water use. Thus huge efforts are required to address these shortcomings.

**URBAN SECTOR**

From the assessment of the scope for WC/WDM in the Upper and Middle Vaal River Basin several key issues were identified from which the following conclusions and recommendations were made:

- WC/WDM can provide a significant reduction in the water demands in the area if the measures are implemented properly and maintained indefinitely.
- The cost of implementing WC/WDM measures is often less that the maintenance costs which are often overlooked with the result that the WC.WDM interventions fail within a year or two of being implemented.
- The projected Rand Water demand in the year 2024-25 is estimated to increase from its current value of approximately 1 200 million $m^3$/annum to more than 1 500 million $m^3$/annum in the event that no WC/WDM measures are implemented.
- The potential savings that can be achieved in the study area range from a maximum optimistic estimate of approximately 400 million $m^3$/annum in Scenario c in the year 2024 ( i.e. demand drops to approximately 1 100 million $m^3$/annum) to a more conservative and possibly realistic estimate of 200 million $m^3$/annum for Scenario e.
- Significant savings can be achieved in Johannesburg, Ekurhuleni, Tshwane and Emfuleni while small savings are achievable in Mogale and Govan Mbeki. High savings relative to the overall water use are also achievable in Rustenberg and Matjhabeng although the volumes involved are small relative to the 4 large Metro’s/Municipalities.
- WC/WDM can be effective and sustainable as shown by several large projects.
- Garden irrigation using potable water must be discouraged in all cases unless the resident specifically chooses to pay for the water used through a properly metered supply.

- Government Departments must co-ordinate their efforts with regard to WC/WDM. The Department of Agriculture must stop promoting the use of hosepipes in urban areas which already experience water shortages.
- DWAF should encourage WDM activities and discourage the use of low quality fixtures in township retrofitting projects. Only high quality fittings should be used in areas of such high usage.
- Lack of maintenance will result in many systems deteriorating into intermittent supply if action is not taken quickly ;
- Municipalities should be encouraged to combine technical and financial services into a single unit .

**Potential Savings in Urban Sector from WC/WDM Interventions**

Considerable effort was spent analysing over 60 areas in detail to assess the potential savings that can be achieved in the study area from various WC/WDM interventions. For each area, a full water balance was undertaken after which all available logging results (supplied by the municipalities from previous investigations) were analysed to asses potential savings. Since it is not possible to predict the savings with any certainty, the project team developed 3 plausible scenario's which are referred to as Scenario C, Scenario D and Scenario E in order to tie in with the main water reconciliation study. The scenarios are discussed individually below.

**Scenario C: 5 Years water loss programme and efficiency**

**Scenario c** is the most optimistic of the three scenarios and assumes that the full potential WC/WDM savings to eliminate wastage can be implemented over a 5-year period and that significant improvements in the level of efficiency in the domestic sector can be achieved – e.g. use of dual flush toilets and low flow showers etc. The results for **Scenario c** are summarised in **Table 1 and Table 2**

**Table 1: Scenario c: Summary of potential savings**

| Year | Demand without WC/WDM (mcm/a) | Demand with WC/WDM (mcm/a) | Reduction (mcm/a) | % Reduction |
|---|---|---|---|---|
| 2004-05 | 1 165.8 | 1140.0 | 25.8 | 2% |
| 2009-10 | 1 248.1 | 1063.2 | 184.9 | 15% |
| 2014-15 | 1 337.5 | 1053.1 | 284.4 | 21% |
| 2019-20 | 1 434.6 | 1080.7 | 353.9 | 25% |
| 2024-25 | 1 540.3 | 1109.1 | 431.2 | 28% |

**Table 2: Scenario c: Budget requirements**

| Year | CAPEX (R million /a) | OPEX (R million /a) | Total (R million /a) | Savings (R million /a) | CBR* |
|---|---|---|---|---|---|
| 2004-05 | 480.0 | 487.6 | 967.7 | 71.2 | |
| 2009-10 | 402.3 | 487.6 | 890.0 | 510.3 | |
| 2014-15 | 230.5 | 487.6 | 718.1 | 784.9 | |
| 2019-20 | 230.5 | 487.6 | 718.1 | 976.8 | |
| 2024-25 | 230.5 | 487.6 | 718.1 | 1190.2 | |
| **Annual average** | **307.1** | **487.6** | **794.7** | **552.3** | **1.4** |
| 25 year total | 3992.0 | 6339.3 | 10331.4 | 7179.7 | 1.4 |

* Cost benefit ratio (CBR) = Total Implementation Cost / Savings

The results from **Scenario c** indicate a total reduction in demand of approximately 30% or 420million m$^3$/annum year 2025. This reduction will reduce the average consumption per capita per day from 330 to 250l/c/d or the consumption per household from 36 to 26m$^3$/property/month.

It can also be seen that almost 50% of the savings can be achieved in Johannesburg, mainly because of Soweto. The other three focus areas should be Tshwane, Ekurhuleni and Emfuleni. It should be noted that the potential savings in the other areas is relatively small which can help to prioritise where most funding should be directed to derive the greatest benefit from WC/WDM interventions.

**Scenario D : 5 Year Water Loss Programme**

**Scenario d** is similar to **Scenario c** except that the additional savings achieved through greater water use efficiency in the home has been excluded from the analysis. It is assumed that the implementation of dual-flush toilets and low flow taps and showers etc will not take place due to financial constraints of the residents. In Australia where the dual-flush toilet was developed, the implementation of water efficient fixtures was promoted by massive government subsidies and this may not be possible in the South African environment. The results for **Scenario d** is summarised in **Table 3 and Table 4.**

**Table 3: Scenario d - Summary of potential savings**

| Year | Demand without WC/WDM (mcma) | Demand with WC/WDM (mcma) | Reduction (mcma) | % Reduction |
|---|---|---|---|---|
| 2004-05 | 1 165.8 | 1140.2 | 25.6 | 2% |
| 2009-10 | 1 248.1 | 1063.5 | 184.6 | 15% |
| 2014-15 | 1 337.5 | 1137.0 | 200.4 | 15% |
| 2019-20 | 1 434.6 | 1224.0 | 210.6 | 15% |
| 2024-25 | 1 540.3 | 1317.6 | 222.7 | 14% |

**Table 4: Scenario d : Budget requirements**

| Year | CAPEX (R million /a) | OPEX (R million /a) | Total (R million /a) | Savings (R million /a) | CBR* |
|---|---|---|---|---|---|
| 2004-05 | 489.0 | 500.0 | 989.0 | 70.7 | |
| 2009-10 | 410.6 | 500.0 | 910.6 | 509.6 | |
| 2014-15 | 236.5 | 500.0 | 736.5 | 553.2 | |
| 2019-20 | 236.5 | 500.0 | 736.5 | 581.2 | |
| 2024-25 | 236.5 | 500.0 | 736.5 | 614.6 | |
| **Annual average** | **312.9** | **500.0** | **812.9** | **435.5** | **1.9** |
| 25 year total | 4067.9 | 6500.1 | 10568.0 | 5661.2 | 1.9 |

Cost benefit ratio (CBR) = Total Implementation Cost / Savings

The results from **Scenario d** indicate a total reduction in demand of approximately 15% or 220million m$^3$/annum year 2025. This reduction will reduce the average consumption per capita per day from 330 to 290l/c/d or the consumption per household from 36 to 31m$^3$/property/month.

**Scenario e : 10 Year Water Loss Programme**

**Scenario e** is the same as the previous scenario with the exception that the WC/WDM interventions are introduced over a 10-year period and not a 5-year period. Many experts consider that the introduction and implementation of WC/WDM interventions cannot be achieved in 5-years and that 10 years is a more achievable time-frame. The results from **Scenario e** are provided in **Table 5 and Table 6**.

**Table 5: Summary of potential savings**

| Year | Demand without WC/WDM (mcma) | Demand with WC/WDM (mcma) | Reduction (mcma) | % Reduction |
|---|---|---|---|---|
| 2004-05 | 1 165.8 | 1140.8 | 25.1 | 2% |
| 2009-10 | 1 248.1 | 1137.4 | 110.7 | 9% |
| 2014-15 | 1 337.5 | 1138.1 | 199.3 | 15% |
| 2019-20 | 1 434.6 | 1224.1 | 210.6 | 15% |
| 2024-25 | 1 540.3 | 1317.7 | 222.7 | 14% |

**Table 6: Scenario e Budget requirements**

| Year | CAPEX (R million /a) | OPEX (R million /a) | Total (R million /a) | Savings (R million /a) | CBR* |
|---|---|---|---|---|---|
| 2004-05 | 372.0 | 500.1 | 872.1 | 69.2 | |
| 2009-10 | 431.9 | 500.1 | 932.0 | 305.5 | |
| 2014-15 | 420.5 | 500.1 | 920.6 | 550.2 | |
| 2019-20 | 250.8 | 500.1 | 750.9 | 581.2 | |
| 2024-25 | 232.5 | 500.1 | 732.6 | 614.6 | |
| **Annual average** | **316.0** | **500.1** | **816.1** | **351.9** | **2.3** |
| 25 year total | 4107.7 | 6501.9 | 10609.6 | 4575.0 | 2.3 |

The results from **Scenario e** indicate a total reduction in demand of approximately 15% or 220million $m^3$/annum year 2025. This reduction will reduce the average consumption per capita per day from 330 to 290l/c/d or the consumption per household from 36 to 31$m^3$/property/month. The results are the same as for **Scenario d**, except that the savings are achieved only after 10 years and not 5 years as in **Scenario d** and **Scenario c**

## CONCLUSIONS AND RECOMMENDATIONS

### Industrial sector

The major motivational factors for water demand management and water conservation prevalent in the Industrial sector include:

- Sustainability Standards Set by Clients (Regular Inspections - Food, Pharmaceutical & Beverage)
- “Specific Water Consumption” per product is monitored and comparisons with international benchmarks generally compare favourably
- Obtaining relevant ISO accreditation is a priority for a number of consumers
- Part of Large International Organisation (Benchmarked)
- High operating Costs (Water and Energy)
- Quality of Abstracted Raw Water (Steel)
- Quality of Effluent Discharged (National Water Act - DWAF) / Discharge Tax

The stumbling blocks to implementing water demand management and water conservation are:

- Cost of implementing projects prohibitive (pay-back 2 years or less)
- Energy costs significantly higher that water, therefore main focus for improved efficiencies

Potential measures for water demand management and water conservation for the industrial sector include:

- Most large companies are implementing Sustainability / Environmental Policies regarding water
- Water Audits/ Water balance – Although prevalent amongst most large consumers, many medium sized and smaller consumers due not have adequate systems in place. There is subsequently significant potential through improved monitoring and control of water used for various industrial processes. Monitoring of processes and equipment ensures that they are operating within optimum water usage limits.
- Organisations targeted by the study stated that retrofitting/ replacement of existing dated equipment with more efficient equipment would results in a reduction in consumption.
- “Specific Water Consumption” per product is not monitored in all industrial sectors. Industries should be encourage to do so as part of water audits (even if only internal benckmarks are established). Comparisons with international benchmarks are often not considered applicable as type of product and process may vary.
- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage. Limited uptake of water efficient devices for domestic usage was found.
- Recycling of effluent through treatment. Discharge of waste water with little or no recycling was found to be common practice amongst industrial consumers.

- Retrofit or eliminate once through cooling systems. Options include: re-circulation of cooling water, air cooled systems, discharge to other applications.
- Proper operation and maintenance of hot water and steam systems. Options include: Active leak detection and maintenance, return steam condensate to boiler, discharge blow down through expansion tanks, insulate steam, condensate, hot water pipes and storage tanks.
- Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the industrial sector.
- Major drivers moving forward are legislation and the cost of water. The most common reason for organisations not implementing water demand measures is financial. Most organisations will only consider capital project with a return on investment period of two years or less.
- A major concern amongst large consumers is growth in demand due to deterioration in water quality.

**Mining**

The major motivational factors for water demand management and water conservation prevalent in the mining sector include:

- Quality of Effluent Discharged (National Water Act - DWAF)
- International Standards – ISO 14 001
- Part of Large International Organisation – Annual SHE targets set (Benchmarked against other operations)
- Security of supply – Alternatives to potable water are used due to supply limits
- Operating Costs (Water and Energy)

Potential measures for water demand management and water conservation for the mining sector include:

- Current legislation (National Water Act - DWAF) is likely to have an ongoing impact on use within the mining sector.
- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage (including retrofitting of water saving devices)

- Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the industrial sector.
- Operating Costs (Water and Energy).
- Non-potable use including partially treated effluent. Additional scope exists for suitably situated mines to make use of partially treated effluent from municipalities for process water.
- Improved efficiency of Effluent Treatment Plants (Reverse Osmosis).
- New technology/ retrofitting. New mining techniques that are specifically suited to water scarce regions are being developed. Upgrading of older workings and equipment will result in a reduction in water consumption.
- Co-operation with other local users (Current legislation/ By-laws may be an obstacle). Mines are investigating the viability of recycling of process and decant water through treatment for supply to other mines/ industrial users as well as municipalities. The use of dual reticulation systems by towns in municipal areas has been implemented on a limited scale to date.

**Power sector**

Motivation to Implement WDM/ WC

- Operating Costs
- Target of Zero Effluent Discharge
- Current legislation (National Water Act - DWAF)

Potential measures for water demand management and water conservation for the power sector include:

- Significant improvements in efficiency achieved 1980 – 2001 through implementation of Dry Cooling.
- Future improvements in efficiency dependant on technology breakthrough.
- Demand Side Management (DSM) Program implemented in 1994 has continued potential (Currently Working with Dept Energy and Minerals).

**Irrigation Sector**

Efforts have been made to identify the causes of water losses in the six schemes in the Vaal catchment in the irrigation sector, and hence to propose achievable water conservation and demand management initiatives. The study reviews the extent of data gaps in the catchment, which, at this stage, presents a stumbling block in water use auditing in the catchment. Analysis of the water balance data obtained from DWAF indicated significant conveyance loss in the catchment. Most of the conveyance losses in the catchment are attributed to operational losses, which can be easily alleviated by equipping water bailiffs with tools which can assist them to release the right amount of water at the right time. The conveyance loss in the Vaalharts scheme, unlike the other schemes, is mainly attributed to canal evaporation and seepage from canals. The high evaporation is reckoned to be due to the length of the channel. The high seepage loss, as people from the area indicated, especially from the North Canal, is due to improper construction.

The potential for water saving by implementing latest technologies has been investigated based on theoretical irrigation application efficiency values. A 2% improvement in each of the six selected schemes would provide a 7.3 million $m^3$/a saving. This can irrigate an area of 948 ha assuming 7700 $m^3$/ha/a water requirement. Similarly if the irrigation application is improved by 5% in each of the schemes, 18.0 million $m^3$/a water, which can irrigate 2 340 ha, which is equivalent to the entire Schoonspruit government water scheme. There are savings in operational costs which can offset the capital costs of improving efficiencies. These are however, closely linked to the types of crops that are being farmed.

As mentioned, while a quota allocation system is in place and while farmers are not using their full allocation, there is little incentive for farmers to implement more efficient irrigation systems, despite the fact that it can be shown that there are sufficient offsets in operational cost savings . It should, of course, be borne in mind that under utilization also serves as a buffer for the risk to farmers of impending drought periods. It would appear reasonable to link the water tariff to assurance of supply, as this is likely to provide the kind of incentive to encourage farmers to balance their risks of supply against using more efficient irrigation systems.

A four-year project titled ” Standards and Guidelines for improved irrigation efficiency from dam wall release to root zone application” is running by a consortium of ten people funded by WRC. The objective of this project is to develop benchmarks for all aspects of irrigation. These benchmarks are imperative to assess irrigation efficiency and hence to quantify the benefits of different water conservation and demand management efficiencies.

There is also huge potential for saving by improving the water management. However, the existing water monitoring system in the whole catchment has to be improved in order to give reliable information, to assist in identifying management problems and to quantify the benefits.

The success of water conservation and demand management initiatives mainly depends on the awareness and, responsibility and accountability of water control officers and the end users. As in Australia, a shift from thinking of productivity in the traditional way, from yield per hectare to yield per $m^3$ can bring about a substantial improvement in water use. Thus huge efforts are required to address these shortcomings.

**Urban Sector**

From the assessment of the scope for WC/WDM in the Upper and Middle Vaal River Basin several key issues were identified from which the following conclusions and recommendations were made:

- WC/WDM can provide a significant reduction in the water demands in the area if the measures are implemented properly and maintained indefinitely. The cost of implementing WC/WDM measures is often less that the maintenance costs which are often overlooked with the result that the WC.WDM interventions fail within a year or two of being implemented.
- The projected Rand Water demand in the year 2024-25 is estimated to increase from its current value of approximately 1 200 million $m^3$/annum to more than 1 500 million $m^3$/annum in the event that no WC/WDM measures are implemented. The potential savings that can be achieved in the study area range from a maximum optimistic estimate of approximately 400 million $m^3$/annum (Scenario c) in the year 2024 ( i.e. demand drops to approximately 1 100 million $m^3$/annum) to a more conservative and possibly realistic estimate of 200 million $m^3$/annum – i.e. demand drops to approximately 1 300 million $m^3$/annum (Scenario e).
- Savings are extremely limited in Mogale and Govan Mbeki as indicated by the relatively low ILI values of 3.4 and 2.6 respectively. In contrast the ILI values for Johannesburg, Ekurhuleni, Tshwane and Emfuleni are 7.2, 4.5, 5.2, and 7.3 which indicate relatively high levels of leakage/wastage in these systems. Rustenberg also has high leakage/wastage as indicated by its ILI value of 8.6 as does Matjhabeng with an ILI of 8.0.
- WC/WDM can be effective and sustainable as has been shown by several large projects undertaken in the study area including:
    - The Sebokeng/Evaton pressure management project

    - The Soweto leak repair, retrofitting and pre-paid metering project;
    - The Kagiso pre-paid metering project.

- Garden irrigation using potable water is a huge problem issue in many low income areas where indiscriminate use of hosepipes and potable water is creating both supply and pressure problems. The use of hosepipes must be either banned completely in such areas or the use restricted to an hour or two every 2nd day during off-peak periods. Irrigation during the hottest part of the day (from 10h00 to 18h00) should be prohibited simply on efficiency grounds.
- Government Departments must co-ordinate their efforts with regard to WC/WDM. The efforts of DWAF where the Department is spending large budgets to educate consumers on the evils of hosepipe irrigation is being undermined by the efforts of the Department of Agriculture where it is providing free hosepipes to the same consumers to grow vegetables. Those wishing to grow vegetables in such areas should be provided with buckets or watering cans which can still be used with good effect without causing the system problems mentioned previously. Alternatively, roof tanks should be provided to capture rainwater which is ideal for such irrigation.
- DWAF should encourage WDM activities – e.g. fund projects like Sebokeng, provide subsidies for roof tanks and low flush toilets etc. The Department should not encourage use of low quality fixtures in township retrofitting projects and should rather use the highest quality pipes, meters and fittings for poor areas since the taps and toilets in these areas experience highest use and lower quality fittings will not last.
- Lack of maintenance will result in many systems deteriorating into intermittent supply if action is not taken quickly – particularly in township systems where lack of maintenance has occurred over past 30 years.
- Municipalities should be encouraged to combine technical and financial services into a single unit – current trend of separate billing/treasury from water supply/technical is causing major problems and a proper water audit is often not possible since the split between Real and Apparent losses cannot be established with confidence.

# POTENTIAL SAVINGS THROUGH WC/WDM IN THE UPPER AND MIDDLE VAAL WATER MANAGEMENT AREAS

***TABLE OF CONTENTS***

# POTENTIAL SAVINGS THROUGH WC/WDM IN THE UPPER AND MIDDLE VAAL WATER MANAGEMENT AREAS

## 1 INTRODUCTION

### 1.1 BACKGROUND

Following completion of the study to investigate the Internal Strategic Perspectives (ISPs) for the Vaal River Water Management Areas (WMAa), which was completed in the year 2004, the Department of Water Affairs and Forestry (DWAF) identified and prioritised several studies to further support Integrated Water Resource Management in the Vaal River System. Although the original ISP Study's water balance assessments indicated that augmentation of the Vaal River System is only required by the year 2025 (**DWAF, 2004a to d**), several factors were identified that could influence this date and required further investigations.

Firstly, it was acknowledged that the water requirement projection scenarios used in the ISP study did not include the influence of potential water conservation and demand management initiatives. As a result, the Directorates National Water Resource Planning and Water Use Efficiency commissioned the Water Conservation and Demand Management Potential Assessment: Business Plan Development for the Upper and Middle Vaal River Water management Areas. The results from this study are documented in the remainder of this report.

Secondly it was recognised that the time required to implement a large water resource augmentation scheme could be as long as fifteen years and coupled with the fact that the future water requirement scenarios exhibit low rates of increase makes the timing of intervention critical.

Finally, a comprehensive Reserve Determination had not been undertaken for the Vaal River System and will have to be incorporated into the balance between the available supply and the projected water requirements.

Given the above factors as well as various other uncertainties identified in the assumptions used in the ISP study, the Directorate: National Water Resource Planning commissioned another major study to reconcile the demand and supply situation in the Vaal River System. Since the water demand projections form one component of the reconciliation between supply and demand, it was agreed that the two studies would be integrated to ensure consistency and to avoid duplication of effort. It was also agreed to combine the management of the studies and provide a single inception report to describe the scope of work for the various activities undertaken in each study.

The remainder of this report describes the objectives and results from the Water Conservation and Demand Management study.

## 1.2 MAIN OBJECTIVES OF THE WC/WDM STUDY

The main objectives of the Water Conservation and Water Demand Management study are to:

- investigate the potential influence on future water requirements in the Vaal River System of WC/WDM activities based on reliable information derived from real case studies;
- identify and develop strategies to improve the effective and efficient use of existing and available water resources in all water sectors (urban, industrial and agricultural);
- assess the likely costs associated with the possible WC/WDM activities to enable the savings to be compared with alternative augmentation schemes;
- assess the current and planned WC/WDM measures within the Vaal River Basin in order to provide realistic future demand scenarios to the study team responsible for the reconciliation of demand and supply.

## 1.3 STUDY AREA

The core of the study area consists of the Upper, Middle and Lower Vaal River Water Management Areas. Due to the numerous inter-basin transfers that link this core area with other WMA's, however, reconciliation planning has to be undertaken in the context of the full Integrated Vaal River System which also includes portions of the Komati, Usutu, Thukela and Senqu River (Located in Lesotho) catchments. In addition, significant water transfers occur to water users in the Olifants and Crocodile (West) River catchments, many of which are totally dependant on the water resources of the Integrated Vaal River System. **Figure A-1** in **Appendix A** shows a map of the Integrated Vaal River System which is the main study area for this project.

The water resource components of the Integrated Vaal River System are highly inter-dependant due to the cascading orientation of the three Vaal River WMAs as well as the links that exist as a result of the transfer schemes (indicated by the arrows on **Figure A-1**). The water resource system has the function of providing water to one of the most populated and economically important areas in the country as reflected by the magnitude of the developments located in the Upper and Middle Vaal, the Olifants and the upper portion of the Crocodile West Marico Water Management Areas. These developments include most of the country's power stations, gold mines, coal mines, platinum mines, petro-chemical plants as well as various other strategic industries. The water requirements in the area are therefore critical to the economy of the country and the well being of its people.

In order to assess the potential savings that can be achieved through the various possible WC/WDM interventions, it is first important to establish the existing water demand distribution in the study area. In this regard, the water demand distribution for the Vaal River System is shown in **Figure 1.1** from which it can be seen that the Rand Water demand is clearly the largest component. It should also be noted, that the Rand Water demand is used almost entirely for urban and industrial purposes. It is also important to note that the bulk of the irrigation demands are supplied with low quality water made up primarily from effluent return flows where the salt concentrations have increased to the level whereby the water cannot be used again for urban purposes. The bulk of this report therefore concentrates on the Rand Water demands which can be distributed among the various municipalities as shown in **Figure 1.2.**

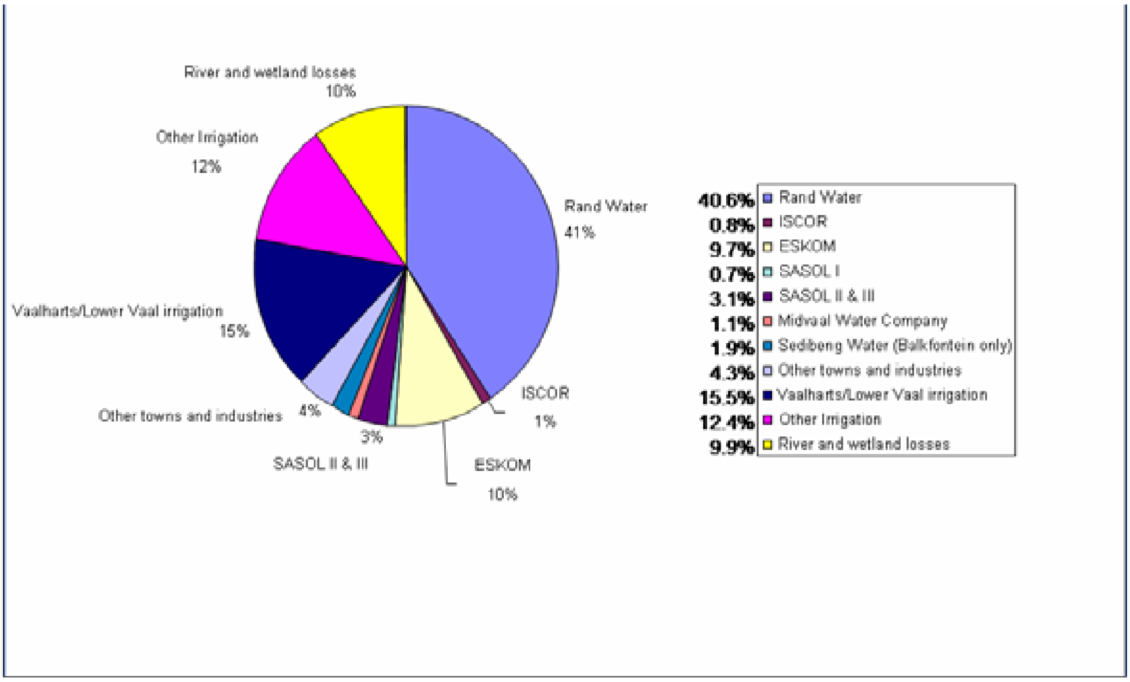



**Figure 1.1: Breakdown of Water Demands in the Vaal River System**

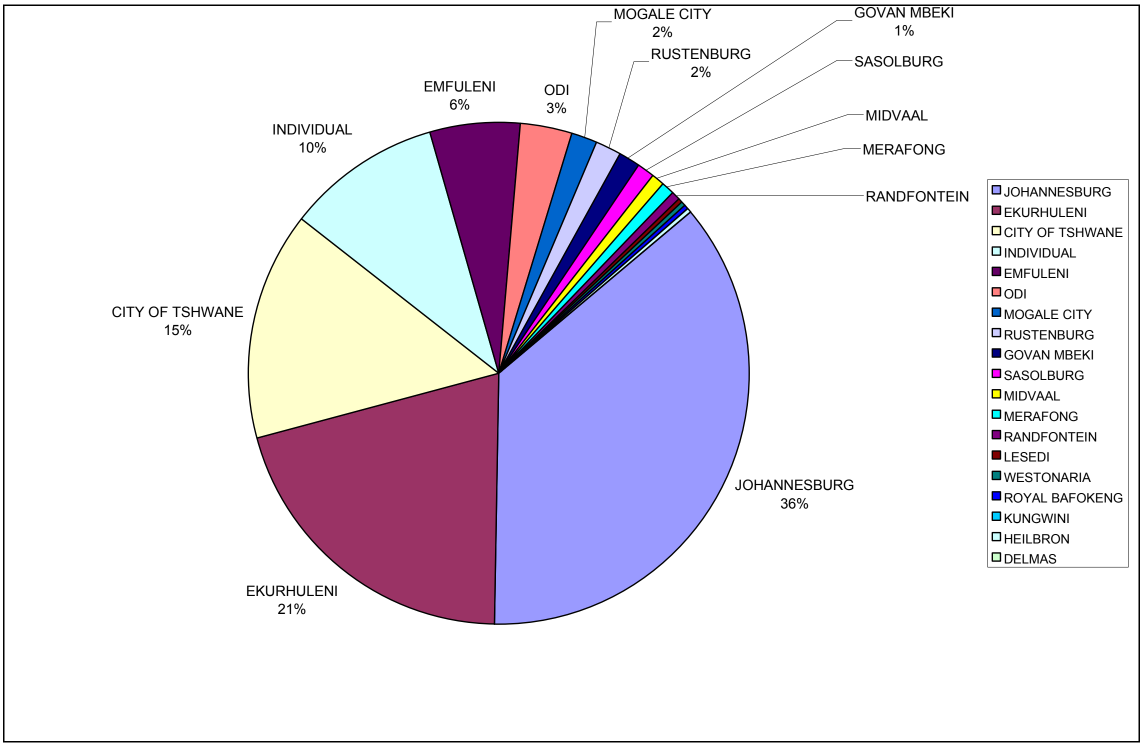



**Figure 1.2: Breakdown of Rand Water's demands**

## 1.4 METHODOLOGY

In order to undertake the WC/WDM study the project was split into a number of tasks and sub-tasks which were effectively completed as separate projects by various members of the study team. The various tasks were integrated into the larger Reconciliation Study and the two projects were effectively managed as a single project although the budgets and programme remained separate. The combined project was split into 14 tasks as illustrated in **Figures B-1 and B-2** of **Appendix B**. These figures highlight the information flow links between the tasks and clearly indicate that the core activity of the two studies is the development of specific reconciliation scenarios as indicated under **Task 11**. The other tasks are all structured to provide the necessary information for assessing the reconciliation scenarios and identifying the most feasible and optimal strategies for reconciliation. Of the 14 tasks included in the joint project, 7 are directly included in the WC/WDM study and their relative inputs are provided in **Table 1.1**. It should be noted that the percentage of input shown in the table refers only to the professional fees associated directly with the WC/WDM project. Some of the tasks also involve certain inputs from the Reconciliation Study and such inputs are not reflected in the table.

**Table 1.1: Summary of tasks in the WC/WDM Study (based on professional Fees)**

| No | Task Description | % of Total |
|---|---|---|
| 1 | Inception Phase and Summary of Previous Studies | 12.8 |
| 2 | Stakeholder Engagement Process | 15.5 |
| 3 | Current and Future Urban Water Requirements and Return Flows | 15.7 |
| 4 | Urban Water Conservation and Demand Management | 11.2 |
| 5 | Opportunities for Water Re-use | - |
| 6 | Irrigation Sector Demands and WCDM | 12.8 |
| 7 | Surface Water Hydrology and Water Resource Analysis | - |
| 8 | Water Quality | - |
| 9 | Reserve Requirement Scenarios | - |
| 10 | Groundwater Resources Assessment | - |
| 11 | Review Schemes and Formulate Reconciliation Scenarios | 12.1 |
| 12 | Review or Assess Social and Environmental Impacts | - |
| 13 | Internal Reviews | - |
| 14 | Study Management and Reporting | 19.8 |
| Total | | 100.0 |

# 2 TASK 1: INCEPTION REPORT

The inception report was developed as a combined report for both the WC/WDM study and the Reconciliation Study to ensure that both studies were properly aligned and to avoid any overlaps which would simply waste the available resources. The combined inception report was completed in November of 2005 and effectively formed the detailed TOR on which the two studies were undertaken.

# 3 TASK 2: STAKEHOLDER ENGAGEMENT PROCESS

## 3.1 INTRODUCTION

PD Naidoo & Associates were tasked to undertake a knowledge, attitudes and perception assessments among key stakeholders. This was primarily looking at the level of information, attitudes and the perception of key stakeholders. The following activities were undertaken:

- Development of an assessment instrument;
- Verification/confirmation of the assessment instrument with DWAF;
- Undertake the assessment;
- Compilation of an assessment report.
- Promote the development of the WC/WDM business plans for local government organisations.

The intention with this component of the work is not to develop business plans, but to encourage the development thereof. The scope of work entailed:

- Identifying whether or not the process of developing business plans has commenced;
- Assess whether or not the various institutions have the capacity to develop such business plans;
- Development of a roadmap to aid the formulation of business plans;
- Develop a WC/WDM awareness campaign for the entire Vaal River System; and
- Compile a document outlining the benefits of WC/WDM measures among local authorities.

## 3.2 DELIVERABLES

### 3.2.1 KAP Survey and Business Planning Assessment Report

**Background**

During the development of the Assessment instrument, it was, as per DWAF’s recommendation, decided that the questionnaires for the Knowledge, Attitude and Perception Survey and the Business Planning Capacity Assessment be combined. Thus, these two activities are included in **Appendix C**, though separated into two parts, Part A (for KAP survey) and Part B (for the Business Plan development capacity assessment).

The following municipalities were included in the assessment:

- Randfontein
- Ekurhuleni
- Mogale City
- Johannesburg Water
- Metsi-a-Lekoa
- Rustenburg
- City of Tshwane
- Matjhabeng
- Govan Mbeki

**Findings**

While detailed information per individual municipality is provided in **Appendix C,** a summary of the key findings from the assessment is provided below:

- Municipalities have knowledge of the basic concepts of WC/WDM, with training being the most common mechanism through which the knowledge was obtained.
- There was a clear call for more training sessions in the area of WC/WDM to increase the level of knowledge of municipal officials;
- It is the view of municipalities that Awareness Campaigns will be the most appropriate method for educating the public about WC/WDM. It is concerning, however, that approximately half of the respondent municipalities indicated that they do not have the capacity to implement such awareness programmes, both financially and from a human resource perspective;
- The attitude of those that responded was overwhelmingly positive.
- There are differing perceptions held by the various respondents in terms of what WC/WDM seeks to achieve. It is generally perceived that WC/WDM is primarily concentrating on the sustainability of the resource and cost savings. This is not surprising given the limited knowledge in terms of the detailed content of these concepts;
- A range of factors that are seen to be constraints to the successful implementation of WC/WDM measures have been raised, with financial limitations and awareness being the most common. Least common constraints include political issues, lack of skills, etc.;
- It is interesting to note that few of the major municipalities rely on consultants to develop their business plans. Many have indicated, however, that lack of adequate human resources hampers their ability to achieve more;

Emanating from the above findings, the following conclusions are made:

- Much still needs to be done to increase the level of knowledge in municipalities in respect of WC/WDM issues;
- WC/WDM are not incorporated in to the Water Services Development Planning process, hence very little focused attention is given thereto;
- Municipalities currently lack appropriately skilled human resources as well as funding to implement WC/WDM measures successfully
- There is a need for broader support networks to assist municipalities with the development and implementation of WC/WDM measures

### 3.2.2 Awareness Campaign Strategy for the entire Vaal River System

**Scope of Works**

It is important to emphasise that it is ideal that a single, comprehensive, multi-faceted campaign be developed and implemented for the entire Vaal River System. The motivation for a strong, solid brand identity for this specific Campaign is to ensure that the Campaign is easily identifiable by anyone, irrespective of which communications element / collateral one is exposed to; as well as to ensure that this Campaign stands out amidst the "*clutter*" of all other DWAF (and Government) campaigns. A typical example causing such confusion concerns the current initiative by the Department of Agriculture which is providing free hosepipes to residents in many areas which effectively encourages the use of potable water for garden irrigation. This is in direct conflict with the DWAF initiatives which are aimed are saving potable water to ensure that all residents have access to a reliable and safe supply of drinking water In view of the current confusion it is essential that steps are taken to ensure that there are no conflicting messages to the targeted audience. However, this should not be seen to disregard the fact that peculiar conditions within different regions and communities may call for different approaches. Thus, the need for core key messages, which becomes greater.

Again, given the diversity of the stakeholder groups, all communications interventions must be cognisant of variables such as:

- Language;
- Learning style;
- Literacy levels;

- Access (or lack thereof) to ICT;
- Communications medium / platform; and
- Actual messages

Further, all communications interventions in this regards must be designed with a '*leaning opportunity*' mechanism / approach inherent therein, from which all parties can benefit. This is, perhaps, the only true litmus test of whether or not any intervention has made a difference – impact, so to speak –one true measure of *Returns-On-Investment (ROI), be it material, human, intellectual, or otherwise!*

The Project should target both institutional and individual stakeholders with varying sets of approaches. Thus, it is clear that different sets of information / knowledge (messages) need to be transmitted to the different stakeholders. As such, it is most likely that this will, in turn, determine the communication media to be used as per the different stakeholders and messages. Any Campaign design and collateral must be able to flex to this challenge.

Specifically the service provider will be expected to carry out the following:

- In consultation with DWAF develop a detailed Work plan and Budget;
- Undertake Creative Work;
- Management of the Campaign Roll-Out; and
- Test Campaign Response.

In keeping with Government's commitment to the transfer of skills from external consultants (should external consultants be used) to members of the Public Service, provision should be made for the Project to ensure that it also advances the development of human capital within DWAF.

This will be done in a manner that is jointly agreed between DWAF and the service provider, with a clear approach to the transfer of skills and indicators to measure performance in this regard.

**Approach**

The following seeks to present the generic overall approach that should be followed. It must be noted that this is a proposed overall approach / method and is, thus, subject to final approval and sign-off by DWAF as part of the Project Inception process.

Some of the additional key considerations underlying the actual proposal include:

- Stakeholders should be provided ample opportunity to provide input into the planning of the Campaign, particularly in terms of Campaign design, and Key Messages.
- Training should be provided to DWAF Regional staff as Campaign Facilitators to drive the Campaign penetration into the respective regions and amongst the various stakeholders within the regions.
- Opportunities should also be made available for impact assessment of the Campaign, which further creates the space for target groups to provide feedback and evaluation in measuring whether or not the Campaign succeeded in moving stakeholders from a baseline state to a desired state in terms of their knowledge re the WC/DM.

These considerations are crucial in ensuring that the key elements of the ***Communications Strategy Cycle*** are achieved.

The Project will have ***three distinct phases***, each building on and entrenching the preceding phase:

- Phase One: Campaign Consultation and Development
- Phase Two: Campaign Launch and Rollout
- Phase Three: Campaign Impact Assessment and Closure

Each Phase should have its own distinct ***Key Deliverables and Activities***.

The entire ***Campaign should have its own identity***, branded in line with that of the Department (and Government) generally. The ***visual-and-verbal identity*** across all elements of the Campaign should be consistent, so as to provide a clear, singular identity, again, across the entire Campaign. This will serve in reinforcing the various messages across the different mediums through an easily identifiable golden thread.

**Some of the Campaign elements should target all of the stakeholder groups; other elements should target only one / some of the stakeholder groups.** This will be determined by the respective communications medium and the respective stakeholder group. This approach is premised by the fact that each stakeholder group has both common and / or peculiar needs, and each communications medium has specific a purpose/s.

**Tactics / Methodology Overall and per Stakeholder Group**

The proposed tactics to be used throughout the Project, generally, and per stakeholder group, specifically, may best be unpacked in presenting the differing Phases of the Project, and their respective Key Deliverables and Activities.

A phased approach should be followed in undertaking the project so as to allow for easy tracking of progress.

<u>Phase One:</u> **Campaign Consultation and Development**

- *Focus Groups.* The intention here is not to clutter the cognitive processes with any pictures; but rather to see if the text is appropriate, relevant and meaningful.
- *Campaign Collateral.* Once the copy for the Key Messages have been tested, the next step is to design and develop the creative for the various Campaign collateral
- *Focus Groups.* The intention here is to test if the pictures, symbols and colours are appropriate, relevant and meaningful
- *Regional* Meetings*.* The primary purpose of the Meetings is to present the Campaign and get endorsement for the same by the participants. This allows for engagement with the various stakeholder groups, without necessarily getting bogged down by their diverse and disparate interests.
- *Train-the-Trainer (DWAF Regional Campaign Facilitators).* It is proposed that each DWAF Regional Office nominates people to be trained to facilitate the Campaign penetration within the respective DWAF Regions and amongst the various stakeholder groups within each region.
- *Pilot Project.* It is recommended that a Campaign pre-test be conducted to ascertain the feasibility and viability of the Campaign and its various elements and collateral.

<u>Phase Two</u>: ***Campaign Launch and Roll-Out (eight months)***

- Campaign National Launch.
- Campaign Regional Roll-Out.

<u>Phase Three</u>: ***Campaign Impact Assessment and Closure (four months)***

- *Campaign Impact Assessment.* This will be conducted across all regions, with all stakeholder groups, and for all Campaign elements and collateral. It is crucial to do this for a number of reasons, including:
  - o To measure the success of the Campaign

  - To assess whether or not there was ROI
  - To gauge change in behaviour from targets groups in presenting the desired behaviour
  - To identify gaps in the Campaign and to make recommendation on gap fill measures / mechanisms for the future
- *Campaign Closure.*

### 3.2.3 Outline of Benefits of WC/WDM

A document outlining the benefits of WC/WDM is included as **Appendix C**. It is anticipated that this document will be concerted into a leaflet or a booklet that would be easy to read by municipalities.

# 4 TASK 3: CURRENT AND FUTURE URBAN WATER REQUIREMENTS AND RETURN FLOWS – INDUSTRY MINING AND POWER SECTORS

## 4.1 INTRODUCTION

This task involved several sub-tasks of which one was undertaken as part of the WC/WDM study and the others under the main Reconciliation study. The sub-tasks were as follows

- **Task 3a: Collate and review existing water demand data**
- Task 3b: Review and update water use database
- Task 3c: Configure Water Requirement and Return Flow Model
- Task 3d: Determine the need to update NWRS water use data
- Task 3e: Liaise with other 3 reconciliation study teams regarding approach and methodology;
- Task 3f: Review of demand and return flow scenarios;
- Task 3g: Reporting

Only a portion of **Task 3a** was included in the WC/WDM study with particular emphasis on the Industrial, Mining and Power (IMP) sectors. It should be noted that most effort was spent on the urban demands which are discussed in **Section 6**.

The primary objectives of the Industry, Mining and Power portion of this study are as follows:

- to promote good governance in water resource management in the Integrated Vaal River system for sustainable socio-economic growth and development;
- to assess the current status quo with regards to effective and efficient use of water resources by stakeholders in the mining, power and industrial sectors;

The secondary objective is as follows:

- to assess the current & planned water conservation / water demand management (WC/WDM) measures to develop reliable estimates of the savings that can be expected;
- to assess the potential for reconciling current and future requirements through the selection and implementation of sector specific WC/WDM strategies
- to assess effective and efficient use of water resources in all water use sectors (i.e. mining, power, industrial sectors)

The Industry, Mining and Power (IMP) sectors place immense pressure on local water resources. For some consumers in these sectors, such as the food and beverage industry, water is required as a raw material and is subsequently exported out of the system. For other consumers, water is required often in large volumes as process inputs. In many industries and in particular the mining and power sectors, water is essentially used as input and mass and heat transfer medium. With the exception of the power sector, much of this water is not consumed or lost but is ultimately discharged as effluent. Water consumption is therefore largely dependant on the type of IMP consumer.

Quality as well as quantity is also of significance for the IMP sector. Some of the consumers in this sector require high quality water for processes while the effluent they discharge is of a poor quality. At best, this poor quality effluent can be recycled for lower grade use such as in the mining sector. For some consumers however, lower quality water results in higher consumption or increased treatment costs, particularly in the power sector where salt build-up reduces the number of cycles that the water can be used for cooling purposes. Other consumers who make use of water in a cascading process often require potable quality water as the base input.

## 4.2 PROCESS OF IDENTIFYING REPRESENTATIVE CONSUMERS

Water Authorities and Providers that were approached for consumption data included:

- Johannesburg Water;
- Rand Water;
- Ekurhuleni Metropolitan Municipality,
- Emfuleni Local Municipality,
- City of Tshwane Metropolitan Municipality and
- Rustenburg Local Municipality

As data became available, a list of the large consumers in each municipal area was compiled. The large consumers that fell within the Industry, Mining or Power Generation sectors were subsequently identified as the focus of this portion of the assessment.

The total number of consumers initially identified was sixty. Due to the time and budget limitations it was impractical to target all large consumers for each municipal area, and the adopted procedure was therefore to obtain sufficient reliable information from as many of the organisations as possible, within the given time-frame and budget. The process of approaching the consumers for information commenced with the largest consumers in each sector, working down the list until sufficient data were obtained to undertake a meaningful assessment.

Representative large consumers for the following industries in the upper and middle Vaal River catchments were identified during this process:

- Power generation;
- Gold Mining;
- Platinum Mining
- Fuel Refining;
- Steel;
- Zinc;
- Pulp / Paper;
- Food / Pharmaceutical;
- Beverages;
- Glass;
- Construction;
- Motor vehicle.

Information regarding the project was sent to as many of the sixty identified consumers as possible. This was to allow for the possibility that some of the consumers would not respond or would not supply sufficiently detailed information for inclusion in the study.

At the request of certain consumers, some of these categories were combined where a particular sector is dominated by one large organisation. This was necessary due to the sensitivity of some of the information required for this study.

The following categories were combined for this purpose:

- Steel Production and Zinc Production
- Food / Pharmaceutical and Beverage

The information received from certain consumers was therefore combined with information from other consumers to ensure that the information would not breach the confidentiality requested by the different organisations.

## 4.3 TARGETING OF REPRESENTATIVE CONSUMERS

A letter requesting assistance in providing information pertaining to the study providing a brief background to the study was drafted at the beginning of the study. This letter was addressed to the consumers in the industry, mining and power sector from the Manager – Directorate: Water Use Efficiency Department: Water Affairs and Forestry, Mr Cain Chunda. The letter was distributed by e-mail or hard copy to all consumers approached to provide information during the course of the study. A copy of the letter is included in **Appendix D**.

A questionnaire developed towards the beginning of the study was used when requesting information from consumers. Minor changes were made to the questionnaire to accommodate different types of consumers and to make provision for any shortfalls identified in the course of gathering information. A summary of the information requested is given below:

**Water Consumption:**

- historical and predicted (Predicted based on estimated future production);
- per Process where available (where you are able to separate this data);
- process per output versus benchmark (e.g. water consumption volumes per ton of product).

**Water Sources:**

- source (abstraction / dewatering / partially treated / other );
- percentage breakdown per source (i.e. 45% raw water abstraction, 55% potable);

**Losses:**

- source / Area and Quantity per annum (known losses from leaks, evaporation or other)

**Water Conservation and Water Demand Management Strategy**

- details of Strategy where available (plans to improve efficiencies, implement water conservation)
- types of initiatives: planned / in progress, savings (water balance, recycling, repair to infrastructure/ reservoirs and underground pipes)
- stumbling blocks to initiatives

Both potable and non-potable water use has been considered for the purpose of the study.

A copy of the Study Questionnaire used for the Industrial, Mining and Power sectors used during the study has been included in **Appendix D**.

### 4.3.1 Industry

Consumption data received from the Water Authorities and Providers indicated that most of the large industrial consumers are concentrated in the Ekurhuleni Metropolitan Municipality with the remainder in the Emfuleni Local Municipality and some in the City of Tshwane Metropolitan Municipality.

Industrial consumers targeted during the study in the Ekurhuleni Metropolitan Municipality fell mostly within the food and beverage; pharmaceutical; paper; glass and steel manufacturing sectors. Industrial consumer in the Emfuleni Local Municipality targeted during by the study included the food and beverage and steel manufacturing sectors. Industrial consumers targeted in the City of Tshwane Metropolitan Municipality included motor vehicle and food and beverage manufacturing. It should be noted that is common for some of the large consumers such as those in the food and beverage industry to have operations in each of the larger municipal areas in which cases all the information required for the study could be obtained directly from the head office for the group.

### 4.3.2 Mining

Most of the mines identified during the study were supplied with potable water by Rand Water and were situated in the West Rand (Merafong Local Municipality and Mogale Local Municipality) and Rustenburg (Rustenburg Local Municipality) areas. The majority of the mining in these areas is either gold or platinum mining with associated by-products. Mines that fall within the Rustenburg Local Municipality were included in the study even though they are situated outside the Vaal catchment since many of them receive their potable water supply from Rand Water.

Since the mines are relatively large consumers of water, considerable time and effort was spent trying to obtain the necessary information for the study. Although a number of mines were approached, submissions were not always received even after repeated requests. After failing to obtain information directly from the mines, more success was achieved in some cases when the head office for the mining houses was approached directly. The majority of the information was then received from the environmental departments of the mines.

### 4.3.3 Power

As the national provider of electricity, Eskom was approached for current information pertaining to the study. A number of power stations are situated within the Vaal Catchment or are supplied from the Vaal Catchment via interbasin transfer schemes.

Although not part of this study, energy usage and electricity demand side management could also be considered when carrying out an assessment of this nature due to the large water volumes required for electricity production.

An important issue which was identified that falls outside the scope of the study concerns the debate between wet cooled and dry cooled power stations. There is a general perception that dry cooled power stations are preferable from a water saving and environmental viewpoint. It must be noted, however, that in many cases, a dry cooled power station will use up to 30% more coal to produce the same power as a traditional wet cooled station. There is no debate that a dry cooled station will use approximately 10% of the water used by a wet-cooled station to generate the same power, however, the 30% additional greenhouse gasses produced may in fact be of greater significance particularly in the current pattern of global warming. This is a very important issue which should be investigated in more detail outside the current study.

## 4.4 COLLECTION OF INFORMATION

Supportive information to the questionnaires was requested from organisations such as copies of Water Conservation (WC) and Water Demand Management (WDM) or similar strategies. Where companies had recently submitted water-use license applications, a copy of the relevant information from the application was requested since much of the information required for the Vaal Study is also covered in the license application.

Some of the consumers approached during the study did not have a WC/WDM strategy or similar where the information could be easily sourced. In such cases sufficient time therefore had to be allocated to collate the information requested in the questionnaire. Consideration also had to be given to the staff members from the various organisations, who in many cases, had to dedicate a significant amount of time to compiling the information requested.

Obtaining the information promised by organisations in the industrial sector required regular follow-ups especially in cases where the information supplied was incomplete or unreliable.

It was found that organisations contacted telephonically were less likely to provide any useful information. Every effort was therefore made to obtain appointments with persons responsible for management of the water usage of the organisation in order to submit and discuss the questionnaire in person.

The Department of Water Affairs and Forestry, Directorate Water Use Efficiency Department responsible for the Industrial, Mining and Power sectors offered guidance during the course of the study and assisted in providing relevant sources from whom to gather information relevant to the study.

The final date for submission of information was extended to the end of May 2006. A number of organisations targeted by the study had however not replied by this date. Numerous phone calls and e-mails were sent to the contact persons for the respective organisations and some success was achieved in the following few weeks in obtaining information. With time constraints towards the end of study, the best course of action for organisations with outstanding information was to arrange a follow-up meeting to go through the questionnaire in person and in doing so, obtain as much information as possible.

Every effort was made to obtain all outstanding information during June 2006 especially any increase in the data sample that was likely to have a positive impact on the findings of the study.

## 4.5 COLLATION OF INFORMATION

As the information requested from consumers became available, it was collated according to sector. Once sufficient data had been collected for the various sectors, it was possible to analyse the data and determine what trends existed. Information received was collated according to the sections outlined in the questionnaire, namely:

- Water Use
- Water Consumption
- Water Sources
- Water Conservation and Water Demand Management Strategy
- Losses

During collation of the information, certain shortfalls in the submissions from certain organisations were identified, necessitating that requests be made for additional information from these consumers.

Up to date consumption data from Rand Water was collated to determine overall consumption trends for the various categories chosen in the industry and mining sectors. A similar exercise could unfortunately not be completed for all of the water service providers as the consumption figures per sector were not always made available. Background information for consumers was collected from the internet as well as water related studies completed in the water sector. This information was included in the report as it is deemed important in understanding how water is used in the various processes for industry, mining and power generation. This background information, provided insight into areas where savings through recycling or other water demand management measures occur or could be achieved. Water resource planning information for the study area was used for the power and industrial sectors in particular when accessing predicted demands.

A number of the consumers approached during the study were part of international organisations and therefore subject to various international legislative restrictions with regards to water use and water quality. This information has also been included in the report. A limited amount of benchmark information was obtained, mostly from international organisations. This information was particularly useful in evaluating consumption per process or output compared to international standards.

A summary of the collated data for representative consumers in each sector has been included in **Appendix D.** Incomplete data have not been included in the appendices but have been considered in the development of recommendations regarding the potential for WC/WDM

## 4.6 WATER CONSERVATION AND WATER DEMAND MANAGEMENT

A review of the WC/WDM measures that have been completed; are currently in progress or that have been planned for most of the organisations targeted during this study are included below. Consideration is given to the water demand management measures as well as the motivation for these measures when assessing the potential for water demand management for the study area.

Section 6 – Detailed Outputs, Activities and Role Players: (Water Conservation and Water Demand Management Strategy for the Industry, Mining and Power Generation Sectors – DWAF) summarises the following strategic outputs:

- Carry out ongoing water audit and water balance
- Benchmark, as far as possible and practical, water use for various processes and industries
- Performance monitoring against benchmarks
- Implement water conservation program
- Marketing and publicising water conservation

This section of the strategy provided the basis for evaluation of the current status of WC/WDM for the Industrial, Mining and Power portions of the study.

### 4.6.1 Industry

***Fuel and Gas***

**Organisation 1 (361.4 Mℓ/d :Section 1 - 77.52 Mℓ/d, Section 2 - 257.9 Mℓ/d, Section 3 - 26 Mℓ/d)**

Predicted growth in demand of 2% per annum over 10 years

Increased production pressures to be moderated by large scale demand management measures:

- **Section 1**: Zero Effluent (Planned):
  - Process water re-use
  - Mine water re-use (reverse osmosis)
- **Section 2**: Reduction at source:
  - Re-cycle and re-use
  - Treatment and disposal of excess
- **Section 3:** Raw water reduction:
  - Natural gas implementation (70Mℓ/d – 52Mℓ/d)
  - Construction of new plants (use recycled water)
  - Closure of old facilities

Deterioration of raw water quality is of primary concern (linked to growth in demand)

**Organisation 2 (0.5 Mℓ/d)**

- Possible reduction in demand due to reduction in high losses (replacement of leaking pipes)
- No additional demand management plans in place

***Steel and Zinc***

**Organisation 3 (Section 1 – 66.3 Mℓ/d, Section 2 – 1.5 Mℓ/d)**

**Section 1 – Demand Management Initiatives include:**

- Implementation of Zero Effluent Discharge Policy (2005/6) resulting in reduction in demand of 29Mℓ/d to 41Mℓ/d. Future capital projects/ capacity increase 2007 – 2009 to increase demand to 44Mℓ/d.
- Discharge Tax major motivator in implementing Zero Discharge Policy
- Target is to reduce demand from Vaal River where quality is poor and fluctuates
-

**Section2** Predicted increase in demand of 20Mℓ per year (3.6% /annum). WC/WDM initiatives include:

- Zero Effluent Strategy over past 5 years (reverse osmosis plant).
- Storm Water Management
- Leak repair and pipe replacement project (underway)

**Organisation 4 (3.1 Mℓ/d)**

- Predicted decrease of 5% in specific water use per annum.
- Environmental Action Management Plan includes annual specific consumption targets for water. Initiatives include:
    - Monthly water audits
    - Recycling for irrigation
    - Re-use
    - Leak audits

**Organisation 5 (4.1 Mℓ/d)**

- Water Demand Management Plan has been developed;

- Target to reduce consumption to 3.3Mℓ/d (25%)
- Reduction in use through infrastructure upgrades
- Improved management and re-use
- Water Balance for monthly consumption monitoring

***Pulp and Paper***

**Organisation 6 (33.3 Mℓ/d)**

- Integrated water management plan includes the following projects:
- Close cooling water circuit and fly ash circuit (Reduction 100Mℓ/month)
- Effluent line swap (Reduction 100Mℓ/month)
- Recycling of effluent (Reduction 250Mℓ/month).
- Specific consumption figures compare favourably with international benchmarks.

**Organisation 7 (5 Mℓ/d)**

- Predicted increase in overall demand of 5% per annum (industry related)
- Current target of 30Kl/ton for specific water use
- Sustainability Guidelines provided by parent organisations with specific consumption targets which are set every five years (Target of 10% reduction in usage set by 2010). Water demand management measures include:
  - Modifications to manufacturing process to reduce water usage
  - Improvements in recycling

***Food/ Beverage/ Pharmaceutical***

**Organisation 8 (18.3 Mℓ/d)**

- Annual increase in demand has been approximately 5%
- Planned Water Demand Measures include:
- Awareness campaigns supported by ISO14001 ongoing.
- Plant 1 – New equipment involving greater use of cascading opportunities and optimisation of cleaning process (saving of 25Mℓ/year)

- Plant 3 – Process optimisation and secondary water use (saving of 455Mℓ/year)
- Water consumption monitored on daily basis through detailed audit/ metering system
- Specific water consumption versus benchmark indicates that future improvements are necessary

**Organisation 9 (5.7 Mℓ/d)**

- Average growth in consumption of 7% predicted for next five years.
- Specific water consumption is well below the system-wide benchmark.
- Currently no comprehensive water audit in place. Long terms plans are to evaluate the feasibility of installing process meters
- Water Demand Management Initiatives include:
    - Leak Repairs (ongoing)
    - Retrofitting of water saving equipment/ device
    - Water Conservation Awareness Campaigns - ISO 14001 (ongoing)
    - Re-use and establishment of in-plant targets

**Organisation 10 (2 Mℓ/d)**

- Demand to double with expansion of plant.
- Water Demand Management Initiatives include:
    - Installation of water efficient equipment
    - Process throughput versus consumption is being monitored daily
    - Water use practices (cleaning) are monitored on an ongoing basis
    - Internal targets/ benchmarks are set and compared within the organisation

**Organisation 11 (1.1 Mℓ/d)**

- Water Management Plan includes the following initiatives:
    - ISO 14000 accreditation for all plants
    - Installation of meters to monitor processes
    - Reduction in effluent discharges
    - Re-use of discharge water (saving of 0.1Mℓ/d achieved)

- Reduction in potable water demand.

### *Glass*

#### Organisation 12

- No predicted increase in consumption
- No existing benchmarks used
- No formal strategy relating to water could be obtained.
- Major processes are metered and consumption is monitored weekly, regular maintenance to target potential losses, re-use “closed loop” system introduced on some processes.

### *Motor Vehicle*

#### Organisation 13 (1.3 Mℓ/d)

- 5% reduction in demand planned
- Water Demand Management measures include:
    - Re-use from effluent dam in place (existing)
    - Implementing cascading system (planned)
    - Increased recycling of effluent. (planned)

#### Organisation 14 (1.6 Mℓ/d)

- Water and Energy Activity Plan in place which includes:
    - : Comprehensive Water Audit is carried out weekly
    - Target areas where savings can be achieved – Leak Detection and Repairs (5.5% Saving in 2006)
    - Awareness program to promoting water saving culture (existing)

### 4.6.2 Mining

***Gold mining***

**Organisation 15 (16.9 Mℓ/d)**

- Current focus of Water Demand Management is as follows:
  - Revamp of water balance system (as per DWAF Guidelines)
  - Optimise use of ground water to reduce potable consumption
  - Recycle water from various processes (including domestic effluent)

***Platinum Mining***

**Organisation 16 (41 Mℓ/d)**

- Water Demand Management initiatives include:
  - Use of partially treated effluent from local municipality
  - Treatment and re-use of domestic effluent
  - Maximising use of recycled water from tailings dams
  - Reduction in potable water consumption
  - Reducing discharge of polluted water
  - Growth in demand likely to be for partially treated effluent

**Organisation 17 (31.8 Mℓ/d)**

Predicted Growth of 2% per annum (will make use of partially treated effluent)

- Water Demand Management initiatives include:
  - Meters recently installed to monitor process usage
  - Annual targets (Specific Consumption) set for usage per mine.
  - Active leakage control and regular maintenance for leaks
  - Water Based Drilling system changing to electric to reduce water usage
  - Use of partially treated effluent from local municipality
  - Recycling of domestic effluent as process water

### 4.6.3 Power

**Organisation (18: 830 Mℓ/d for integrated Vaal System)**

- Large scale water demand management measures in place which include:
  - Dry Cooling - Implemented on new power stations where feasible (estimated combined saving of over 200 Mℓ/day) for indirect and direct dry-cooled power stations.
  - Desalination - Currently two power stations operate desalination plants to comply with ZLED requirements (saving of 10 Mℓ/day)
  - Lime treatment - Older wet-cooled power stations retrofitted to use cold lime softening method of control (instead of acid to control). The result is less raw water make-up to the cooling water system reducing outflow water (cooling water blow-down) to the ash system.
  - Bonus System - Incentive for power stations to reduce their consumption through maximising their efficient use of water. This ensures that water management constantly receives priority at power station level.
  - Electricity Demand Side Management Program - To improve the pattern of electricity use (i.e. the load profile) and improve efficient use of electricity, and will continue until at least 2020.
  - Renewable Electricity Generation Program to evaluate the viability of the following technologies as a supply-side option for electricity generation:
  - Solar Thermal Electric
  - Biomass Energy
  - Wind Energy
  - Wave Energy

The latter two technologies, should they be viable, would have a far lower specific consumption than for existing coal driven power generation.

## 4.7 CONSTRAINTS TO IMPLEMENTING WATER CONSERVATION AND WATER DEMAND MANAGEMENT

The stumbling blocks or constraints to implementing water demand management and water conservation in the industrial sector include:

Costs of implementing projects are often prohibitive. Most of the organisations would only consider investments with a return of two years or less. Replacement of dated or inefficient technology on such financial grounds is often not considered viable.

Energy costs for industries relative to water costs are often significantly higher. Consequently, the main focus for improved efficiencies in many industries is energy with less emphasis on water. This also brings in the issue of greenhouse gas emissions where energy is the key driver. As mentioned previously, the trade-off between dry cooled and wet cooled power stations is a very important and contentious issue since the dry cooled stations use less water but produce more carbon dioxide emission to generate an equivalent unit of power.

There is often limited awareness within industry for the need to establish, implement and maintain a water conservation and water demand management strategy. Difficulty in accessing tools and guidelines necessary to establish a water conservation and water demand management strategy is also not uncommon. This is especially true for older or more complex industrial of mining operations that were not designed with adequate monitoring and control measures in place.

Some organisations are unaware of the standards or benchmarks for their particular industry type. This issue is compounded by the complexity of the sector and variations in technology usage and processes within the same sector which makes valid comparisons difficult.

## 4.8 MOTIVATION TO IMPLEMENT WATER CONSERVATION AND WATER DEMAND MANAGEMENT

The quality of information received and willingness to co-operate in the study was significantly better from large industries and mines and the power sector. In general, larger industries and mines were found to be actively engaging in water conservation and water demand management and therefore had programmes or strategies in place making study related information more accessible. The following were considered to be contributing factors to this:

- Larger organisations are more likely to be making use of non-potable water sources and are therefore required to submit application for water use licenses subject to the National Water Act.
- Larger organisations are often part of international concerns and are subsequently self regulating

- Large organisations who are large users tend to have higher discharge volumes and the associated quality constraints/ taxes then apply forcing the users to consider improved water use efficiency.

### 4.8.1 Industry

The major motivational factors for water demand management and water conservation prevalent in the Industrial Sector include:

- Sustainability Standards are often set by clients (Clients carry out regular inspections to ensure compliance - Food, Pharmaceutical & Beverage sub-sector).
- “Specific Water Consumption” per product (where available) is monitored and comparisons with international benchmarks generally compare favourably
- Obtaining relevant ISO accreditation is a priority for a number of consumers (Although the accreditation does not prescribe water demand management standards in particular, monitoring of processes is necessary)
- Part of large international organisations (Benchmarked against other operations within the organisations and targets are reviewed periodically)
- High operating costs (Water and Energy)
- Quality of abstracted raw water (Deterioration in quality provides incentive to make more efficient use of existing resources – see Steel and Zinc Sector)
- Quality of effluent discharged (National Water Act - DWAF) / Discharge Tax
- Social responsibility – More common amongst larger organisations is desire to assist in ensuring that there is equitable distribution of water services to communities within the supply system that the organisation is based, and to improve the profile of the organisation.
- According to the Industry Mining and Power Strategy (DWAF 2004), the role of the Water Service Authority with respect to water conservation and water demand management includes:
    - Developing an implementation plan for the WC/WDM components of its Water Service Development Plan (WSDP). Including the requirements for those industries falling within its jurisdiction
    - Ensure and monitor the implementation of WC/WDM by Water Service Providers and their bulk water suppliers.
- Most of the metropolitan or district municipalities are implementing large scale water demand management strategies. The City of Tshwane and the Ekurhuleni Metropolitan Municipality are currently targeting industrial areas through meter investigation, repair or replacement and monitoring programs. The aim of these programs includes reducing unaccountered for water,

increasing revenue and improving customer relations. Emphasis is not however placed on promoting water conservation and water demand management amongst the industries themselves.

- Small and medium sized industries obtain the bulk of their water supply from the municipalities as potable water. Although the exact industrial portion of consumption could not be obtained from the municipalities, information received from such organisations suggest that there is significant scope for water conservation and water demand management as current initiatives are limited or non-existent. For example, Benoni South Industrial Area within the Ekurhuleni Metropolitan Municipality, is one of a number of industrial areas within the metro and has approximately 98 consumers who use ±450 Mℓ/a. The top 10 of 98 consumers use ±300 Mℓ/a or 67% of the ±450 Mℓ/a. Implementing water conservation and demand management amongst the top ten to twenty percent of the industrial consumers is therefore recommended. The cumulative effect of implementing these measures for small to medium sized industries is likely to have a significant impact on the respective municipal demands, as well as helping to meet the requirements of the Water Services Act. A review of municipal pricing structures for industrial consumers should also be considered to ensure that increases are kept in line with inflation for adequate revenue recovery for the water service providers.

### 4.8.2 Mining

The major motivational factors for water demand management and water conservation prevalent in the mining sector include:

- Quality of effluent discharged (National Water Act - DWAF) - Particularly relevant for larger operations
- International Standards – These include the ISO (14 001) as well as other self regulatory standards imposed by organisations who operate internationally
- Part of large international organisation – Annual SHE targets set (Benchmarked against other operations within the group)
- Security of supply – Limits to existing sources forces organisations to consider re-use from other sectors or recycling (closed circuit/ zero discharge).
- Operating Costs (Water and Energy) – High water and energy costs are drivers toward improved efficiencies.
-

### 4.8.3 Power

- Operating Costs – Due to the significant volumes of water required for power generation, reducing consumption and consequently operating costs is beneficial to the country as well as the consumer. The positive impact with respect to the sustainable use of the resource is also extremely important.
- Target of Zero Effluent Discharge – Implemented as part of the organisation's water policy which includes addressing issues such as improved efficiency and sustainable development
- Current legislation (National Water Act - DWAF)

## 4.9 PREDICTED SAVINGS THROUGH WATER CONSERVATION AND WATER DEMAND MANAGEMENT

**Figure 4.1** provides a breakdown of the water consumption for the integrated Vaal River System for 2005 excluding irrigation. Organisations 1, 2, 5, 7, 13, 14, 15 and 16 are shown separately to illustrate the significance of their demand for the study area. The figure also serves to support the view that failure to implement water conservation and water demand management in this sector (especially amongst the large users) will require the continuous development of new water resources at increasingly higher costs.

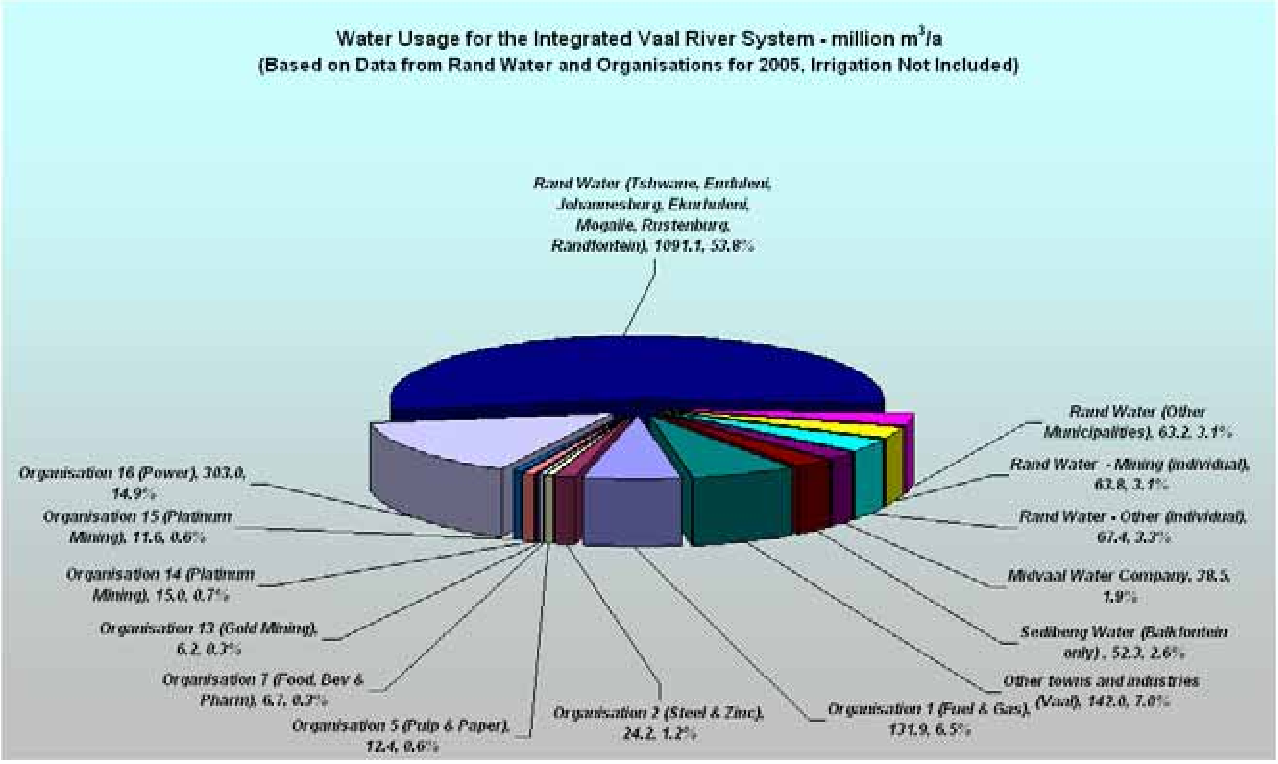



**Figure 4.1: Water Usage for the Integrated Vaal River System for 2005 (Excluding Irrigation)**

**Table 4.1** provides a summary of information from top consumers in the various sectors who provided current water usage and predicated water demand.

This current usage and predicted demand figures have been combined per sector to illustrate the following:

- The impact of the large scale planned water demand management measures for the organisations in the Steel and Zinc Sub Sector and in the Pulp and Paper Sub Sector
- Continued overall growth in the Food, Beverage and Pharmaceutical Sub-Sector (includes Fast Moving Consumer Goods) which is likely to result in a net overall increase in demand
- Restricted growth within the Motor Vehicle Industry Sub Sector is likely to be largely offset by water demand management measures
- Continued growth due to product demand in the Platinum Mining Sub Sector resulting in a predicted increase in demand for water (The increase in demand is moderated by various water conservation and demand management measures discussed earlier).

Factors such as population growth; provision of services and a positive economic climate are considered when setting targets for the Power Sector

### Table 4.1: Current and Predicted Demand and Specific Consumption versus Benchmark

| Current and Predicted Demand and Specific Consumption Versus Benchmark (Where Available) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Sector | Sub-Sector | Consumption | | | | Product | Benchmark | |
| | | | Current Daily Demand (Ml) | Predicted Change in Demand (%) | Predicted Change in Demand (ML) | Duration | | Specific Consumption | Benckmark |
| 1.1 | Industry | Fuel & Gas | 77.52 | 2.0 | 1.55 | Per annum | Chemicals | 0.87 (1000)m$^3$/ kt | |
| 1.2 | | | 257.87 | 1.0 | 2.58 | Per annum | Energy | 7.9 (1000)m$^3$/ kt | 10 |
| 1.3 | | | 26.04 | | | | Mining | 2.1 (1000)m$^3$/kt | |
| *Total (Fuel & Gas))* | | | *361.43* | *1.1* | *4.13* | *Per annum* | | | |
| 2.1 | Industry | Steel & Zinc | 66.32 | -43.7 | -29.00 | 2005 - 2006 | Steel Products | 6.3m3/t | <5 |
| 2.2 | | Steel & Zinc | 1.50 | 3.6 | 0.05 | Per annum | Steel Products | 1.5m$^3$/t | <5 |
| | | | 67.82 | | -28.95 | | | | |
| 3 | Industry | Steel & Zinc | 3.10 | 0.0 | | | Steel Products | 2.36m$^3$/t | <5 |
| 4 | Industry | Steel & Zinc | 4.13 | -20.4 | -0.84 | ±2 years | Zinc | 9.87 (1000)m$^3$/t | |
| | | | | | | | Sulphuric Acid | 8.91 (1000)m$^3$/t | |
| *Total (Steel & Zinc)* | | | *75.05* | *-39.1* | *-29.37* | *Per annum* | | | |
| 5 | Industry | Pulp & Paper | 33.88 | -70.0 | -23.72 | by 2009 | Pulp | 0.03 Ml/t | 0.03 - 0.135* (0.05-0.075) |
| | | | | | | | Paper | 0.046 Ml/t | 0.025 - 0.66* |
| 6 | Industry | Pulp & Paper | 4.95 | 5.0 | 0.25 | Per annum | Tissue/ Diapers | 33.5kl/t | 30kl/t* |
| *Total (Pulp & Paper)* | | | *38.83* | *-59.2* | *-22.97* | *by 2009* | | | |
| 7 | Industry | Food, Beverage & Pharmaceutical | 18.28 | 12.7 | 2.33 | *by 2010 (4 yrs)* | Brewing | 2.36 - 2.55 l/l product | <2.2* |
| 8 | Industry | Food, Beverage & Pharmaceutical | 5.73 | 7.4 | 0.42 | Per annum | Beverages | 2.4 l/l product | <3* |
| 9 | Industry | Food, Beverage & Pharmaceutical | 2.00 | 100.0 | 2.00 | 1 year (increase in capacity) | Food | - | |
| 10 | Industry | Food, Beverage & Pharmaceutical | 1.08 | 0.0 | 0.00 | Per annum | Food | - | |
| *Total (Food, Bev & Pharm)* | | | *27.10* | *22.2* | *6.02* | *by 2010 (4 yrs)* | | | |
| 11 | Industry | Motor Vehicle | 1.30 | -5.0 | -0.07 | 1 year (2006) | Motor Vehicle | - | |
| 12 | Industry | Motor Vehicle | 1.64 | 2.0 | 0.03 | Per annum | Motor Vehicle | - | |
| *Total (Motor Vehicle)* | | | *2.94* | *-1.1* | *-0.03* | *1 year (2006)* | | | |
| 13 | Mining | Gold | 16.90 | 0.0 | 0.00 | Per annum | Gold | - | |
| 14 | Mining | Platinum | 41.00 | 2.0 | 0.82 | Per annum | Platinum | - | |
| 15 | Mining | Platinum | 31.80 | 2.0 | 0.64 | Per annum | Platinum | 0.43m$^3$/t | 0.48m3/t* |
| | | | | | | | | 19.34m$^3$/t | 17.8m3/t* |
| *Total (Mining)*** | | | *89.70* | *1.6* | *1.46* | | | | |
| 16 | Power | | 830.00 | 3.1 | 25.73 | 2006 - 2007 | Power | 1.5 l/USO (kwh) | <10 |
| *Total (Power)* | | | *830.00* | *3.1* | *25.73* | | | | |
| *Benchmark figures provided by the organisation | | | | | | | | | |
| ** Non-potable water consumption not included | | | | | | | | | |

Medium to long term predicted demand should be viewed with caution due to the complexity of factors that influence levels of growth in the industry, mining and power generation sectors. These factors include:

- **International markets** - Demand for products, especially those being exported such as minerals, motor vehicles and steel are influenced by various factors including the status of international markets and commodity prices. Trends in international prices cannot be predicted with certainty.

- **Local Markets** - Due to the nature of markets, the status of the various sectors of the country's economy will continue to fluctuate. A significant down turn in certain sectors is likely to have an impact on production and therefore water usage. Free markets are also more vulnerable to international competition (A flood of cheaper imported products has had a negative impact on the clothing industry).
- **Currency Fluctuations** - Strategic decisions regarding expansion of industries and mines are largely effected by the strength of the Rand against other currencies. The volatility of an emerging market and the subsequent currency fluctuations can result in significant changes in production plans over a fairly short time.
- **Technology Breakthroughs** - Particularly in industries where a large amount of money is often spent on the development of new technologies. As an example, a breakthrough in the pulp and paper industry or power sector in developing new highly water efficiency processes or improved performance in recycling could have a significant impact on water consumption.

## 4.10 POTENTIAL FOR WATER CONSERVATION AND WATER DEMAND MANAGEMENT

### 4.10.1 Industry

Potential measures for water demand management and water conservation for the industrial sector include:

- Most large companies are implementing Sustainability / Environmental Policies regarding water. Small to medium sized companies need to be encouraged to follow suit. More emphasis should be placed on water conservation and water demand management and not just energy.
- Water Audit/ Water balance – Although prevalent amongst most large consumers, many medium sized and smaller consumers do not have adequate systems in place. There is subsequently significant potential through improved monitoring and control of water used for various industrial processes. Monitoring of processes and equipment ensures that they are operating within optimum water usage limits.
- Organisations targeted by the study stated that retrofitting/ replacement of existing dated equipment with more efficient equipment would result in a reduction in consumption. Further investigation is required to explore ways of encouraging such practices.
- "Specific Water Consumption" per product is not monitored in all industrial sectors. Industries should be encouraged to do so as part of water audits. Comparisons with international

benchmarks are often not considered applicable as type of product and process may vary. The benefits of establishing benchmarks where existing ones do not apply should be promoted.

- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage. Limited uptake of water efficient devices for domestic usage was found.
- Recycling of effluent through treatment. Discharge of waste-water with little or no recycling was found to be common practice amongst some industrial consumers. Industries also identified efficiency of the recycling plants as an area where improvements could be made.
- Retrofit or eliminate once through cooling systems. Options include: re-circulation of cooling water, air cooled systems, discharge to other applications.
- Proper operation and maintenance of hot water and steam systems. Options include: Active leak detection and maintenance, returning steam condensate to boiler, discharge blow down through expansion tanks, insulation of steam systems (condensate, hot water pipes and storage tanks), utilising efficient heat exchanger designs and operate according to specifications.

Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the industrial sector. Water wastage due to failure to monitor process use or to suspend supply when processes are halted is common. Improved access to information regarding water conservation and water demand management pertinent to this sector would also have a positive impact.

Major drivers moving forward are legislation and the cost of water. The most common reason for organisations not implementing water demand measures is financial. Most organisations will only consider capital projects with a return on investment period of less than two years.

A major concern amongst large consumers is growth in demand due to deterioration in water quality. The issue of water quality should be considered by the sector as an integral part of their water demand management strategies, especially larger organisations with high discharge volumes.

Although it is generally accepted that charging for waste discharge is likely to have a greater impact on improving water efficiency than the pricing of abstracted water, the price of both potable water and abstracted water in South Africa is comparatively cheap by international standards. Compared to energy costs, water costs for industrial consumers are significantly less and therefore efficient water use seems to be a low priority. The sector needs to be made aware that the current status quo is not sustainable and could result in substantial increases in water prices should demand continue to increase at the current rate.

### 4.10.2 Mining

Potential measures for water demand management and water conservation for the mining sector include:

- Current legislation (National Water Act - DWAF) is likely to have an ongoing impact on use within the mining sector.
- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage (including retrofitting of water saving devices) as on average, 20 – 25% of potable water consumption is for domestic use.
- Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the mining sector.
- Operating Costs (Water and Energy). Future increases in the cost of water are likely to encourage continued innovation in the field of efficient water usage.
- Non-potable use including partially treated effluent. Additional scope exists for suitably situated mines to make use of partially treated effluent from municipalities for process water.
- Improved efficiency of Effluent Treatment Plants (Reverse Osmosis).
- New technology/ retrofitting. New mining techniques that are specifically suited to water scarce regions are being developed internationally. Upgrading of older workings and equipment with new water efficient equipment will result in a reduction in water consumption.
- Co-operation with other local users (Current legislation/ By-laws may be an obstacle). Mines are investigating the viability of recycling of process and decant water (cross sectoral trading) through treatment for supply to other mines/ industrial users as well as municipalities. The use of dual reticulation systems in municipal areas has been implemented on a limited scale to date and may provide further opportunities.
- Washington State in the U.S.A. provides state funded specialist expertise on the reduction of Water Use and Wastewater with no authority to enforce regulations. This system could be adopted to assist both the mining and industrial sectors in establishing and implementing water conservation and water demand management strategies. A similar approach could be taken as

Eskom's at a water service authority level to promote a demand side management program for water use.

#### 4.10.3 Power

Potential measures for water demand management and water conservation for the power sector include:

- Significant improvements in efficiency achieved 1980 – 2001 through implementation of Dry Cooling.
- Future improvements in efficiency dependant on technology breakthrough.
- Demand Side Management (DSM) Program implemented in 1994 has continued potential (Currently working with the Department of Energy and Minerals).
- Within the Power sector there is therefore currently limited scope for water conservation and water demand management based on current technology. Scope does exist within the mining sector as the mines that formed part of this study were at various stages in implementing water demand management of sustainability strategies. Significant scope exists within the industrial sector, especially the medium and smaller industries where limited effort is current being made to use water efficiently.
- Continued application of the Department of Water Affairs Strategy should be encouraged with emphasis on the various responsible stakeholders including the water authorities, bulk suppliers and the water users to carry out the measures recommended. Continued interaction between the role-players is crucial in ensuring the successful implementation of the strategy. Resource limitations at various levels amongst stakeholders could be contributing to the slow uptake of the strategy. Comments on progress amongst the organisations targeted by the study with respects to the strategic outputs identified in the strategy by the Department of Water Affairs are as follows:
- Water audit and water balances are often not carried out, are only occasionally carried out or can only be partly undertaken as adequate monitoring and control measures are not in place
- Many organisations are unaware of benchmarks pertaining to their sub-sector while others maintain that the existing benchmarks cannot be used due to variances in processes particular to their organisation or local conditions. Consideration should therefore be given to establishing local benchmarks.

- Water Conservation programs are being implemented primarily by larger organisation and larger water users. There appears to be limited uptake amongst the many medium to small industries in particular.
- Marketing and publicising of water conservation for the sector especially amongst water service providers is limited. Promotion of demand-side management for water within the sectors is also limited. There appears to be a lack of awareness on how to gain access to the necessary information on water conservation.

# 5 IRRIGATION SECTOR

## 5.1 INTRODUCTION

PD Naidoo & Associates were members of the team involved in the Water Conservation and Demand Management Study for the Upper and Middle Vaal Catchment, undertaken as part of the Integrated Water Supply Reconciliation Strategies Study for the Vaal. PDNA were tasked with undertaking certain aspects of the WC/WDM components of the Irrigation Sector for the Upper and Middle Vaal. Some of the remaining aspects under the Irrigation Sector have been undertaken by the lead consultant WRP.

Although the WC/WDM component is aimed at the Upper and Middle Vaal, it was considered important to include the Vaalharts Government Water Scheme in the Lower Vaal, receiving water from Bloemhof Dam as being the single largest irrigation scheme in the Vaal catchment.

This report provides an analysis of the situation of irrigation practice in selected irrigation schemes in the Vaal catchment. The report highlights the potential for water conservation and demand management in irrigation sector. Issues such as the discrepancy of irrigation area and allocation from various sources and unlawful water use will be assessed by the lead consultant WRP.

## 5.2 NATIONAL WATER RESOURCE STRATEGY (NWRS)

Irrigated agriculture accounts for about 62 per cent of water use in South Africa. Although there are areas where water use is highly efficient, there are significant losses in many distribution and irrigation systems. Efficiency gains in the sector will make water available for the Reserve and for other uses.

The NWRS provides a framework of regulatory support and incentives designed to improve irrigation efficiency. It promotes the equitable and efficient use of water in the sector in order to increase productivity and contribute to reducing income inequalities among people supported by farming activities. The framework of action defined by the strategy is briefly described in the following outputs:

**Strategy outputs**

- Appropriate measures are implemented that bring about a reduction in water wastage.

- Water user associations and end users understand and appreciate the need to progressively modernise their water conveyance systems and irrigation equipment.
- Water allocation processes to promote the equitable and optimal utilisation of water.
- Preventive maintenance programmes are in place.
- Sufficient irrigation information is generated and is accessible to all stakeholders.
- Water management institutions and service providers implement audits from the water source to end-users and beyond.

To facilitate achievement of the objectives consideration will be given to requiring water users in the agriculture sector who apply for water use licenses to develop and submit to the responsible authority a water management plan in accordance with the *Implementation Guidelines for Water Conservation and Demand Management in Agriculture: Development of Water Management Plans*.

## 5.3 WATER CONSERVATION AND DEMAND MANAGEMENT IN IRRIGATION SECTOR

The definition of Water Conservation is clearly stipulated in the Water Conservation and Demand Management strategy (DWAF, 1999) as “The minimisation of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water.” Similarly, water Demand Management is defined as “The adaptation and implementation of a strategy (policies and initiatives) 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.”

The need for water conservation and demand management arises due to the high capital cost of water resources supply development as well as the limitation of water resources to cope with the rapid increase in water demand. Many countries such as Denmark, Israel, Australia, and others, have benefited from this kind of initiative.

In general, water conservation and demand management initiatives have three major components namely, technical, institutional and socio-economical. The technical aspect comprises the installation of equipment that enhances efficient water utilization and reduces water losses such as pressure control in the domestic sector and changing from less efficient systems, such as flood irrigation to more efficient systems, such as drip irrigation, in the irrigation sector.

Technical interventions, without functional institutional arrangements, are unlikely to bring sustainable improvement in terms of water conservation and demand management. Thus a well-structured and equipped institutional setup, which promotes the smooth transfer of information, accountability and transparency, is crucial in water conservation and demand management. The socio-economic aspect includes, among others, creating awareness, creating sense of ownership, and promoting competition among users to attain best management practice.

Unfortunately, in South Africa, water for irrigation is supplied via a quota system, and farmers pay for their quota irrespective of the amount of water used. This provides little incentive for farmers to be more efficient in their application, particularly since most farmers are not using their full quota. It is important to find ways of introducing incentives that will promote more efficient use of water. One possibility is to link the water tariff with the assurance of supply. This will provide an incentive to farmers to be more efficient in their irrigation.

However, before embarking on proposing or implementing a water conservation and demand management initiative, the following three stages must be fulfilled:

- An audit of current practices
- Calculation of efficiency measures and indices and benchmarking
- Application of efficiency measures and indices to the audit

### 5.3.1 Audit of Current Irrigation Practice

A detailed irrigation sector study for the Vaal River Basin was undertaken by Loxton Venn and Associates in 1999. This report stipulates the irrigation areas, proportion of various irrigation systems, cropping patterns and crop growing seasons. There are some discrepancies between the total crop requirements and values obtained from other sources. This is expected to be refined once the field verification process has been finalized. Obviously, this limitation affects the auditing.

A detailed audit on the current practice in the Vaal Catchment was not been within the scope of this study. Six of the largest schemes in the catchment were selected for detailed analysis representing approximately 55% of irrigated schemes in the catchment and include:

- Schoonspruit
- Erfenis
- Allemanskraal

- Mooi
- Klerksdorp
- Vaalharts

The auditing is based mainly on information extracted from the Loxton Venn and Associates report as well as information gathered from specialists who have experience in the area.

**Schoonspruit Irrigation Scheme**

This irrigation scheme starts at the Ventersdorp Eye and extends to downstream of Rietspruit Dam. The water balance report for the scheme, obtained from DWAF, indicated the total irrigated area to be 2 432 ha.

There are three water distribution points in this scheme. The first is the diversion weir at the Ventersdorp Eye. This weir diverts water to Ventersdorp Municipality for domestic and industrial use as well as for irrigation around the town. The irrigation area at this section is 506 ha.

The next water diversion point is at Elandskuil Dam. The dam supplies water for 647 ha of irrigated land via a canal system.

The remaining portion receives water from Rietspruit Dam. There are left and right bank canals, which supply water to the irrigators. The total irrigation area in this section is 1 280 ha.

**Table 5.1** shows the annual water balance at each of the distribution points in the scheme.

**Table 5.1: Summary of water balance of Schoonspruit irrigation scheme**

| Year | Enlisted Irrigation Area (ha) | Total Inflow to scheme ($10^3m^3/a$) | Full Quota ($10^3m^3/a$) | Agricultural Use ($10^3m^3/a$) | Livestock use ($10^3m^3/a$) | Industrial use ($10^3m^3/a$) | Municipal Use ($10^3m^3/a$) | Gov. Water Use ($10^3m^3/a$) | Free water ($10^3m^3/a$) | Delivery to other canal ($10^3m^3/a$) | Total Usage ($10^3m^3/a$) | Total Loss ($10^3m^3/a$) | % of Loss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distribution Point/ Canal Name: Schoonspruit Eye | | | | | | | | | | | | | |
| 2001/2002 | 506.7 | 27230 | 3901 | 2212 | 29 | 0 | 1400 | | | 16827 | 19470 | 7760 | 28.5% |
| 2001/2003 | 506.7 | 28777 | 3901 | 2165 | 29 | 0 | 1566 | 0 | 0 | 16815 | 20576 | 8201 | 28.5% |
| 2001/2004 | 506.7 | 30042 | 3901 | 2133 | 28 | 0 | 1585 | 0 | 0 | 17732 | 21480 | 8562 | 28.5% |
| 2004/2005 | 506.7 | 34603 | 3901 | 3224 | 29 | 0 | 1561 | 0 | 0 | 19925 | 24741 | 9862 | 28.5% |
| *Distribution Point/ Canal Name: Elandskuil* | | | | | | | | | | | | | |
| 2001/2002 | | | | | | | | | | | | | |
| 2002/2003 | 648.0 | 4550.0 | 4989.6 | 2528.2 | 12.2 | 0.0 | 0.0 | 0.0 | 0.0 | 1736.6 | 4277.0 | 273.0 | 6.0% |
| 2003/2004 | 648.0 | 5306.0 | 4989.6 | 2175.2 | 11.4 | 0.0 | 0.0 | 0.0 | 0.0 | 2081.1 | 4987.6 | 318.4 | 6.0% |
| *2004/2005* | 648.0 | 4688.3 | 4989.6 | 2229.6 | 11.1 | 0.0 | 0.0 | 0.0 | 0.0 | 2166.3 | 4407.0 | 281.3 | 6.0% |
| Distribution Point/ Canal Name: Rietspruit | | | | | | | | | | | | | |
| 2001/2002 | | | | | | | | | | | | | |
| 2002/2003 | 1277.9 | 7347.0 | 9839.8 | 5499.4 | 12.9 | 0.0 | 0.0 | 0.0 | 0.0 | 1158.8 | 6671.1 | 675.9 | 9.2% |
| 2003/2004 | 1277.9 | 7248.6 | 9839.8 | 5256.6 | 11.8 | 0.0 | 0.0 | 0.0 | 0.0 | 1313.3 | 6581.7 | 666.9 | 9.2% |
| 2004/2005 | 1277.9 | 7529.6 | 9839.8 | 5964.5 | 12.6 | 0.0 | 0.0 | 0.0 | 0.0 | 859.7 | 6836.9 | 692.7 | 9.2% |

Based on the crop pattern obtained from Loxton Venn and Associates report, the crop water requirement in the Schoonspruit scheme is estimated to be 4 822 $m^3$/ha/a which approximately 62.6% of the current water quota. The total water allocated for the scheme is approximately 18.73 million $m^3$/a according to the information obtained from the water balance. However, other sources have come up with different values. The average agricultural usage in the scheme from 2001/2002 to 2004/2005 hydrological year is 9.67 million $m^3$/a, which is 51.6% of the total allocation. This implies farmers have not used their full allocation. The total crop water requirement, assuming 100% irrigation efficiency, is 11.73 million $m^3$/a, which is still marginally higher than the actual water use.

**Mooi River Irrigation scheme**

Starting from Klerkskraal dam, this irrigation scheme stretches to the confluence of Mooi and Vaal River. There are six main canals which deliver water to the scheme. The first two canals divert the water release from the Klerkskraal Dam to irrigation areas left and right of the Klerkskraal River. The total irrigation area supplied by these two canals is 865 ha. Water released from Boskop dam is also delivered to the farms via the left and right canal. The total irrigation area supplied by Boskop dam is 2 495 ha. The remaining two canals are the Gerhardminneborn and Lakeside canals. The Gerhardminneborn canal diverts water from the Gerhardminneborn eye to supply 278 ha of irrigation land. Similarly, the Lakeside canal delivers water from Lakeside dam to 939 ha of irrigated land along the Mooi River. The water quota in this area is 7 700 $m^3$/ha/a.

Water balance of each of the canals is shown in **Appendix E**. Conveyance losses in the scheme range from a reasonably 5.40% in Gerhardminneborn to as high as 28.5% in the Klerkskraal Right Bank.

The total water allocation, according to the water balance data obtained from DWAF, is 35.25 million $m^3$/a. Of this, an annual average of only 18.525 million $m^3$ has been used between 2001 and 2005. Similar to the Schoonspruit Irrigation Scheme, the total allocation has not been used. The crop water requirement, calculated based on the cropping pattern obtained from the Loxton Venn and Associates report, is estimated to be 6 236 $m^3$/ha/a, which is 81% of the water quota. In addition to the slight difference in climate, the reason for relatively higher crop requirement in the Mooi River compared to Schoonspruit is attributed to a large area of perennial pasture crops such as Lucerne.

**Klerksdorp**

According to Loxton Venn and Associates report, the total scheduled area for irrigation is 1 239ha of which 730 ha is currently under irrigation. The Schoonspruit Catchment Management Study identified four points of abstraction in the Klerksdorp irrigation scheme. These are:

- Irrigation from the Schoonspruit just upstream of Johan Neser Dam
- Abstractions directly from the dam basin and pipe outlet
- Irrigation directly from the canal from the dam
- Abstraction from the Schoonspruit River below the dam.

The total irrigation area in this study is 1 681.9 ha, which is higher than what has been stipulated in Loxton Venn and Ass.,1999. The water quota is 6 100 $m^3$/ha/a. Based on the crop composition in Loxton Venn and Ass.,1999, the crop water requirement is estimated to be 5 764 $m^3$/ha/a. This value may change depending on the crop type and cropping pattern.

Although there are no available records of flow to the area as well as any indication of conveyance losses. Conveyance losses are expected to be small, as most of the abstraction is taking place by means of pipes and concrete lined canals.

**Allemanskraal (Sand)**

Water from the Allemanskraal Dam is diverted from the Sand River into concrete lined canals. The total length of the canals is 171 km. Water is delivered to 5 172 ha of irrigation land. In the 1999 study Loxton Venn and Associates determined the total crop area to be 8 314 ha, which is about 161% of the total irrigation area. The crop water requirement based on this information is found to be 7 200 $m^3$/ha/a, which is equal to the water quota for the scheme. Total water allocated for this scheme is 37.24 million $m^3$/a. However, the water applied from the hydrological year of 1996/1997 to 1997/1998 is only 19.34 million $m^3$/a. The water supplied is therefore only about 51.9% of the total water allocated to the scheme.

**Erfenis (Vet)**

Water from Erfenis Dam is diverted from the Vet River into a concrete-lined primary canal that distributes irrigation water to 5 245 ha of irrigation area. The canal is reported to be in poor state of repair by Loxton Venn and Ass., 1999.

Similar to Allemanskraal, the crop area in 1999 study reported to be 192% of the total irrigation area. The crop water requirement is found to be 8 431 $m^3$/ha/a while the water quota is 7 200

$m^3$/ha/a. The crop water requirement is much higher than the water quota in this case because of double cropping practice in the scheme. Though the total water allocation is 37.85 million $m^3$/a an average of only 23.45 million $m^3$/a (62%) of water was used in 1996/1997 and 1997/1998 hydrological years.

**Vaalharts**

The Vaalharts irrigation scheme is the largest irrigation scheme in South Africa. Vaalharts Government Water Scheme was established in 1933. There are two main canals namely the North and the West canal, which supply water diverted by Vaalharts weir to irrigators. There is also a canal called Barkley West, which delivers water to irrigation farms around Barkley West. Taung also gets most of its water from the Vaalharts weir through the North canal. The scheduled irrigation area and the water allocation for sub-irrigation areas in the Vaalharts system are shown in **Table 5.2**.

**Table 5.2: Summary of water quota and water allocation in Vaalharts**

| Canal and irrigation area | Total Allocated | | | Currently developed | | |
|---|---|---|---|---|---|---|
| | Area (ha) | Quota ($m^3$/ha/a) | Volume (million $m^3$/a) | Area (ha) | Quota ($m^3$/ha/a) | Volume (million $m^3$/a) |
| Barkley-Wes Canal | 1951.3 | 11855.0 | 23.1 | 1951.3 | 11855.0 | 23.1 |
| West canal | 4344.0 | 9140.0 | 39.7 | 4344.0 | 9140.0 | 39.7 |
| Ganspan settlement | 299.8 | 7700.0 | 2.3 | 150.0 | 7700.0 | 1.2 |
| Small Farms | 123.0 | 11855.0 | 1.5 | 123.0 | 11855.0 | 1.5 |
| **Sub-total West Canal** | **4766.8** | | **43.5** | **4617.0** | | **42.3** |
| Main Canal | 381.0 | 7700.0 | 2.9 | 180.5 | 7700.0 | 1.4 |
| Vaalharts North Block Q & R | 1858.6 | 9140.0 | 17.0 | 1858.6 | 9140.0 | 17.0 |
| Block A to D | 5526.8 | 9140.0 | 50.5 | 5526.8 | 9140.0 | 50.5 |
| Block EFG | 5528.2 | 9140.0 | 50.5 | 5528.2 | 9140.0 | 50.5 |
| Block H | 2110.8 | 9140.0 | 19.3 | 2110.8 | 9140.0 | 19.3 |
| Block I | 2308.5 | 9140.0 | 21.1 | 2308.5 | 9140.0 | 21.1 |
| Block J to N | 7504.5 | 9140.0 | 68.6 | 7504.5 | 9140.0 | 68.6 |
| Vaalharts Small Farms | 176.3 | 11855.0 | 2.1 | 176.3 | 11855.0 | 2.1 |
| **Sub-total Vaalharts North Canal** | **25013.7** | | **229.1** | **25013.7** | | **229.1** |
| **Sub-total Vaalharts North+Main Canal** | **25394.7** | | **232.0** | **25194.2** | | **230.5** |
| Taung | 6424.0 | 8470.0 | 54.4 | 3764.0 | 8470.0 | 31.9 |
| **Total** | **38536.8** | | **353.1** | **35526.5** | | **327.8** |

The crop water requirement calculated for the crop composition determined by Loxton Venn and Assoc. report is 6 653 $m^3$/ha.

The percentage of conveyance losses in each of the sub-areas is shown in **Table 5.3**

**Table 5.3: Percentage of conveyance loss**

| Description | % Loss |
|---|---|
| Barkley-West Canal | 30.6 |
| Vaalharts North | 33 |
| Vaalharts West | 28.8 |
| Taung | 26.9 |

## 5.4 BENCHMARKING EFFICIENCY MEASURES AND INDICES

Four measures of water use efficiency in irrigation sector have been identified in studies made in Australia (Dalton, et al., 2001 and Barraclough and Co., 1999). These are:

**Water Use**

This is expressed as water use per unit of land ($m^3$/ha)

**Engineering Efficiency**

This refers to how much water was input to a given area compared to how much water the plants in that given area actually use. It is expressed as volume of water used / volume of water input.

Engineering efficiency depends on the type of irrigation system, irrigation system design and irrigation system management. It includes conveyance efficiency, application efficiency, distribution uniformity as well as leaching requirement where there is a salinity problem. Application efficiencies of different irrigation systems are shown in **Table 5.4**.

The values in **Table 5.4** indicate the percentage of water delivered at a farm and hence available for the actual plant use. This excludes the amount of water lost due to evaporation and deep percolation without being used by a plant.

**Table 5.4: Irrigation system efficiency values obtained from different sources**

| Irrigation System | Irrigation Application Efficiency (%) | | | |
|---|---|---|---|---|
| | Water Balance Model | Irrigation Manual | Roger et al. ** | Solomon (1993) ** |
| *Surface Irrigation* | | | | |
| Basin | 65 | | 60-95 | 80-90 |
| Border | | | 60-90 | 70-85 |
| Furrow | | | 60-90 | 60-75 |
| Surge | | | | |
| *Sprinkler Irrigation* | | | | |
| Hand move | 75 | 80 | 65-80 | 65-75 |
| Traveling Gun | | | 60-70 | 60-70 |
| Center Pivot and Linear | 80 | 85 | 70-95 | 75-90 |
| Solid Set | | | 70-85 | 70-80 |
| *Micro Irrigation* | | | | |
| Point sources emitter | 85 | 85 | 75-95 | 75-90 |
| Line sources emitter | 90 | 95 | 70-95 | 70-85 |

** See REFERENCES

Another engineering irrigation efficiency factor that must be considered in irrigation systems is uniformity distribution. Uniformity distribution refers to the distribution of water in the field. Uniformity distribution of pressurized irrigation systems, such as sprinkler and drip irrigation, depends on the pressure in the system. Wind is another factor, which determines uniformity distribution in sprinkler systems. In surface irrigation, the precision of levelling determines irrigation uniformity. The effects of uniformity distribution on yield have been thoroughly assessed in the USA. The capital cost of improving uniformity distribution of a given irrigation system, in most cases, may appear high, however this can be offset as the yield increases and the operating cost decreases. This is illustrated as shown on **Figure 5.1**.

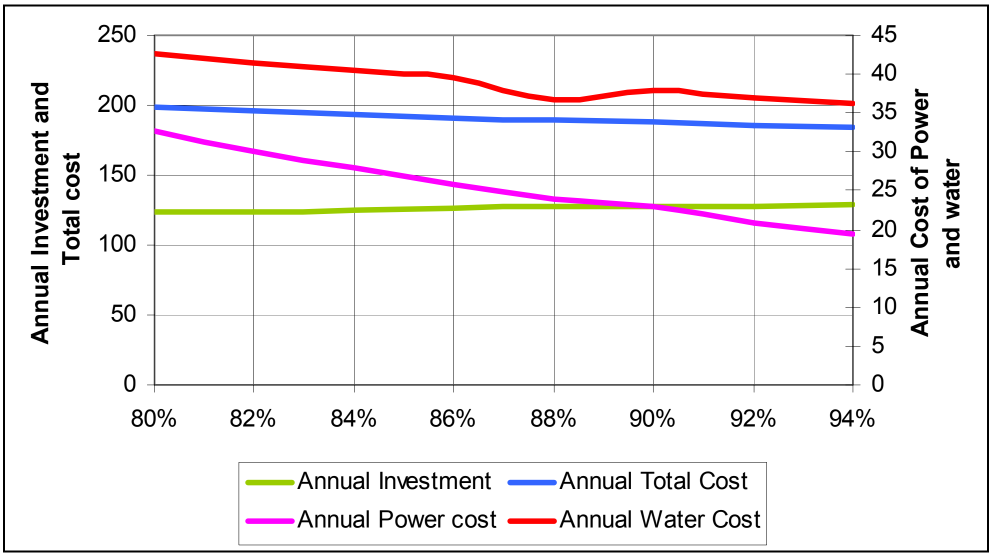



**Figure 5.1: Capital and operational cost of improved distribution uniformity**

**Agronomic Water Use Index**

This index represents the amount of production achieved by inputting a given amount of water. It is expressed as crop yield / volume of water. The values for Vaalharts obtained from Mr. Peter van Heerden who practiced as a consultant in agronomy and irrigation in the area for long years. The values are 15 years old but can give some indication in respect to the international values.

**Table 5.5: Comparison of water utilization efficiency of Vaalhart to the FAO**

| Crop | Maximum yield (tons/ha) | | Water utilization Efficiency (kg/m$^3$) | |
|---|---|---|---|---|
| | Vaalharts | FAO | Vaalharts | FAO |
| Citrus | NA | 25-40 | | 2-4 |
| Cotton | 3.5 | 3-4.5 | 0.33 | 0.4-0.6 |
| Dry Beans | 3 | 1.5-2.5 | 0.3-0.6 | 0.3-0.6 |
| Grapes | 20 | 15-30 | 2.19 | 2-4 |
| Green Beans | 4.5 | 6-8 | 1.9 | 1.5-2.0 |
| Groundnuts | 2 | 3.5-4.5 | 0.27 | 0.6-0.8 |
| Lucerne | 18 | 15-25 | 1.3 | |
| Maize | 5 | 7-9 | 0.78 | 0.8-1.6 |
| Potatoes | 25 | 25-35 | 3.36 | 4-7 |
| Soybeans | 3 | 1.5-2.5 | 0.6 | 0.4-0.7 |
| Wheat | 5 | 4-6 | 0.8 | 0.8-1.0 |

**Economic Water Use Index**

The economic water use index indicates the economic gain by inputting a given amount of water. Greengrowth Strategies CC, (2003) estimated the net irrigation income in Vaalharts to be R1 138/ha. Should the crop composition have included more high value crops the net income would have increased significantly. Greengrowth Strategies CC. (2003) also generated a demand curve for irrigation water use based on this net income. They estimated the average price of a unit cubic meter of water to be 14.48 cents. Though they made many assumptions to arrive at this value, their approach gives an indication of how farmers could respond to an increase in water price.

## 5.5 OPPORTUNITY FOR WATER SAVING IN ACCORDANCE TO INTERNATIONAL BEST PRACTICE

### 5.5.1 Approaches of water conservation and demand management

There have been various approaches to water conservation and demand management. Rothert (2000) identified the following, which could be applicable in Southern Africa,

- Optimum irrigation quantity
- Switching from low to high value crops
- Proper (non-subsidized) water pricing
- Metering of usage
- Micro/drip irrigation
- Reducing canal losses
- On-farm regulating reservoirs
- Surface mulching
- Field leveling
- Tail water recovery systems
- On-farm programme incentives

The above-mentioned practices can be grouped into three major water conservation and demand management initiatives, namely, technical, institutional and socioeconomic.

Technical Water conservation and demand management initiatives

- Improving conveyance efficiency

- Improving irrigation efficiency

Institutional Water conservation and demand management initiatives

- Establishing water use regulatory institutions
- Establishing by-laws to promote water use efficiency
- Establishing a metering system
- Establishing a dynamic database to evaluate water use efficiency in terms of yield

Socio-economic water conservation and demand management initiatives

- Creating awareness
- Provide incentives
- Implement water pricing
- Create competition among farmers to achieve best management practice.

### 5.5.2 Evaluation of Best Management practice to achieve water conservation and demand management objectives: International practice

Despite many options for WC/WDM proposed in the past, there are very few reports which clearly quantify the benefit, both in terms of water saving as well as the economics. This is because of the variability of suitability or applicability of a practice in different areas. However, a report compiled in Australia on the "Audit of water and irrigation water use efficiency" focuses on a holistic approach of WC/WDM. The report is the outcome of an intensive survey in Queensland horticulture. The procedure used in the report to identify the best practice can be a best model to assess efficiency and productivity of an irrigation system. Best irrigation practice, by definition, is an irrigation practice, which can yield optimum product with the least amount of water. Thus as shown in **Figure 5.2**, the study first identified growers within one standard deviation (-1) of average water use (u). Within this data set growers with above average production are selected as the best practice.

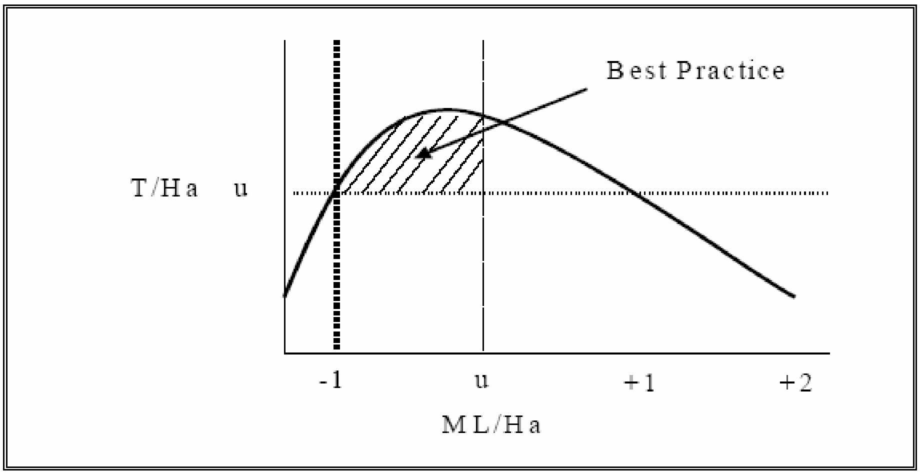



**Figure 5.2: Determining best irrigation practice**

Based on the above graph, pathways of improving irrigation practice have been identified. These are illustrated in **Figure 5.3** to **Figure 5.7**

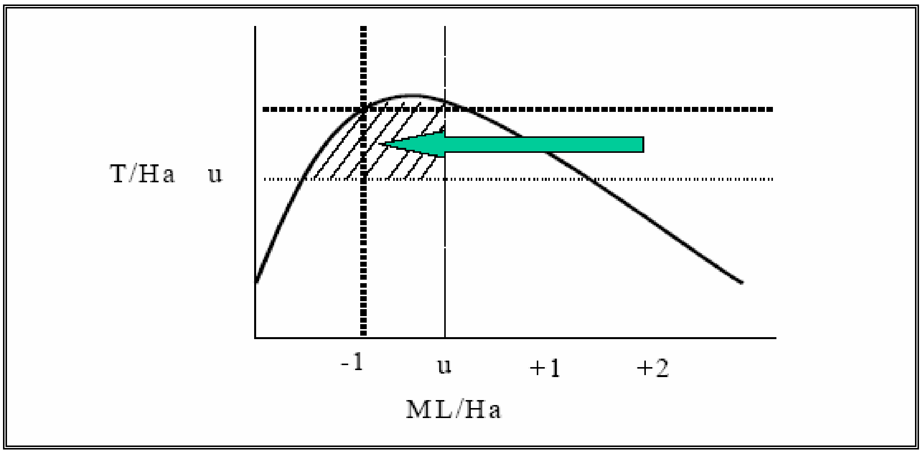



**Figure 5.3: Decrease water use toward best practice**

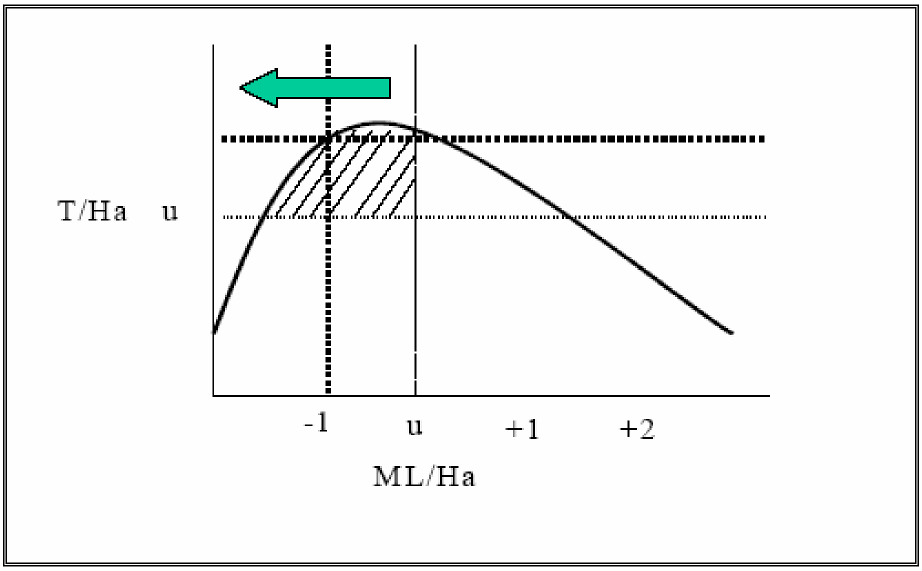



**Figure 5.4: Improve water use practice over time**

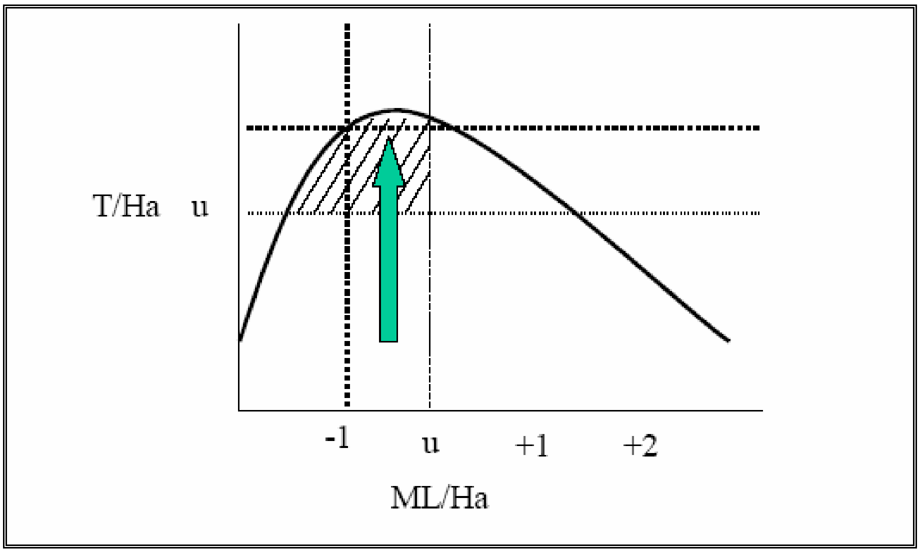



**Figure 5.5: Increase yield toward best practice**

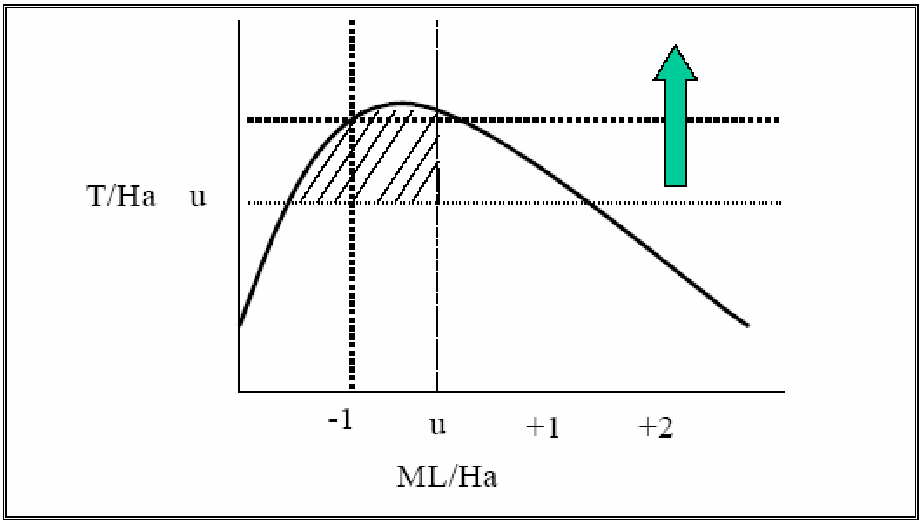



**Figure 5.6: Improve best practice yield over time**

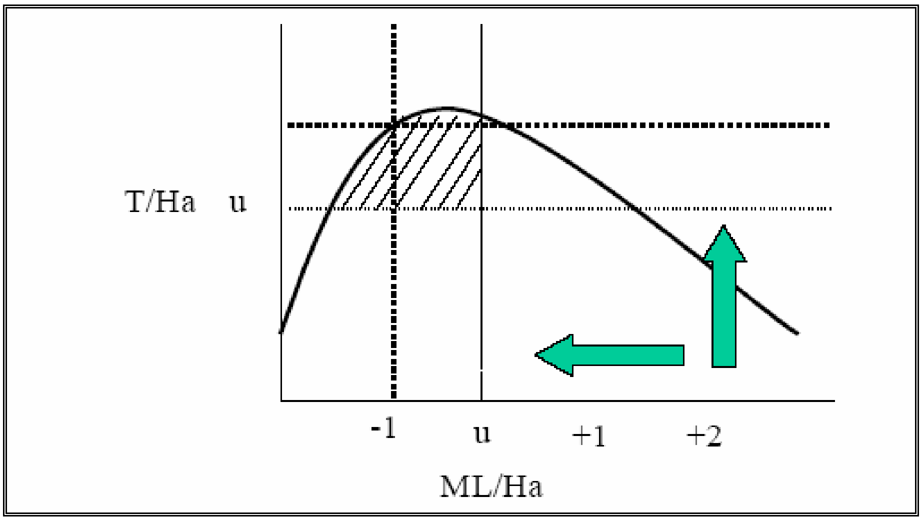



**Figure 5.7: Improve lower quartile performance**

Because it includes both rate of applied water and yield per hectare, the method can be used to gauge the efficiency of irrigation as well as its productivity. Another advantage of this method is that it can be used to encourage farmers to save water. However, the technique requires detailed information on the amount of water applied and yield for each type of crop. Without this valuable information, its applicability is limited.

## 5.6 POTENTIAL FOR WATER CONSERVATION AND DEMAND MANAGEMENT IN THE VAAL CATCHMENT

Due to limited available information the approach of evaluating the efficiency of irrigation schemes discussed above cannot be implemented as part of this study. It is quite difficult to obtain realistic information without undertaking extensive field survey in each of the selected irrigation schemes, as the yield of various crops vary depending on the production input used by farmers as well as from year to year.

As the result of the above limitation, the water saving potential, subsequent to improving irrigation management, cannot be comprehensively included in this report.

### 5.6.1 Reducing conveyance losses

The conveyance loss in the Schoonspruit scheme ranges from 6% for Elandskuil to 28.5% for the Ventersdorp Eye. Most literature indicates that an 80% conveyance efficiency (that is 20% loss through conveyance) is justifiable, considering associated capital and maintenance costs required. This implies that the loss for the Ventersdorp Eye should be reduced. Thus, if only a 20% conveyance loss is targeted there is a potential saving of 2.4 million $m^3$/a. Almost 90% of the conveyance loss for the Eye is attributed to operational loss, that is loss during operating of the sluice gate or leakage through the sluice gate at the weir.

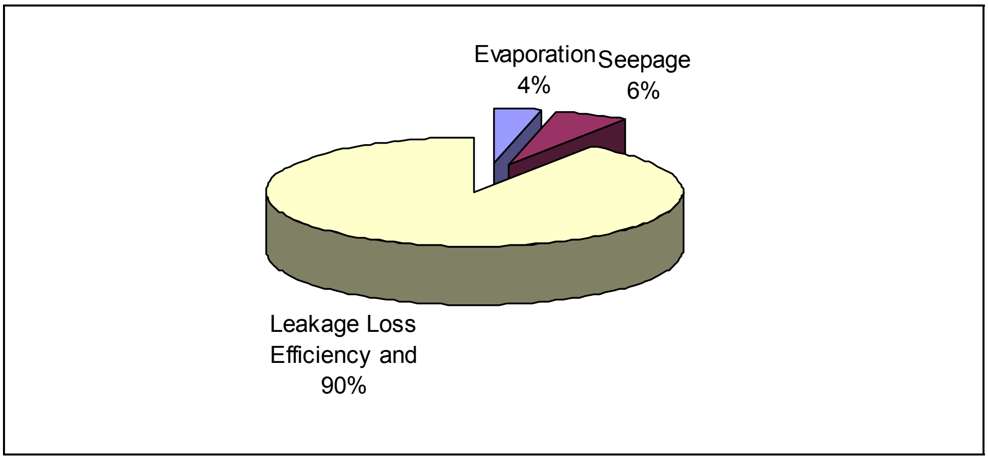



**Figure 5.8: Distribution of total losses in Ventersdorp Eye diversion canal**

In the Mooi River irrigation scheme the conveyance efficiency loss is above 20% in all sub areas except Grehardminneborn and Lakeside, which are only 5.4% and 16.7% respectively. The average conveyance loss in the scheme excluding Grehardminneborn and Lakeside is calculated to be 24.7%. Based on the three year water balance data obtained from DWAF, if the conveyance loss is reduced by 4.7%, a total of 6.1 million $m^3/a$ can be saved. As shown in **Table 5.6** the biggest proportion of loss in the Mooi River scheme is attributed to operational loss.

**Table 5.6: Summary of loss and distribution of losses**

| Description | % Losses | % Distribution of Loss | | | |
|---|---|---|---|---|---|
| | | Canal Terminal | Evaporation | Seepage | Efficiency and Leakage Losses |
| Boskop Right Bank | 22.30 | 0.00 | 6.55 | 3.66 | 89.78 |
| Boskop Left Bank | 21.82 | 0.00 | 5.57 | 5.02 | 89.41 |
| Klerkskraal Right bank | 28.50 | 0.00 | 10.19 | 25.13 | 64.68 |
| Klerkskraal Left bank | 26.20 | 0.00 | 22.49 | 28.26 | 49.25 |
| Lakeside | 16.70 | 0.00 | 17.29 | 10.69 | 72.02 |
| Grehardminneborn | 5.40 | 0.00 | 9.83 | 13.66 | 76.51 |

For Allemanskraal and Erfenis no water balance data was obtainable. However, the information obtained from DWAF indicated the percentage of loss for the whole Sand-Vet government water scheme for 2003 was 24%. This indicated that there is a potential of 4% saving.

Similarly there was no information found for Klerksdorp in terms of water distribution in the scheme.

The conveyance loss in Vaalharts is estimated to be about 32%. The distribution of the scheme losses is shown in **Table 5.7**. Unlike the Schoonspruit and the Mooi River schemes the major portion of the losses in Vaalharts are seepage and evaporation losses. The proportion of loss due to evaporation and seepage add up to more than 65% of the total loss. It might be hard to reduce the losses to 20% in one phase. However, if a 7% loss reduction is targeted, then 29.9 million $m^3/a$ of water can be saved.

**Table 5.7: Vaalharts water balance**

| Description | Volume (million $m^3$/a) | % of total water diverted | % Distribution of losses |
|---|---|---|---|
| Observed Releases | 428 | 100 | |
| Actual & Applications | 291 | 67 | |
| Total Network Distribution Losses | 137 | 32 | 100 |
| Tail Water Irrigation Canals | 17 | 3 | 12 |
| Canal Evaporation Losses | 45 | 10 | 32 |
| Canal Seepage Losses | 45 | 10 | 32 |
| Canal operating & leakage | 31 | 7 | 22 |

The potential of water saving by limiting the conveyance loss to 20% is summarised in **Table 5.8**.

**Table 5.8: Summary of water saving potential**

| Scheme | Current Loss (%) | Targeted Loss (%) | Difference | Water Saving Potential (million $m^3$/a) |
|---|---|---|---|---|
| Schoonspruit | 28.5 | 20 | 8.5 | 2.57 |
| Klerksdorp* | | | | |
| Mooi River | 24.7 | 20 | 4.7 | 6.1 |
| Allemanskraal | | | | |
| Erfenis | 24 | 20 | 4 | 1.87 |
| Vaalharts | 32 | 25 | 7 | 29.96 |
| **Total** | | | | **40.5** |

* No available information

### 5.6.2 Improving Irrigation efficiency

The distribution of different irrigation systems in the six schemes is summarized below in

Table 5.9 as obtained from Loxton Venn and Ass., 1999. The table includes theoretical efficiency values for each of irrigation system as used in Water Balance Model.

**Table 5.9: Percentage of Irrigation systems in the selected five schemes**

| Type of Irrigation System | Irrigation Efficiency | % of Irrigation systems in Irrigation schemes | | | | | |
|---|---|---|---|---|---|---|---|
| | | Schoonspruit | Erfenis | Allemanskraal | Vaalharts* | Klerksdorp | Mooi |
| Flood | 65.0% | 60.0% | 3.0% | 8.0% | 70.0% | 25.0% | 60.0% |
| Mechanical | 80.0% | 15.0% | 93.0% | 73.0% | 10.0% | 0.0% | 15.0% |
| Sprinkler | 75.0% | 25.0% | 4.0% | 18.0% | 15.0% | 75.0% | 25.0% |
| Micro | 85.0% | 0.0% | 0.0% | 1.0% | 3.0% | 0.0% | 0.0% |
| Drip | 90.0% | 0.0% | 0.0% | 0.0% | 2.0% | 0.0% | 0.0% |
| Scheme Efficiency | | 0.70 | 0.79 | 0.78 | 0.69 | 0.73 | 0.70 |

* Information obtained from regional office. The rest retrieved from the Loxton Venn Report

**Table 5.10** compares total water allocation obtained from various sources, actual agricultural water usage and crop water requirement, estimated based on the cropping pattern obtained from Loxton Venn and Ass.,1999. This table clearly indicates the discrepancy of various data sources. Thus, it is difficult to assess the irrigation efficiency with a reasonable confidence level. A reasonable factor for comparison, in this case, could be a comparison of the water quota and the crop water requirement, as the total allocation has to be verified. However, this comparison by itself cannot give an indication of potential for water conservation and demand management in a scheme for the following reasons:

- The crop pattern or crop composition in a scheme may vary from one year to another
- Total crop area may vary from time to time
- Crop water requirement has been estimated using a SAPWAT model considering optimum condition and production. However, in reality, farmers tend to marginalize low value crops when water is scarce.
- SAPWAT model is a historical model which is used to estimate crop water requirement for irrigation system design purpose. It cannot be used as a reasonable means of evaluating efficiency of a scheme.

**Table 5.11** compares crop water requirement and water quota. The calculated crop water requirement is found to be higher than the water quota in Erfenis. In Allemanskraal the crop water requirement is 100% of the quota. Other than in these two schemes, the crop water requirement is found to be less than the quota. The reason for very high crop water requirement in Erfenis and

Allemanskraal is attributed to intensive farming practice in those areas. The percentage of cropped land use in the two schemes is 192% and 162% of the total irrigated area respectively, due to double cropping practices.

**Table 5.10: Comparison of water allocation from different sources, actual irrigation use and crop water requirement**

| Irrigation Scheme | Total Irrigation Area | | | Water Quota | | | | Actual Irrigation Water Use[1] (million $m^3/a$) | Calculated Crop water Requirement In this study** (million $m^3/a$) | Vaal Reconciliation Study (million $m^3/a$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Loxton Venn study (ha) | DWAF (Water Balance Data) (ha) | Other Sources (ha) | VRSAU Study WRYM Nett Water Use (million $m^3/a$) | Loxton Venn Study WRPM Theoretical Crop water use (million $m^3/a$) | WARMS data (million $m^3/a$) | DWAF Water Balance (million $m^3/a$) | | | |
| Schoonspruit | 1703 | 2432 | 2434 | 12.77 | 9.04 | 31.16 | 18.73 | 10.57 | 8.21 | |
| Klerksdorp | 730 | | 1682 | 13.80 | 4.81 | | | | 4.20 | |
| Mooi River | 4760 | 4578 | 4580 | 77.61 | 36.81 | 24.39 | 35.25 | 19.90 | 29.68 | 35.27 |
| Allemanskral | 5172 | | 5137 | 36.52 | 39.67 | 44.52 | 19.34 | 19.34 | 37.24 | 36.99 |
| Erefins | 5245 | | 5489 | 43.81 | 46.40 | 69.71 | 23.45 | 23.45 | 43.22 | 39.28 |
| Vaalhart Weir | | | | | | | | | | |
| K.B Canal | | 2296 | 1951 | | | | 26.74 | 27.62 | | 23.13 |
| North Canal | | 25013 | 25194 | | | | 171.05 | 189.56 | | 230.50 |
| West Canal | 32033 | 4983 | 4617 | | | | 45.58 | 35.79 | 212.92 | 42.30 |
| Taung | 6424 | 6424 | 3764 | | | | 54.41 | 35.12 | | 31.90 |
| Total VaalHarts | 38457 | 38716 | 35526 | 350.47 | 354.13 | 365 | 297.78 | 288.09 | | 327.83 |

**The above figures produced by PDNA, 2007

**Table 5.11: Comparison of water quota, theoretical crop water requirement and Irrigation water requirement assuming 80% efficiency**

| Irrigation Scheme | Water Quota ($m^3/ha/a$) | Total Crop Water Requirement ($m^3/ha/a$) | Irrigation Requirement Assuming 80% efficiency ($m^3/ha/a$) |
|---|---|---|---|
| Schoonspruit | 7 700 | 4 822 | 6 027 |
| Klerksdorp | 6 100 | 5 315 | 6 644 |
| Mooi River | 7 700 | 6 185 | 7 731 |
| Allemanskraal | 7 200 | 7 200 | 9 000 ** |
| Erfenis | 7 200 | 8 341 | 10 426 ** |
| Vaalharts | 9 140 | 6 653 | 8 316 |

** Due to double cropping

As there is no means of calibrating the theoretical crop water requirement based on the actual irrigation water use, the potential for water saving is merely assessed by “what if” scenarios. Thus, **Table 5.12** and **Table 5.13** show the potential of water saving in each of the selected schemes for two levels of irrigation efficiency improvement.

**Table 5.12: 2% Improvement in irrigation application efficiency**

| Scheme | Actual Water Use ($10^6m^3/a$) | Current scheme Efficiency (%) | Target Efficiency (%) | Water Saving Potential ($10^6m^3/a$) |
|---|---|---|---|---|
| Schoonspruit | 10.57 | 70 | 72 | 0.2114 |
| Klerksdorp | 4.81 | 73 | 75 | 0.09 |
| Mooi River | 19.9 | 70 | 72 | 0.398 |
| Allemanskraal | 19.34 | 78 | 80 | 0.3868 |
| Erfenis | 23.45 | 79 | 81 | 0.469 |
| Vaalharts | 288.09 | 69 | 71 | 5.7618 |
| **Total** | **366.16** | **-** | **-** | **7.317** |

**Table 5.13: 5% improvement in irrigation application efficiency**

| Scheme | Actual Water Use ($10^6m^3/a$) | Current scheme Efficiency (%) | Target Efficiency (%) | Water Saving Potential ($10^6m^3/a$) |
|---|---|---|---|---|
| Schoonspruit | 10.57 | 70 | 75 | 0.5285 |
| Klerksdorp | 4.81 | 73 | 78 | 0.2405 |
| Mooi River | 19.9 | 70 | 75 | 0.995 |
| Allemanskraal | 19.34 | 78 | 83 | 0.967 |
| Erfenis | 23.45 | 79 | 84 | 1.1725 |
| Vaalharts | 288.09 | 69 | 74 | 14.4045 |
| **Total** | **366.16** | | | **18.308** |

Oosthuizen, et al., (2005) established cost-estimating procedures for different irrigation systems. Based on the information obtained in Oosthuizen, et al.,(2005) the annualized capital cost and annual operational cost of three irrigation systems is shown in **Table 5.14**.

**Table 5.14: Capital and operation cost of different irrigation systems**

| | Micro | Drip | Furrow |
|---|---|---|---|
| Annualized capital cost + Fixed cost (R/ha/a) | R1 598.77 | R1 147.00 | R352.45 |
| Operational (R/ha/a) | R2 870.33 | R2 778.51 | R4 625.03 |
| Total cost (R/ha/a) | R4 469.10 | R3 925.51 | R4 977.48 |

As shown in the above table, although the capital cost of efficient irrigation systems can be relatively high compared to surface irrigation, this can be offset by low operational costs.

Obviously, although drip irrigation is relatively cheaper, it is not always practical to switch to drip irrigation, which is really only suitable for orchard type crops and is impractical for ploughed crops.

In Erfenis and Allemanskraal there is a comparatively small proportion of land under flood irrigation. The target to improve efficiency by 2% and 5% can be attained by replacing the sprinkler system by drip. In the remaining irrigation schemes there is still a large proportion of land under flood irrigation which can be replaced with a drip system. The graph in Figure 6.2 shows that the annual cost of highly efficient scheme is in fact lower than a less efficient scheme. The lower operational cost and the saving of water significantly offsets the high capital cost of introducing an efficient system. However, this benefit can only be achieved if the implementation of a drip irrigation system is incorporated with high value orchard type crops.

**Table 5.15** and **Table 5.16** show the theoretical net cost savings that could be achieved by implementing scheme 2% and 5% efficiency improvements respectively. These are indicative theoretical savings assuming that the percentages of land are suitable for crops associated with drip irrigation.

**Table 5.15: Annual cost savings by achieving a 2% improvement in scheme irrigation efficiency** ***(changing from furrow to drip irrigation)***

| Scheme | % of land Targeted for Drip Irrig. | Area of land targeted for Drip Irrig. (ha) | Additional Capital Cost (R/a) | Operational Cost Savings (R/a) | Total Improvement Savings (R/a) | Water Saving (mil.$m^3$/a) | Water Tariff (R/$m^3$) | Cost save as a result of water saving (R/a) | Net Cost Savings Total (R/a) |
|---|---|---|---|---|---|---|---|---|---|
| Schoonspruit | 6 | 64 | 73 866 | 118 916 | 45 050 | 0.21 | 0.10 | 20 727 | 65 777 |
| Klerksdorp | 5 | 58 | 66 984 | 107 837 | 40 853 | 0.09 | 0.03 | 2 304 | 43 157 |
| Mooi River | 6 | 285 | 327 353 | 526 997 | 199 644 | 0.40 | 0.09 | 37 240 | 236 884 |
| Erfenis | 5 | 262 | 300 800 | 484 250 | 183 450 | 0.38 | 0.03 | 9 690 | 193 140 |
| Allemanskraal | 5 | 259 | 296 614 | 477 510 | 180 896 | 0.47 | 0.05 | 22 795 | 203 691 |
| Vaalharts | 5 | 1 600 | 1 835 200 | 2 954 432 | 1 119 232 | 5.76 | 0.06 | 350 208 | 1 469 440 |
| *Total* | | *2 529* | | | | *7.31* | | | *2 212 088* |
| | | | | | | | | R/ha/a | 875 |

**Table 5.16: Annual cost savings by achieving a 5% improvement in scheme irrigation efficiency** ***(changing from furrow to drip irrigation)***

| Scheme | % of land Targeted for Drip Irrig. | Area of land targeted for Drip Irrig. (ha) | Additional Capital Cost (R/a) | Operational Cost Savings (R/a) | Total Improvement Savings (R/a) | Water Saving ($x10^6m^3$/a) | Water Tariff (R/$m^3$) | Cost save as a result of water saving (R/a) | Net Cost Savings (R/a) |
|---|---|---|---|---|---|---|---|---|---|
| Schoonspruit | 16 | 272 | 311,984 | 502,253 | 190,269 | 0.52 | 0.1 | 51,324 | 241,593 |
| Klerksdorp | 18 | 126 | 144,522 | 232,662 | 88,140 | 0.24 | 0.03 | 6,144 | 94,284 |
| Mooi River | 17 | 809 | 927,923 | 1,493,835 | 565,912 | 0.99 | 0.09 | 92,169 | 658,081 |
| Erfenis | 26 | 1363 | 1,563,361 | 2,516,807 | 953,446 | 0.96 | 0.03 | 24,480 | 977,926 |
| Allemanskraal | 25 | 1293 | 1,483,071 | 2,387,550 | 904,479 | 1.17 | 0.05 | 56,745 | 961,224 |
| Vaalharts | 15 | 4800 | 5,505,600 | 8,863,296 | 3,357,696 | 14.14 | 0.06 | 859,712 | 4,217,408 |
| *Total* | | *8,663* | | | | *18.02* | | | *7,150,516* |
| | | | | | | | | R/ha/a | 825 |

### 5.6.3 Improving agronomic and economic efficiency of water

Loxton Venn and Ass., 1999 as shown in **Figure 5.9**, identified that about 72% of the total crop grown in the Upper and Middle Vaal catchment are low value crops. To improve the economic return of water use in the catchment the proportion of high value crops need to be increased. Loxton Venn and Ass., (1999) indicated the presence of high market potential of these crops as the schemes are within close proximity of the densely populated areas.

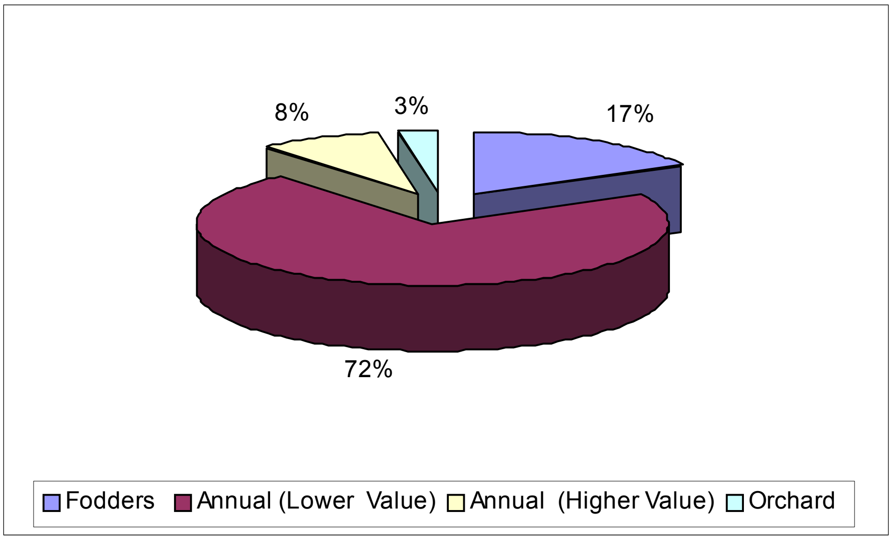



**Figure 5.9: Proportion of major crops in the Upper and Middle Vaal Catchment (Loxton Venn and Ass., 1999)**

### 5.6.4 Institutional arrangement

The following shortcomings have been observed in terms of the irrigation sector institutions in the Vaal catchment:

- Inconsistencies in measuring water use and distribution;
- Accuracy and reliability of measurement equipment;
- Little monitoring of water use and abstraction; and
- Pricing is in terms of water allocation rather than water use which deters incentive for water saving.

# 6 TASK 4: URBAN WATER CONSERVATION AND DEMAND MANAGEMENT

## 6.1 INTRODUCTION

The assessment of the urban demands was undertaken by WRP Pty Ltd as part of two parallel studies being undertaken for the Department. The objective of this task was to review and critically assess the potential savings to be achieved through water conservation and demand management for the major consumers of the Vaal River system. The water use database from the National Water Resource Strategy and Rand Water consumption figures was used to identify the key demand centres for the Vaal River system. The key demand centres are shown in **Figure 6.1** and discussed in the following paragraphs which between them represent approximately 80% of the total urban demand. Due to time and budget limitations it was not possible to investigate every demand centre and for this reason the investigations were limited to the major demand centres which are responsible for most of the urban water demands in the study area.

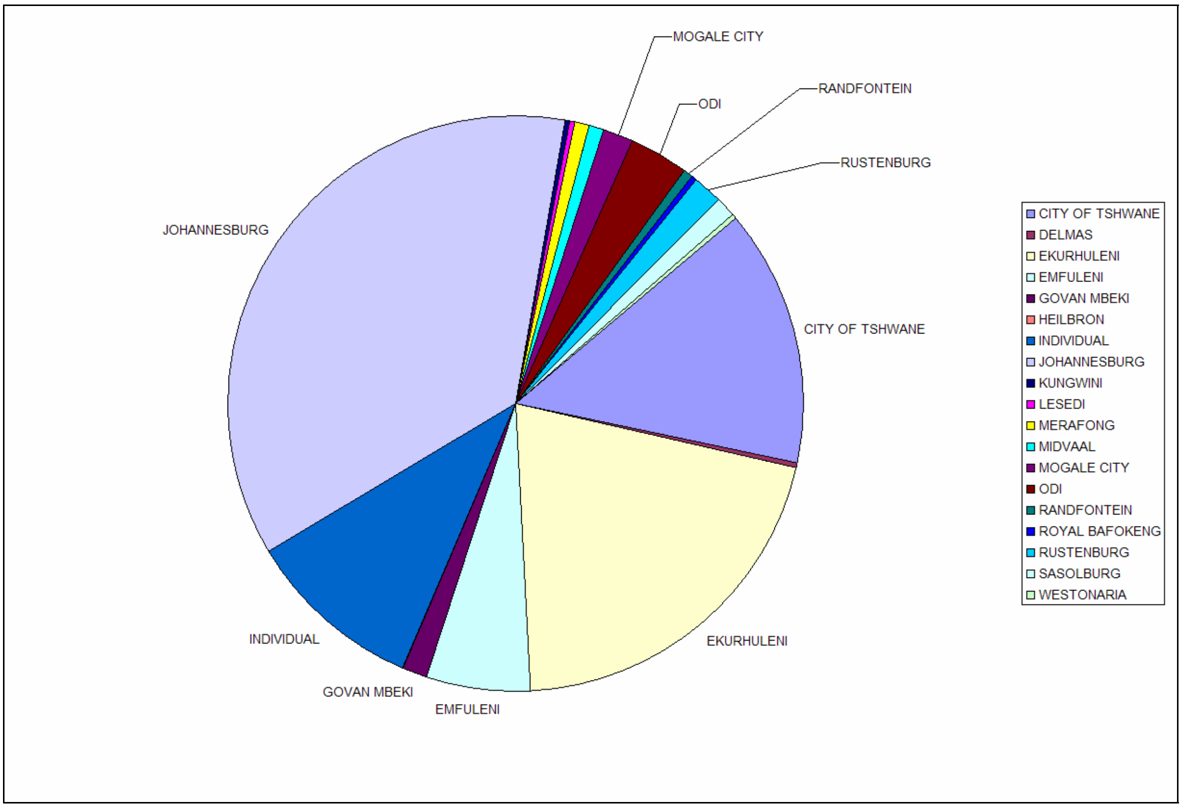



**Figure 6.1: Breakdown Rand Water Supply**

**Johannesburg** is the largest municipal consumer (36%) in the Rand Water supply area with an annual consumption of approximately **455 million m$^3$/annum** (Rand Water, 2003) and population of 3.2 million (Census 2001). It includes Ennerdale, Grasmere, Halfway House, Hyde Park, Johannesburg, Lenasia, Midrand, Modderfontein, Randburg, Roodepoort, Sandton and Soweto. The average consumption, including industrial use is 389 ℓ/c/d.

**Ekurhuleni** is the second largest municipal consumer (21%) in the Rand Water supply area with an annual consumption of approximately **259 million $m^3$/annum** (Rand Water, 2003) and population of 2.5 million (Census 2001). It includes Alberton, Bapsfontein, Bedfordview, Benoni, Boksburg, Brakpan, Calyville, Daveyton, Duduza, Edenvale, Etwatwa, Germiston, Isando, Katlehong, Kempton Park, Kwa-Thema, Nigel, Springs, Tembisa, Tokoza, Tsakane, Vosloorus and Wattville. The average consumption, including industrial use is 283 ℓ/c/d.

**Tshwane including ODI** is the third largest municipal consumer (17.9%) in the Rand Water supply area with an annual consumption of approximately **250 million $m^3$/annum** (2006) and population of approximately 2 million (CENSUS 2001). It includes Akasia, Atteridgeville, Centurion, Mamelodi, Mabopane, Ga-Rankuwa, Winterveldt, Hebron, Temba and Pretoria. The average consumption, including industrial use is 305 ℓ/c/d. In the inception report ODI (Mabopane, Ga-Rankuwa, Winterveldt, and Hebron) was considered as a separate area as it was managed and operated by Rand Water.

**Emfuleni** is the fourth largest municipal consumer (6%) in the Rand Water supply area with an annual consumption of approximately **72 million $m^3$/annum** (2003) and population of 0.65 million. It includes Boipatong, Bophelong, Evaton, Houtheuwel, Loch Vaal, Orange Farm, Sebokeng, Sharpville, Vanderbijlpark and Vereeniging. The average consumption, including industrial use is 303 ℓ/c/d.

**Mogale City** is the fifth largest municipal consumer (1.8%) in the rand Water supply area with an annual consumption of approximately **22 million $m^3$/annum** (2003) and population of approximately 300 000. It includes Hekpoort, Kagiso, Krugersdorp, Maanhaarrand, Magaliesburg and Muldersdrift. The average consumption, including industrial use is 209 ℓ/c/d.

**Rustenburg urban and dense areas** are the sixth largest municipal consumer (1.6%) in the Rand Water supply area with an annual consumption of approximately **20.3 million $m^3$/annum** (Rand Water only - 2003) and population of 228 000. It includes Freedom Park, Ga-Luka, Kanana, Boitekong, Cashan, Geelhoutpark, Paardekraal and Rustenburg. The average consumption is estimated to be 263 ℓ/c/d.

**Govan Mbeki** is the seventh largest consumer (1.3%) in the Rand Water supply area with an annual consumption of approximately **17 million m$^3$/annum (2003)** and population of 222 000. It includes Bethal, Evander, Kinross, Leandra, Secunda and Trichardt. The average consumption is 210ℓ/c/d.

**Randfontein** is the only the twelve largest consumer (0.6%) in the Rand Water supply area with an annual consumption of approximately **7.3 million m$^3$/annum** (2003) and population of 129 000. It includes Brandvlei, Mothlakeng, Randfontein and Toekomsrus. Average consumption is 155l/c/d.

**Matjhabeng** is the largest consumer in the Sedibeng Water supply area with an annual consumption of **15.7 million m$^3$/annum (2003)** and population of 175 000. It includes Welkom, Riebeeckstad, Bronville and Thabong. The average consumption is 247ℓ/c/d.

These nine areas represent 86% of Rand Water's and almost 25% of Sedibeng Water's (Free State region) supply areas. The remaining municipalities in the Rand Water supply area represent 3.8% of the their supply with the remaining 10% supplies to mines, individual consumers and Rand Water's own use.

## 6.2 MANAGEMENT AREAS

The nine municipalities were split into the respective management areas as currently managed by the municipality or most convenient way of supplying the required information. Most of the municipalities are still operating as the former transitional local municipalities. By splitting the municipal areas into smaller areas, it was possible to provide a better estimate of the potential savings and interventions to reduce the water losses. The management areas for each of the municipalities considered in the analysis are summarised in **Table 6.1** with drawings included in **Appendix F**

**Table 6.1: Municipal Management Areas**

| No | Municipality | Key demand centres |
|---|---|---|
| 1 | City of Johannesburg<br><br>(6 areas) | Midrand (incl Ivory Park), Sandton / Alexandra (incl Rosebank, Northcliff), Roodepoort / Diepsloot, Soweto (incl Doornkop, Diepkloof / Meadowlands), Johannesburg Central, Deep South (Ennerdale / Orange Farm), |

| No | Municipality | Key demand centres |
|---|---|---|
| 2 | Ekurhuleni Metropolitan (17 areas) | Alberton / Tokosa, Benoni / Daveyton / Etwatwa, Brakpan / Tsakane, Boksburg / Vosloorus, Germiston / Katlehong, Springs / Kwa Thema, Nigel / Duduza, Kempton Park / Tembisa, Edenvale / Modderfontein |
| 3 | City of Tshwane (8 areas) | Centurion, Pretoria, Akasia, Soshanguve, Mamelodi, Atteridgeville, Odi (Mabopane, GaRankuwa, Winterveldt), Temba (Hammanskraal, Temba, Moretele LM) |
| 4 | Emfuleni Municipality | Vereenging (incl Sharpville), Vanderbijlpark (incl Boiphatong, , Bophelong, Tshepiso), Sebokeng, Evaton |
| 5 | Matjhabeng Municipality (4 areas) | Welkom, Thabong, Riebeeckstad, Bronville |
| 6 | Mogale City Municipality (2 areas) | Krugersdorp, Kagiso |
| 7 | Rustenburg (1 area) | Rustenburg |
| 8 | Govan Mbeki ( | Secunda, Bethal, Leandra, Kinross, Evander, Mbalenhle, Trichardt |
| 9 | Randfontein (1 area) | Randfontein including Mohlakeng, Hillside, Rietvallei |

## 6.3 TERMINOLOGY

### 6.3.1 Introduction

In recent years, there has been a growing realisation that a standard methodology and terminology is required to assist Water Utilities in assessing the water balance of their systems. The use of terms such as leakage, Unaccounted-for Water (UFW or sometimes abbreviated to UAW), Non-Revenue Water (NRW), real losses and apparent losses tends to confuse if the terms are not explained properly. Clearly, it is necessary to explain the terminology used to define water losses so that there is absolutely no confusion.

Until recently, the standard approach of expressing leakage/losses in a system involved taking the water supplied into a system and subtracting the authorised use in order to establish the total losses which were also often termed to be the UFW. This standard water balance is shown in **Figure 6.2**. As can be seen, the UFW is a collective term covering a multitude of different losses including both physical leakage as well as administrative losses (i.e. meter error and theft etc). Such unaccounted-for losses were also generally expressed in terms of a percentage of the system input which is a poor performance indicator and one that should be avoided if possible despite the fact that it is favoured by most organisations countrywide including many directorates within DWAF. As a result of the development of the Burst and Background Estimate procedures, it became possible to assess various components of the losses in a system to the extent that much of the UFW could in fact be accounted for. By some careful and selective manipulation of the figures, it is now possible to greatly reduce the UFW significantly without any form of improvement to the system. This is shown in **Figure 6.3** from which it can be seen that the level of UFW has reduced significantly from that shown in **Figure 6.2** and is indicated as the “balancing Error”.

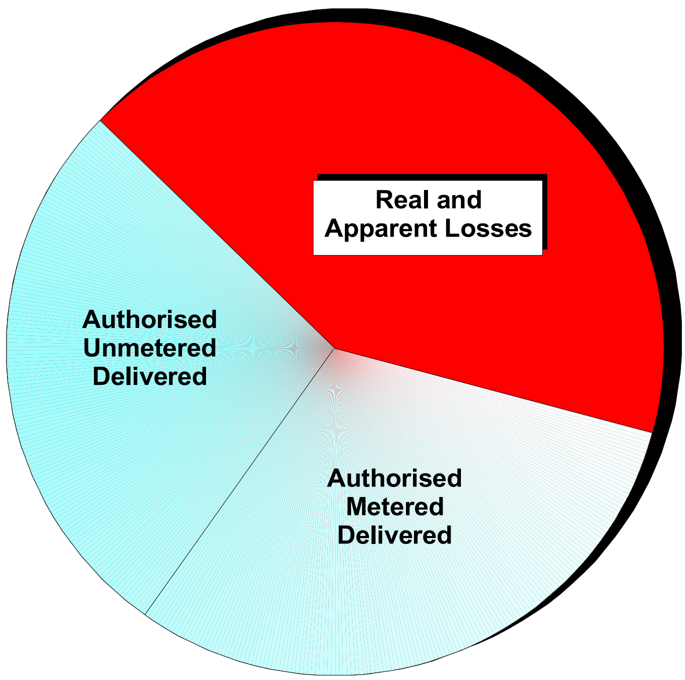



**Figure 6.2: Traditional Water Balance**

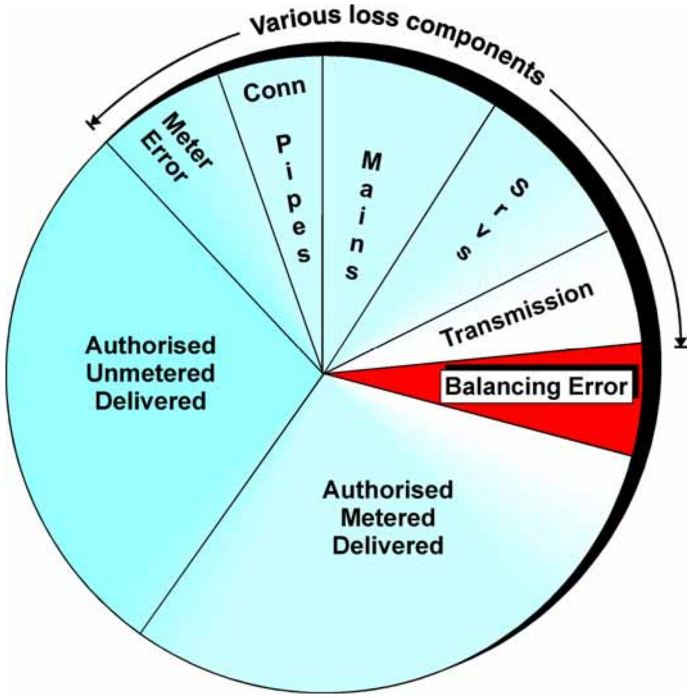



**Figure 6.3: BABE Water Balance Approach**

The key problem with the term UFW is the fact that there is no universal definition for the term and it varies from country to country and even from one Water Services Institution to another within the same country. The second key problem is that the level of UFW can be manipulated quite easily as is shown from the following simple example based on the paper presented in Australia by the Chairperson of the IWA Water loss Task Force, Ken Brothers (Brothers, 2005). In his paper on the subject Mr Brothers demonstrates how the UAW can be manipulated to a lower value through the use of a “Cheat Sheet” as shown in **Figure 6.4**. If it is assumed that a Water Services Institution has a total system input after any known bulk meter errors have been taken into account of 1 000 units and an authorised consumption of 750 units, the level of UFW is 250 units or 25% of the total system input. This would be the standard approach for defining UFW as used by many Water Services Institutions throughout the world.

**"Unaccounted - For" Water Use Estimates** *(i.e.. The Cheat Sheet)*

| | |
|---|---|
| Water Breaks - Accounted for… | 1- 2% |
| Hydrant Flushing ………………. | 1% |
| Fire Fighting ……………………. | 1% |
| Public Works ……………………. | 2 - 3% |
| Meter Error …………………………. | 3 - 4% |
| Allowable Leakage ………………. | 3% |
| Unmetered Water / Theft ……….. | 1% |
| Total (Off the Top) ……………. | 11 - 15 % |

**Figure 6.4: Typical "Cheat Sheet" for manipulating UFW (from Brothers 2005)**

If the values suggested in **Figure 6.4** are applied to the simple example, the level of UFW decreases by at least 120 units to 130 units representing 13 % compared to the previous estimate of 25%. This form of water auditing is unacceptable since it is clearly very subjective and open to abuse and manipulation. This is the key reason behind the decision by the International Water association to discourage the use of AUW in preference to Non Revenue Water (NRW).

Before developing a standard water auditing procedure, it is therefore essential to develop and use the same standard terminology. In this regard, it is now generally accepted throughout most countries in the world that the standard terminology used and promoted by the International Water Association (IWA) is the most robust and comprehensive approach. The elements of the IWA water balance are shown in **Figure 6.5**. This water balance represents many years of discussion and debate and has been accepted by virtually all water auditing and leakage management specialists worldwide.

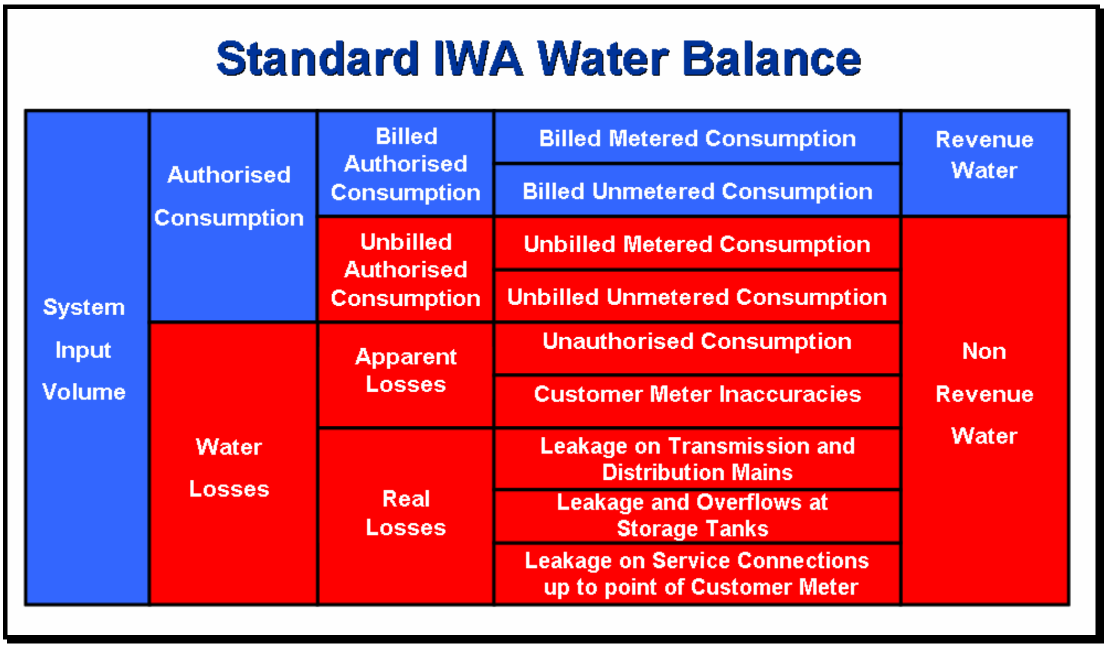



**Figure 6.5: The Standard IWA Water Balance**

**Figure 6.6** presents a modification to the IWA water balance for South African circumstances as proposed in the recently completed Water Research Commission project (Seago and Mckenzie, 2006). In the figure it can be seen that the Revenue Water component has been split into 3 smaller components. It was felt that this modification was necessary in the South African context because water that is billed in South Africa is not always paid for by the customers. While this problem is normally a very small component of the overall water balance in most developed countries, it is known to be a large component of the water balance in most low income areas of South Africa. In other words, it is found in many municipalities throughout South Africa that the "revenue water" often includes a large component that may be metered and billed but will never be paid due to the financial limitations of the customers. In South Africa, the "Billed Water" can therefore not always be termed revenue water. This "bad-debt" phenomenon is common in many municipalities throughout South Africa , however, the proposed modification to the water balance is necessary due to the relatively large quantities of billed water for which no income is received. An additional complication involves the free basic water allowance involving 6 kℓ of water per property per month which is supplied free of charge. This water is authorised, and is technically considered to be billed (metered or unmetered), but billed at a zero rate. The application of this policy is a complex issue and is discussed further in this section. The free basic water is still considered to be revenue water although it is charged at a zero rate.

The key issue requiring the modification to the IWA water balance is the fact that in some cases, a large portion of the billed consumption is not paid for by the customer and will in fact never be paid for due to the financial limitations of the customer. If proper billing and payment mechanisms are created to ensure that all water is paid for by the consumers, the water used will decrease significantly. In effect, the portion of the "Potential Revenue Water" that is shown as "Non-Recovered Revenue" water in **Figure 6.6**, represents a potential saving that can be achieved through appropriate WDM activities. For this reason, the block has been highlighted in red in the figure which signifies non-revenue water as opposed genuine revenue water.

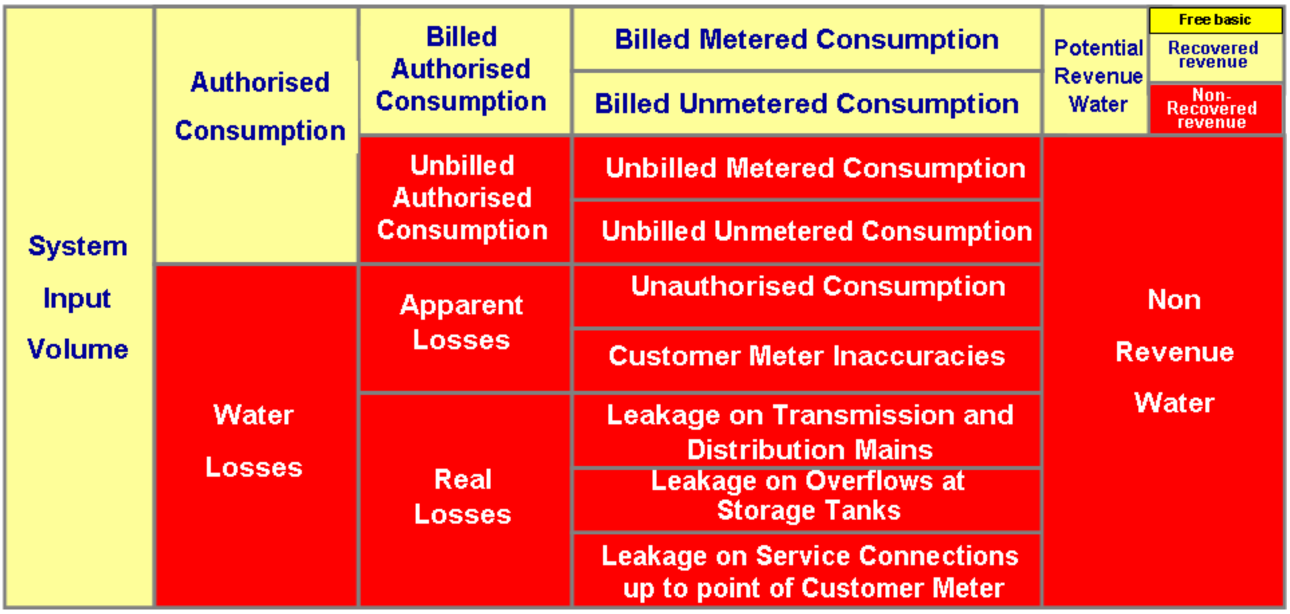



**Figure 6.6. Modified IWA water balance for South Africa (from Seago and Mckenzie, 2006)**

To overcome the controversy concerning the use and abuse of the term UFW, there is now growing consensus throughout the informed water supply community that the term Non-Revenue Water (NRW) should be used in place of UFW. This does not mean a complete substitution of the term UFW with NRW, but rather an adjustment in volumes of water that are reported on and discussed. Although there can still be some manipulation between some of the terms shown in **Figure 6.6**, the overall level of NRW is unaffected by such changes. It is therefore a more meaningful and reliable indicator of water supply efficiency in a water supply system.

### 6.3.2 Performance Indicators

As awareness grows throughout the world that water resources are finite and require careful management, the water lost from potable water distribution systems is becoming an important issue throughout the world. Figures for UFW are often quoted in the media or in public presentations, usually expressed as a simple percentage of system input volume. Such figures tend to be accepted blindly by both the media and public, who find them easy to grasp and assume they are a meaningful indicator of performance.

Over the last decade, however, it has been recognised that the term UFW and the use of percentages are often unsuitable and can be very misleading due to the fact that percentage figures are strongly influenced by the consumption.

A simple example can be used to highlight this problem. In this example a distribution system with 250 000 consumers and 1 000 km of mains experiences real losses of 10 $m^3$/km mains/day. The percentage Real Losses can easily be calculated for a range of different unit consumption as shown in **Table 6.2**.

**Table 6.2: Example showing the problem of using percentages to quantify leakage.**

| Per capita Consumption (litres/head/day) | Daily Consumption ($m^3$ per day) | Distribution Losses ($m^3$ per day) | Daily Input ($m^3$ per day) | Losses (%) |
|---|---|---|---|---|
| 25 (Standpipe) | 6 250 | 10 000 | 16 250 | 62 |
| 50 (Jordan) | 12 500 | 10 000 | 22 500 | 44 |
| 100 (Czech Rep) | 25 000 | 10 000 | 35 000 | 27 |
| 150 (UK, France) | 37 500 | 10 000 | 47 500 | 21 |
| 300 (Japan) | 75 000 | 10 000 | 85 000 | 12 |
| 400 (USA) | 100 000 | 10 000 | 110 000 | 9 |

From **Table 6.2** it can be seen that although the real losses in m$^3$ per day are identical in all cases, the percentage losses vary between 9% and 62% as a result of the varying per- capita consumption. It is clearly not meaningful to compare the percentage losses of a water distribution system in parts of Africa for example with a system in the USA. Similarly, it may not be meaningful to use percentages to compare a system in Africa with another system in Africa even if they are adjacent to each other since the average per-capita water use may be different which in turn will influence the results. If one utility has a single large consumer, it will have the effect of lowering the percentage losses and if the consumer re-locates to another area, the percentage losses will increase despite the fact that the real losses may not have changed. Conversely, if the Water Utility is able to persuade all users to use MORE water, the percentage real losses will decrease – hardly an acceptable WDM measure!

Another interesting point to be considered is the implementation of a water demand management programme to promote more efficient water use amongst the consumers. If such a programme is successful it may reduce the per-capita consumption significantly which would be an indication of a successful programme. In such a case, however, the percentage losses will increase and not decrease unless action is also taken to reduce the real losses.

The problem to be addressed is therefore how to express real losses (the physical leakage) in such terms that the leakage in one system can be meaningfully compared to the leakage in other systems. To address this problem the Infrastructure Leakage Index was introduced based on the ratio of the actual level of real losses compared to a theoretical unavoidable level of real losses or UARL. This indicator tends to vary from approximately 2 to 10 in most parts of South Africa where 2 is “very good” and 10 is “very poor”. In some extreme cases the ILI can exceed 20 in which case the level of physical leakage (real losses) is completely out of control. This performance indicator has now been widely accepted and used in many parts of the world and some details of how it is calculated are provided below although a full explanation should be referenced in various Water Research Commission reports on the topic.

**UARL: Unavoidable Annual Real Losses**

One of the most important concepts used in the BABE procedures concerns the minimum or unavoidable level of leakage for any given system. Effectively, it is a simple concept based on the fact that no system can be entirely free from leakage and that every system will have some level of leakage which cannot be reduced any further. Even a new reticulation system with no use will have some level of leakage, although it may be relatively small. The minimum level of leakage for a system is termed the unavoidable annual real losses or UARL. This is the level of leakage that can be achieved if the system:

- Is in top physical condition and is well-maintained;
- All reported leaks are repaired quickly and effectively;
- Active leakage control is practiced to reduce losses from unreported leaks.

The procedure to estimate the UARL was developed by the International Water Association's Task Force on Water Losses. The estimation of the UARL involves three components of infrastructure, namely:

- Transmission and distribution mains (excluding service connections);
- Service connections, mains to street/property boundary;
- Private underground pipe between street/property boundary and customer meter.

The various elements of the distribution network included in the UARL calculation are shown in **Figure 6.7** which highlights the typical configuration used in South Africa in which the "length of underground pipe" between the curb-stop and the meter is usually very small and can be considered as zero.

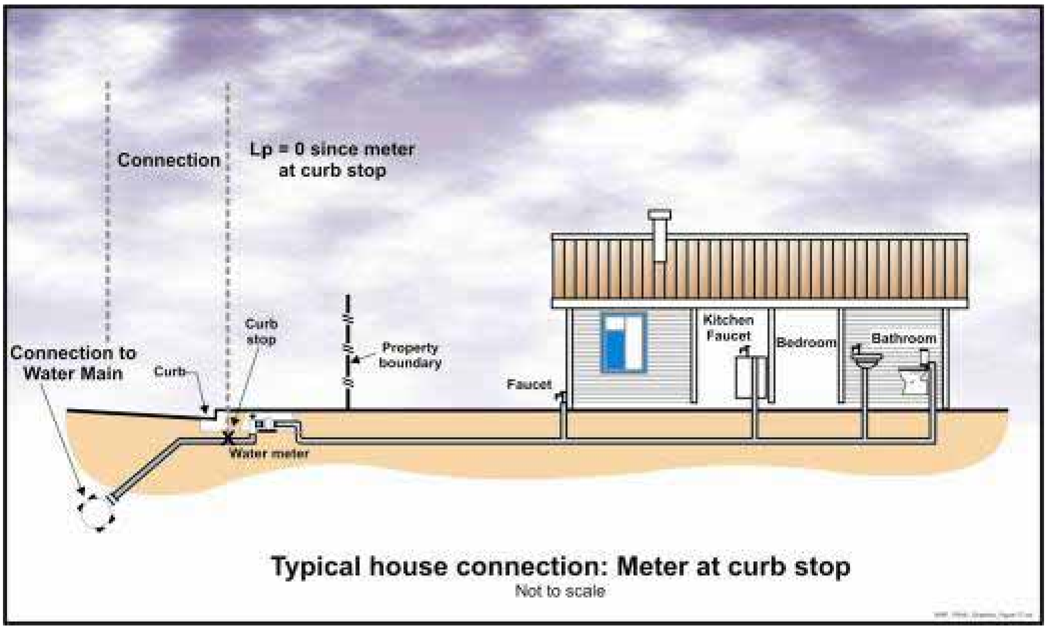



**Figure 6.7: Configuration with meter at property boundary**

The calculation of the UARL can be expressed as follows although in the South African situation, the last term involving "Lp" is usually ignored.:

$$\boxed{UARL = (18 * Lm + 0.80 * Nc + 25 * Lp) * P}$$

Where:

| | | |
|---|---|---|
| UARL | = | Unavoidable annual real losses (ℓ/d) |
| **Lm** | = | Length of mains (km) |
| **Nc** | = | Number of service connections (main to meter) |
| **Lp** | = | Length of unmetered underground pipe from street edge to customer meters (km) |
| **P** | = | Average operating pressure at average zone point (m) |

The calculation is best explained through the use of an example.

**Example**: A system has 114 km of mains, 3920 service connections all located at the street property boundary edge and an average operating pressure of 50 m.

$$\begin{aligned} UARL &= (18 * 114 + 0.80 * 3920 + 25 * 0) * 50 \quad \ell/d \\ &= 102\,600 + 156\,800 \ \ell/d \\ &= 259\,400 \ \ell/d \\ &= 259.4 \ m^3/d \\ &= 94\,681 \ m^3/year \\ &= 66 \ \ell/conn/d \end{aligned}$$

In other words, the minimum level of leakage that could be expected from the example system which is operated at a pressure of 50m would be 66 litres per connection per day or alternatively 94 681 $m^3$/year on the assumption that the system is fully pressurised 24-hours per day. This value is then compared to the estimated physical leakage (real losses) in order to derive the appropriate ILI value. If for example the actual physical leakage for the system was found to be 132 litres per connection per day the ILI value would be 2.0 (i.e. 132 / 66).

### 6.3.3 Recommended Performance Indicators

For many years, various water loss specialists from around the world have been proposing and recommending the use of one or other performance indicator to define real losses (leakage) from a water distribution system. There have been numerous attempts at introducing new indicators some of which have been accepted and others rejected outright. Following the IWA Water Loss Taskforce workshop held in Australia in February 2005 it appears that the situation is gradually becoming clearer. Based on the findings of the workshop and experiences from around South Africa, the following recommendations are made:

The use of percentages as an indicator for real losses should be discouraged although it is accepted that percentages will always remain since few Water Utility managers are prepared to discard percentages completely from their list of PI's. It is therefore important when using percentages to highlight the potential pitfalls and to ensure that other PI's are also provided.

The ILI should be used but not on its own.

| Infrastructure Leakage Index ILI = CARL/UARL |
|---|

In addition to the ILI, various previously recommended PI's for real losses should be used namely:

| litres/connection/day – metric units |
|---|

The average operating pressure should be used as a PI since many systems are apparently achieving very low ILI values but are being operated at very high pressures which are not necessary. For this reason the average system pressure is a key indicator which can be used to determine if some form of pressure management is required in a specific area.

**Non Revenue Water**

In many instances the term Unaccounted for Water (UAW or UFW) is used to indicate the level of wastage in a water distribution system and this has become the standard term adopted by most utilities around the world. This term, however, is open to subjective judgement with the result that it can be manipulated to some extent based on various assumptions as discussed previously. Numerous papers and presentations on the subject have been presented at conferences around the world and all clearly recommend that the term UAW is replaced with the term Non-Revenue Water (NRW) which cannot be manipulated to the same extent.

**Apparent Losses**

The issue of apparent losses (administrative and metering errors including theft of water) continues to be a problem area particularly in the South African context. Due to the manner in which water is measured and billed in certain parts of the country, it is often very difficult to differentiate between the apparent losses and the real losses. Under normal circumstances, apparent losses are valued in terms of the selling price of the water on the assumption that such losses can be converted to sales if the water is measured properly and billed effectively. In the South African situation, this is often not the case since much of the unbilled water is effectively household leakage or simply gross wastage occurring after the domestic meter. The problem arises in such cases where the water is either not being billed according to the metered consumption (as is the case with a flat rate tariff) or it is not being paid for. Various projects have been initiated to address this issue and in most cases, the water consumption drops significantly, when the payment issue is resolved and the consumers start to pay for water based on the metered use. Various forms of pre-payment have been initiated and are currently being implemented in many parts of the country while in other areas the billing and metering systems are being improved to ensure that water is measured correctly and that customers are encouraged to pay for what they use. The issue of apparent losses has not been fully resolved but various recommendations have been made on how to estimate such losses in the annual water audits undertaken as part of the Vaal WC/WDM assessment and certain default values have been proposed which can be used in the absence of any more reliable information.

Various organisations around the world have now adopted a very similar approach involving the use of default values in the absence of any more reliable values to estimate the apparent losses in a system. It should be noted that the default values tend to be the lowest values that could normally be achieved and if any higher values are used by the Water Utilities in their annual audits, they must be properly motivated and justified through proper field investigations. Such values are appropriate for well managed systems with high payment levels which will also be appropriate in many parts of South Africa where water payments are based on metered consumption and the payment levels are high. In other areas where payment levels are low, the default values will not be appropriate and a more comprehensive assessment of the apparent losses will be necessary. To date, there are at least 4 countries where default values for the Apparent Losses have been used including, Australia, New Zealand, USA and Canada. The suggested default values for each country are shown in **Table 6.3** (from Lambert, 2005 personal communication). The values proposed for use in South Africa are presented in **Table 6.4** (Mckenzie and Seago, 2005).

It should be noted that any underestimation in the Apparent Losses will result in an over-estimation of the real (physical) losses which in turn will be reflected in various PI's for Real Losses including the ILI. In many municipalities, the responsibility for the Apparent Losses lies with the Treasury Department while the responsibility for the Real Losses lies with the Water Supply and Sanitation

Department. By assuming that the Apparent Losses are very low when in fact they may be very high will simply shift the apparent “blame” onto the wrong department. The figures quoted for Real and Apparent losses in this report must therefore be used with caution as the split between the different losses may not be realistic.

**Table 6.3: Suggested default values for apparent losses (international)** ***(Ken Brothers, 2005, personal comm.)***

| | Unbilled Authorised | Unauthorised Consumption | Domestic Meter Under-registration | Non-domestic Meter Under-registration |
|---|---|---|---|---|
| **Australian WSAA, American WWA M36, UK (OFWAT), Canada *** | 0.5% of Total System Input | 0.1% of Total System Input | 2% of metered consumption | 2% of metered consumption |

*** = as proposed by A Lambert – yet to be formally accepted**

**Table 6.4: Suggested default values for apparent losses for South Africa**

| Illegal connections | | Meter age and accuracy | | | Data transfer | |
|---|---|---|---|---|---|---|
| | | | Good Water | Poor Water | | |
| Very high | 10 % | Poor > 10 years | 8 % | 10 % | Poor | 8 % |
| High | 8 % | | | | | |
| Average | 6 % | Average 5- 10 years | 4 % | 8 % | Average | 5 % |
| Low | 4 % | | | | | |
| Very low | 2 % | Good < 5 years | 2 % | 4 % | Good | 2 % |

**Note: Percentages represent percentage of current annual real losses**

As can be seen in **Table 6.3**, the allowances are generally small and effectively represent the “best practice” values that could be expected from a very well managed system.

### Billed consumption that is not paid for

As discussed previously, to address the South African situation it was necessary to add a final column to the IWA water balance whereby revenue water (or more accurately termed “potential revenue water”) is divided up into recovered and non-recovered revenue. This section deals with the non-recovered revenue water which is water that is billed but never paid for. These figures are often difficult to obtain from the various municipalities in the Vaal WC/WDM study area since the revenues collected generally lie within the financial section of the WSA rather than the technical section. Some of the Metros and Municipalities indicated that this is a major problem since the technical section is often held accountable for non-revenue water; however, they do not obtain accurate figures for this portion of non-revenue water. Tshwane Metro is only one of several large Metro's trying to address this problem and considerable effort has been spent by the Metro in recent months investigating this specific issue. In view of the importance of this problem to the overall water balance for the Metro, several detailed and expensive investigations have recently (September 2006) been initiated which should help to identify the levels of Real and Apparent losses within its water supply system. Unfortunately, the results from the investigations will only be available during 2007 and could not be included in this report.

The following presents a breakdown of the billed authorised component of the water balance. The three main segments are:

- water sold for which an income is obtained;
- water billed at a zero rate and therefore no income is obtained, no intervention can reduce this volume; and
- water used which should be paid for but payment is never received. Interventions should convert some of this volume to revenue water, however, the bulk of this water will not be used if proper billing and recovery processes are implemented. This component therefore represents a possible saving although it is often considered to be part of the normal "revenue water" component in which case it is largely ignored as a problem issue.

It is very important to realise that in the South African situation, it is unlikely that much of the authorised (currently both billed and unbilled) water that is not paid for can in fact be converted to fully recovered revenue water. As soon as the payment process is formalised and enforced, the water consumption tends to drop significantly. For example 5 000 households in a certain area do not pay for water because they do not receive a bill or because payment is not enforced. These 5000 households each use on average 50 kℓ per month of which 6 kℓ / household / month is the free basic component and 44 kℓ / household / month should effectively be paid for. The WSA that supplies these households sells water at R2 / kilolitre. The WSA should not assume that it will automatically obtain R440 000 (44kℓ x 5000 houses x R2) if payment is enforced since it is likely that much of the 44 kℓ / household / month is wasted as the users never intend to pay for it. Should payment be enforced they are likely to use water much more sparingly and could drastically drop their consumption. This is clearly highlighted in several large scale case studies undertaken in the Vaal WC/WDM Study area including Soweto and Kagiso.

**Unbilled metered consumption**

In the Vaal WC/WDM Study Area, it was found that most of the Metro's and Municipalities have a policy for metering all connections and billing the consumers based on metered consumption. There are a few key exceptions where large areas are supplied with water which is metered but no accounts are sent to the consumers. Such areas tend to be the previously disadvantaged and low income areas and these are clearly reflected in the summary section of this report which highlights where most savings can be achieved. In such areas, meters have been installed, however, the WSA does not have a proper billing system in place or there is simply an unwillingness for the consumers to pay for services. In many cases, the meters are vandalised or covered by the consumer to prevent the meter readers from reading the meters as shown in **Figure 6.8.**

**Figure 6.8: A customer meter which can not be read**

**Unbilled unmetered consumption**

A new portion of the unbilled unmetered consumption component was introduced due to the specific circumstances of some South African WSAs. **Figure 6.9** shows the proposed breakdown of bulk system input volume where it is known that consumers are being billed on a flat rate amount that is significantly lower than their actual consumption.

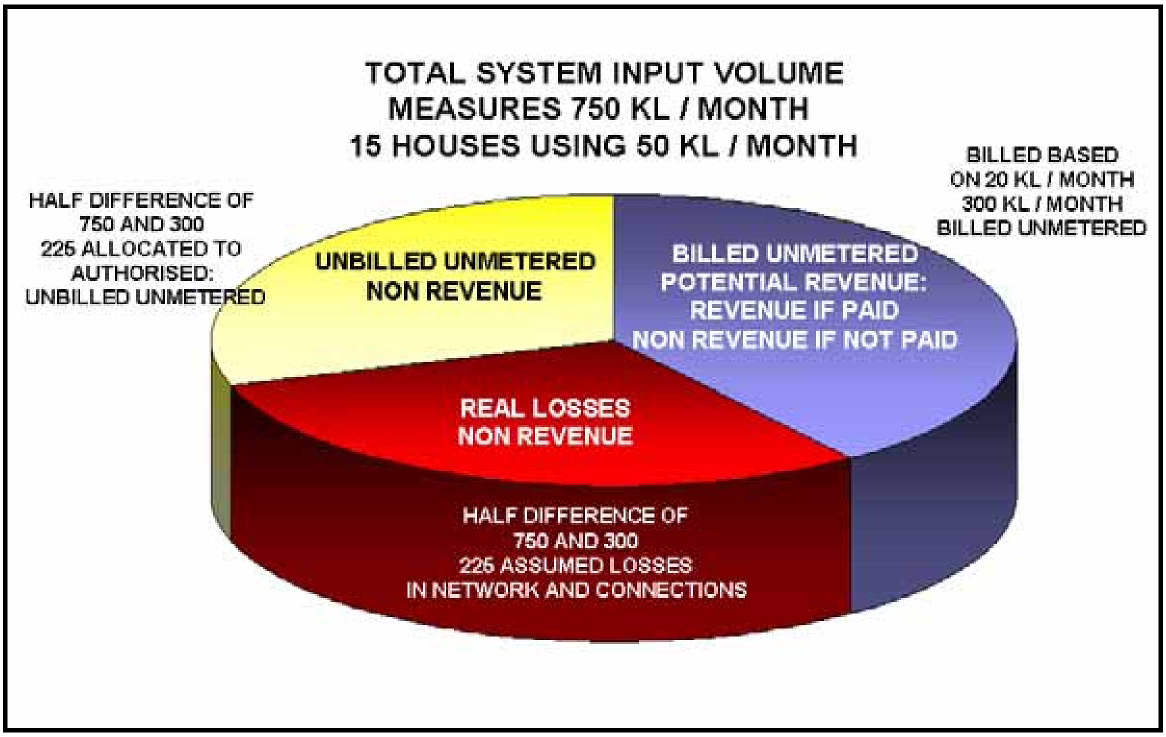



**Figure 6.9: Illustration of water billed on a flat rate tariff basis**

Some typical figures from the City of Johannesburg are used to illustrate this example. **Table 6.5** shows the water that is billed in the three systems presented. It also shows the amount of known authorised consumption in the three areas and the measured water that is actually entering the areas.

**Table 6.5: Deemed areas in the City of Johannesburg**

| WRS | Standpipe use Unbilled unmetered(1) | Billed Volume (1) | Measured Volume (1) | Real losses (2) | Unbilled unmetered consumption (2) |
|---|---|---|---|---|---|
| Alexandra | 187 | 2 097 | 14 653 | 6 185 | 6 185 |
| Soweto | 6 027 | 36 442 | 130 359 | 43 945 | 43 945 |
| Deep South | 1 762 | 2 359 | 12 520 | 4200 | 4 200 |

Note 1: Source: City of Johannesburg
Note 2: Estimated based on proposed 50 – 50 split (described hereafter)

It should be noted that it has been assumed that the unaccounted for water is split evenly between real losses (leakage) and unbilled unmetered consumption which tends to be wastage and/or leakage after the meter (if any).

The following schematic represents how the Sandton / Alexandra and Soweto areas were analysed according to the above mentioned methodology. The Deep South area was analysed in the same manner as Sandton / Alexandra and is therefore not presented.

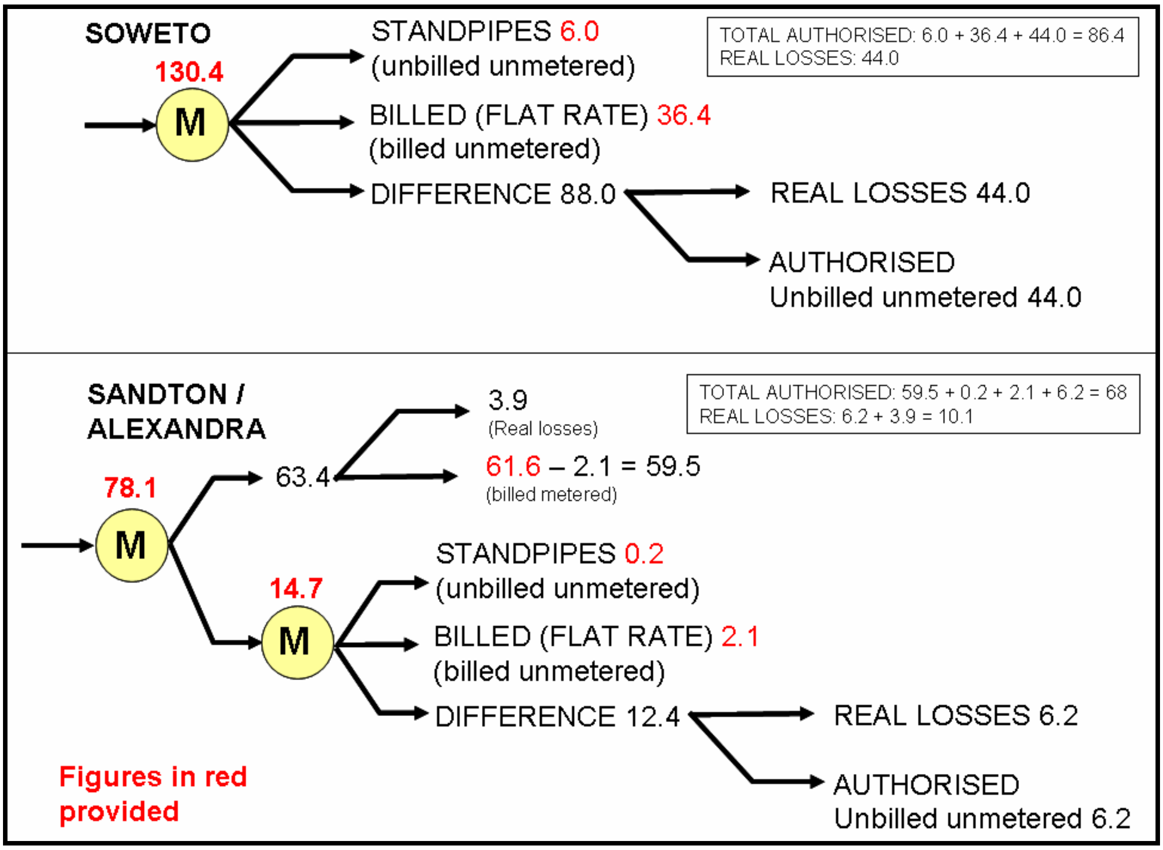



**Figure 6.10: Schematic representing water balance in deemed areas**

**Unauthorised consumption**

Experience shows that illegal connections tend to be highest in low income areas where billing is taking place. Many of the large Metro's in the Vaal WC/WDM Study Area confirmed that they consider Illegal connections and illegal use of fire-fighting water to be a serious problem. Most of the water suppliers in the study area are aware of the problem and are attempting to eliminate it by removing or legalising any illegal connections that they find as well as metering all fire fighting connections.

It may be argued that there is no longer a problem of illegal connections in South Africa since all people have the right of access to basic water use. The definition of an illegal connection used here is where a consumer connects directly onto a distribution pipeline or other water source without the knowledge of the water supplier, or when a person who has an existing metered service connection bypasses the meter and uses more than the basic allocated amount. Examples of this are shown in **Figure 6.11** and **Figure 6.12**.

**Figure 6.11: An illegal connection where a consumer meter has been bypassed**

**Figure 6.12: An illegal connection on an air valve**

It should be noted that one common problem where illegal connections certainly exist concerns the situation where residents convert a single standpipe connection into multiple individual household connections. This can cause problems with system capacity constraints since the original system was designed for standpipe use and not individual metered connection use.

**Customer meter inaccuracies**

Customer meter inaccuracies are mostly dependant on the age of the meter, as well as the water quality of the area. Most water suppliers stated that they thought their meters were in a fair condition except for Soweto and Deep South where they indicated that the meters are in a poor condition. It is difficult to estimate the amount of water theoretically “lost” through meter under registration. Poor customer meters are generally found in lower income areas.

**Leakage on transmission and distribution mains**

Often viewed as the main contributor to real losses, leakage on water mains is made up of bursts and background leaks. As discussed previously, a certain portion of leakage is unavoidable, and all systems will leak to some extent. Leakage in excess of the accepted minimum levels is usually due to low maintenance on distribution systems. A lack of maintenance, in turn, often results from insufficient funds and/or capacity within the WSA and tends to be more of a problem in lower income areas. Another contributing cause of such leakage occurs when consumers are not aware of the necessity to save water and therefore allow bursts to continue without reporting them. Water losses in such cases can often be reduced through social interventions such as public awareness campaigns and education activities.

**Figure 6.13: A leak which has not been reported**

Keeping good records of pipe bursts within a WSA can often assist the WSA in determining problem areas within their systems. Pipe bursts are usually a result of either high pressures or older pipes. Plotting the bursts on a map as they occur will highlight these areas and assist with planning of interventions such as pressure reduction or pipe replacement. It is also useful to continue record keeping once interventions have taken place in order to show the affects of such interventions. Tshwane was the only WSA able to provide information on pipe bursts on request.

**Leakage on overflows at storage tanks**

When questioned on the condition of their storage systems, most WSAs stated that they were in a fair condition and that they did not feel that a large portion of real losses were a result of leakage from storage tanks. Unfortunately, the issue of reservoir overflows is often underestimated since much of the spillage occurs at night when no-one is aware of the leakage. In general, however, most reservoirs in South Africa are of reasonable quality and reservoir leakage is regarded as a minor issue in most areas. **Figure 6.14** shows overflow at a reservoir.

**Figure 6.14: Overflow at a Tower Reservoir due to theft of electrical cabling**

**Leakage on service connections up to the point of customer meter**

In most systems, leakage from connections is by far the greatest source of physical leakage; often 80% or more of the total physical losses (Tim Waldron, personal communication). A portion of the service connection leakage also contributes to the unavoidable annual real losses. The total volume of water lost as a result of this leakage is therefore dependant mainly on the number of service connections within a system and the average operating pressure.

**Figure 6.15: A leak at a service connection**

### 6.3.4 Distribution of non-revenue water components

Having discussed the various components of non-revenue water, it is necessary to break them down on a percentage basis in order to gain a thorough understanding of the larger components of non-revenue water in South Africa. The breakdown is subjective to some extent based on experience as well as discussions with many WSAs. **Figure 6.16** and **Figure 6.17** show the approximate proportions of the eight components of non-revenue water for two different categories of WRSs, namely, medium to high and low income areas. It is important to note that these are approximate estimates of the non-revenue water component and not the bulk system input volume. Further investigation and measurements are required to verify these figures. The figures show that the greatest contribution to non-revenue water in medium to high income areas lies with real losses, (i.e. physical leakage) while for low income areas the greatest contribution to the non-revenue water originates from authorised consumption that is not paid for. This does not imply that the actual volumes of real losses are higher in medium to high income areas since the overall level of non-revenue water in such areas is likely to be much lower.

**BREAK DOWN OF NON REVENUE WATER FOR MEDIUM TO HIGH INCOME AREAS**

| | | | |
|---|---|---|---|
| Non-Revenue Water | Authorised Consumption: Non rec. revenue | Billed Consumption that is not paid for | 3% |
| | | Unbilled metered Consumption | 2% |
| | | Unbilled unmetered Consumption | 2% |
| | Apparent Losses | Unauthorised Consumption | 1% |
| | | Customer Meter Inaccuracies | 5% |
| | Real Losses | Leakage on Service Connections up to point of Customer Meter | 70% |
| | | Leakage on Transmission and Distribution Mains | 16% |
| | | Leakage on Overflows at Storage Tanks | 1% |

**Figure 6.16: Non-revenue water components in a medium to high income area**

**BREAK DOWN OF NON REVENUE WATER FOR LOW INCOME AREAS**

| | | | |
|---|---|---|---|
| Non-Revenue Water | Authorised Consumption: Non-recovered revenue | Billed Consumption that is not paid for | 10% |
| | | Unbilled Consumption | 55% |
| | Apparent Losses | Unauthorised Consumption | 11% |
| | | Customer Meter Inaccuracies | 1% |
| | Real Losses | Leakage on Service Connections up to point of Customer Meter | 18% |
| | | Leakage on Transmission and Distribution Mains | 3% |
| | | Leakage on Overflows at Storage Tanks | 2% |

**Figure 6.17: Non-revenue water components in a low income area**

**Potential water savings methodology for South Africa**

A key objective of the Vaal WC/WDM Study was to estimate the potential savings that can be achieved through a range of WC/WDM interventions. In order to address this objective a methodology was developed to determine realistic water uses for the various areas based on the number of properties being served. Using this realistic use combined with the actual bulk system input volumes; it was possible to estimate approximate savings that each WSA could expect should they attempt certain water demand management interventions. **Figure 6.18** presents the approach used to calculate the potential water savings in the study area.

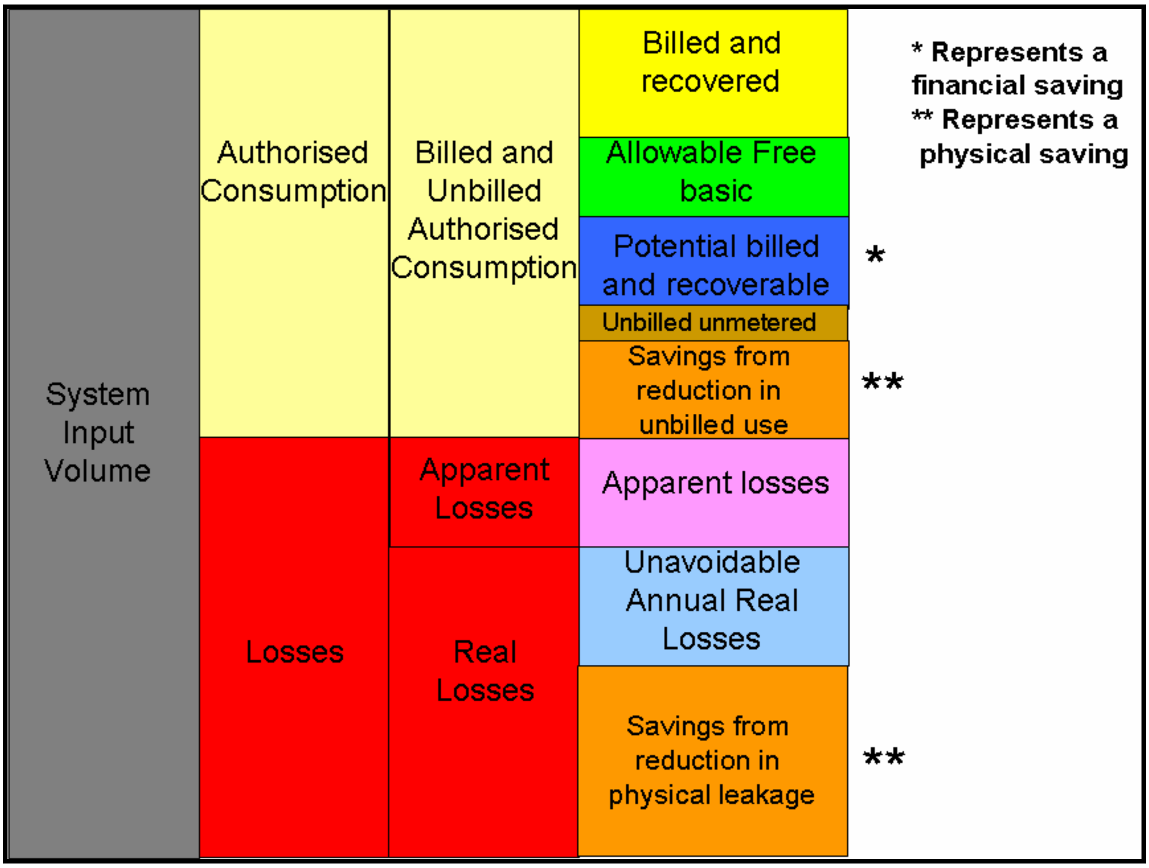



**Figure 6.18: Breakdown of system input volume for estimating potential savings**

The descriptions for each component of the water balance are as follows:

**Billed and recovered:** this represents the volume of water that is billed and paid for. It does not include the free basic allowance.

**Allowable free basic:** This represents the free allowance of 6 kl/property per month and can technically be considered as billed water which is billed at a zero rate. This component cannot be reduced.

**Potential billed and recoverable:** This is a volume of water that is currently either metered or unmetered, however, the customer is not billed and therefore does not pay. This represents water that will be paid for by the consumer if the water supplier is able to address the non-billing issues. The volume of potential billed water is usually calculated to be about 2% of system input volume.

**Unbilled Unmetered:** This is normally a very small component of the water supplied to an area and there is generally little to be saved from this component since there is already a policy in place to ensure that all connections are metered. This component represents mainly the water used for fire fighting and mains flushing.

**Savings in reductions in unbilled use**: This is one of the components where most savings can be achieved In many of the water systems analysed in the Vaal WC/WDM Study Area. It is made up of consumers who are currently billed but do not pay, as well as water users who are not billed at all. A realistic volume of use per household is approximately 12 kℓ / month in most low-income areas. This includes the 6 kℓ that are provided free. It is likely that WSAs that implement an effective payment system for use above the allowable free limit will achieve significant savings as a result of a drop in use as well as wastage from internal plumbing leaks. This is clearly shown by the Soweto project being implemented by Johannesburg Water where the water use per property has dropped from over 50 kℓ / household / month to less than 12 kℓ / household / month through the implementation of pre-payment for water. Similar reductions have been observed in other parts of South Africa as well as in other parts of the world (e.g. Sa Paulo in Brazil) where similar conditions exist.

**Apparent losses:** The apparent losses were based on an assessment of the levels of illegal connections in the system as well as the age of the meters and quality of the water. This approach is subjective to some extent and dependant on the in-depth knowledge of the system by the manager who completed the water audit.

**UARL:** This volume of water is calculated from the standard UARL equation and is a function of length of mains, number of service connections and average operating pressure as discussed in **Section 4.3.1**.

**Savings from reductions in Physical Leakage:** This can represent a sizeable component of the overall water balance in areas where maintenance of the water reticulation system has been neglected due to lack of financial resources or technical capacity. In most of the well established municipalities, the water distribution systems are in relatively good condition and leakage is addressed as a matter of priority. Leakage does occur in many of the low income areas where maintenance of the water reticulation system has been neglected for various reasons over a prolonged period. In general, the levels of physical leakage (real losses) in most of the large water supply systems in the Vaal WC/WDM Study Area are not considered to be abnormally high. A few pockets of very high physical leakage do exist, however, these are being addressed as a matter of priority. **Physical leakage is not the main problem issue facing most of the water suppliers in the study area.**

## 6.4 TASK 4A: COLLECTION AND COLLATION OF DATA FROM PREVIOUS STUDIES

The objective of this task was to review the contents of current water demand management and conservation strategies developed by the respective Water Services Authorities (WSA). Studies which were used as basis for the development of WDM strategies included :

Water loss assessments in the Rand Water / Gauteng area for:

- Mogale City (Rand Water, 2003)
- Randfontein (Rand Water, 2003)
- Emfuleni Municipality (Rand Water, 2003)
- Rand Water Odi (Rand Water, 2001 and 2002)
- Ekurhuleni Pressure Management Study - Phase 1, (Rand Water, 2003)

The objectives of these studies were to identify areas of high leakage, quantify the losses and provide recommendations on how to reduce them through a range of WC/WDM activities. In most cases the projects and recommendations were based on the collection and interpretation of actual data and were not simply desk-top studies involving the assessment of billing records and water purchases. The investigations often involved flow and pressure logging of each supply zone and the analyses of the logging results using the SANFLOW, PRESMAC and BENCHLEAK models develop by WRP for the Water Research Commission.

Other WCDM studies /projects investigated included :

- Ekurhuleni Pressure Management Study - Phase 2 & 3, (Ekurhuleni Metro, 2003 to 2004);
- Johannesburg Water Conservation and Demand Management Strategy (HABITAT, 2001);
- Pressure Management Project in the Johannesburg supply area (Johannesburg Metro, 1999 to 2001);
- Upper, Middle and Lower Vaal: Internal Strategic Perspectives (DWAF-2004);
- Vaal System WC/WDM: Preliminary Assessment (DWAF-2001);
- Provincial Growth and Development Plans, IDPs and WSDPs;
- NDA – Provincial Agricultural Development Plans;
- National WC/WDM Strategies and Guidelines;
- NWA and WSA requirements for WC/WDM; and
- Water Cycle Management Initiative for the Vaal System.

## 6.5 TASK 4B: STATUS QUO ASSESSMENT

### 6.5.1 General water loss contributing factors

The municipalities are characterised by institutional, operational and maintenance problems which directly affect the WCDM initiatives but is difficult to address and quantify. These problems include:

**Loss of skilled resources and expertise in the water sector** - Municipalities are run by skeleton staff and with the lack of skilled resources, there is limited time to undertake planning and most time is spent on crisis management.

**Supply minded thinking and system operation -** Engineers have, for a very long time, increased the supply from new sources when the demand increased instead of addressing the demand. The key objective is to supply water, with no consideration for WC/WDM. Zone boundaries are compromised, low pressure problems in zones are resolved through opening of pressure reducing valves although the problem is related to unauthorised closed valves. It is very difficult to and will take a long time to change this attitude.

**Lack of system understanding -** The system operation is not documented and municipalities experienced major staff turnover in recent years with many posts often not refilled.

**Lack of system control -** The municipalities do not have access to information systems that supply demand trends and patterns.

**Lack of funds -** The financial situation of municipalities has deteriorated to such an extent that operation and maintenance function cannot be correctly performed. They can also not apply for funding, as they are not credit worthy.

**Lack of maintenance -** Control valves and water meters are not maintained. Very few municipalities can provide you with control valve and bulk meter details such as size, model, make, settings, historical readings, service dates, etc. These points are often critical in the efficient operation of the system.

During the course of the investigations, the issues of management and maintenance were identified as a key stumbling block to the implementation of WC/WDM interventions. Some typical sights that exist in the study area and most other parts of the country are shown in **Figure 6.19**, **Figure 6.20**, and **Figure 6.21** which help to emphasise the extent of the maintenance problems.

**Figure 6.19: A long running leak on a trunk main**

**Figure 6.20: Dangerous and leaking valve chambers**

**Figure 6.21: Stolen taps in hostel washing area**

In many cases where WC/WDM interventions are planned or implemented, they fail dismally due to many external factors related to management and maintenance of the water distribution systems. In the case of the Sebokeng/Evaton Pressure Management Project, the initial pressure control installation was relatively straightforward to design and construct. The problems associated with maintenance and operation, however, only became apparent after the installation had been completed and the project team started to reduce the pressure during off peak periods. In theory and in accordance with the available GIS and associated network modelling drawings, the process of reducing the pressure should have been simple and straightforward. In practice, however, it was chaotic since many of the pipes shown on the drawings had never been installed and many of the basic control valves which are used to create discrete zones had not been serviced for more than 30 years. In many cases it was difficult to find the valves let alone check that they were operating as can be seen in **Figure 6.22** and **Figure 6.23** which shows two valve chambers, one before cleaning and the other after being cleaned. The actual valves had not been used in more than 30 years and were rusted to such an extent that they could not be used.

**Figure 6.22: Typical valve chamber**

**Figure 6.23: Typical valve chamber after cleaning**

The valves shown in the above figures, are essential to the efficient operation of a water reticulation system and in the case of the system shown, it was impossible to shut down small portions of the system in the event of a burst pipe. The situation had deteriorated to such an extent that it was almost impossible to isolate certain areas for essential maintenance. If this type of problem is not addressed, the system will eventually collapse and no safe and reliable water supply will be possible. In the case of the valves pictured in **Figure 6.22** and **Figure 6.23,** the Municipality was eventually able to service the valves using some of the savings achieved from their WC/WDM measures. The valves could not simply be replaced since they were more than 50 years old and manufactured in using the imperial sizes and therefore they had to be refurbished as shown in **Figure 6.24** and **Figure 6.25**. In order to redress the backlog of maintenance in the area shown for example, it is estimated that an investment of R400 million will be required. It should be noted that this investment is actually required whether or not WC/WDM is to be introduced, however, it will not be possible to achieve the savings required from WC/WDM if the basic system is not restored to an acceptable level of operation.

**Figure 6.24: Repair of boundary valve**

**Figure 6.25: Replacing broken valve**

**Consumer metering -** Although not focussed on during the studies, consumer water metering has been identified as one of the key problem areas. These include illegal connections, theft through fire connections, lack or poor water meter readings as well as no or broken meters.

Another key problem issue that materialised through discussions with various municipalities concerns the problems experienced between the Technical and Treasury operations within the various municipalities. Most municipalities are unwilling to allow the Water and Sewage Departments to operate and run the complete water service which also includes the billing and treasury operations. As a result, there is often major conflict between the two Departments which leads to serious inefficiencies and general apathy amongst many of the managers. This problem was recently highlighted in Tshwane Municipality where the Technical Services Department has no control over the billing and cost recovery components associated with water sales. In order to establish a proper water balance for the system it is necessary to establish how much water is supplied to the system and how much water has been sold. The difference between the two figures is often referred to as the Unaccounted-for-Water (UFW) and in the case of Tshwane this indicator was used to measure the performance of the manager of the Water Services Department. When the Treasury operations were moved onto the new SAP system, many problem issues arose which have yet to be fully resolved. In May of 2006, figures were provided by Treasury which suggested that the UFW had increased from the 2005 value of 26% to a new high of 33%. This raised serious concerns which were raised by the Municipal Manager who acted on the basis that the UFW had increased dramatically when in fact the real figures showed that there was little change and in fact a small decrease. The figures are shown in **Figure 6.26**.

| Description | Water Purchased (kl) | Water Sold (kl) | UAW (%) |
|---|---|---|---|
| SAP Figures May 2006 | 215 974 476 | 142 130 151 | 34.2 % |
| SAP Figures August 2006 | 255 278 548 | 189 382 858 | 25.8 % |

**Figure 6.26: Influence of new billing system on UFW figures**

**Institutional arrangements -** The roles and responsibilities of the water services authority, provider and bulk water service provider is not always properly defined with the results certain aspects are neglected.

**Garden Watering** – One of the greatest problems facing many municipalities is to curb the use of water for garden watering and particularly the use of hosepipes in areas where water is not being paid for by the consumers based on metered consumption. The situation is very serious and is currently being largely ignored by most municipalities and government departments.

From the investigations undertaken as part of the study, it was clear that there is a major problem issue in many areas due to uncontrolled garden watering. The problem is particularly evident in areas where water is not being paid for by residents or is being charged at a fixed tariff. The extent of the problem was much greater than expected and is causing serious problems for many Municipalities particularly when hosepipes are used to irrigate lawn areas as shown in

**Figure** 6.27 and **Figure 6.28**

**Figure 6.27: Typical garden irrigation in township area**

**Figure 6.28: Unauthorised irrigation in industrial area**

There are several key issues associated with garden watering which can be summarised as follows:

- Most municipal water supply systems cannot sustain the minimum level of service during peak demand periods when excessive garden irrigation takes place. Such irrigation causes major problems since the normal water pressure cannot be sustained in the higher lying areas. The influence of garden irrigation on the water demands is shown in **Figure 6.29** which highlights the water use during warm dry days and cool wet days in Sebokeng. The increase in garden irrigation results in an increase of almost 30% on the water demand in the area. The impact on the water pressure is shown in **Figure 6.30** which clearly highlights the problem of insufficient water pressure during the high irrigation periods. It should be noted that that the key problem is not the irrigation of gardens as such but rather the abuse of water where residents irrigate during the peak demand periods using hosepipes which in many instances are left running unattended for many hours. Many of the systems have been designed to provide a reasonable water supply even in cases where there is no payment for water. Such systems cannot support many thousands of hosepipes running simultaneously during the peak demand periods.

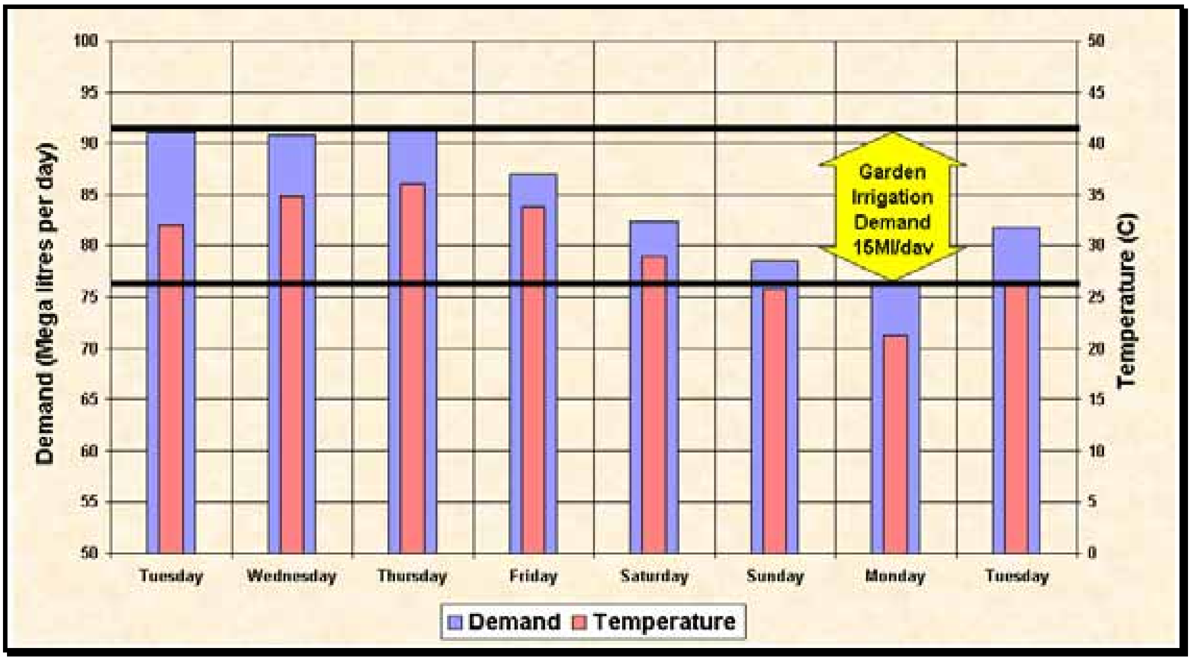



**Figure 6.29: Influence of garden irrigation on water demands in Sebokeng**

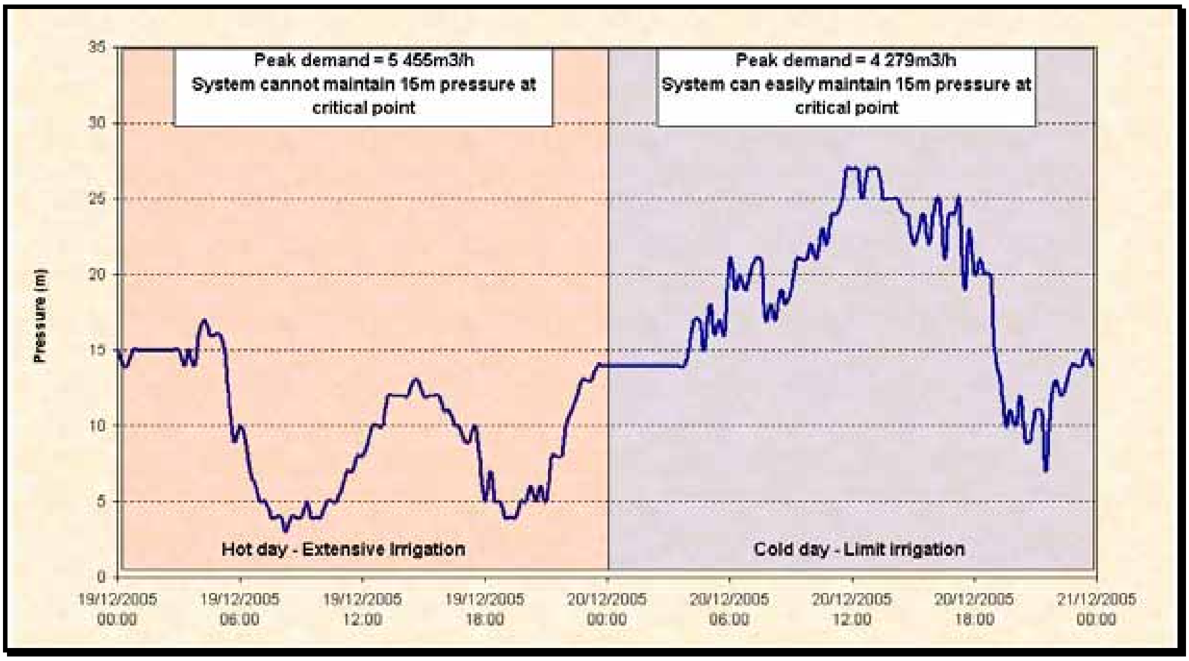



**Figure 6.30: Influence of garden irrigation on water pressures in Sebokeng**

- As a result of the excessive garden irrigation, the water percolates into the ground and eventually surfaces at the low points in the area as "man made groundwater". Such groundwater is shown in **Figure 6.31** and the consequences are shown in **Figure 6.32** which highlights the plight of one family who's house is located towards the low lying area in Sebokeng. The picture was taken during the winter period many months after the last rains of summer. The water shown in the picture is not sewer overflows but rather groundwater originating from garden irrigation in the higher lying areas of the suburb. The same situation has been observed in many other areas including Letabong in Rustenburg and in several parts of the Western Highveld area. In all of the cases, the houses were constructed on =relatively dry land which only became a marsh after the houses had been completed and the leakage/garden irrigation caused the excessive groundwater. The solution to this problem is quite simple and can be implemented immediately – a complete ban on hosepipe use. Alternatively, hosepipe use can be restricted to allow irrigation for a maximum of 1 hour every 2nd day as is currently the case in many parts of South Africa (e.g. Knysna) where users who pay for water are restricted on all irrigation use.

**Figure 6.31: "Man made groundwater" in Rustenburg**


**Figure 6.32: House damaged by man made groundwater in Sebokeng**

Another interesting issue that arose concerning garden watering relates to the recent promotion of vegetable gardens in many low income areas. It has been shown that a healthy diet can help to reduce the ravages of aids and TB. Many such gardens are now being established in many parts of South Africa as shown in **Figure 6.33** and **Figure 6.34**.

**Figure 6.33: Vegetable garden in Sebokeng irrigating with potable water**

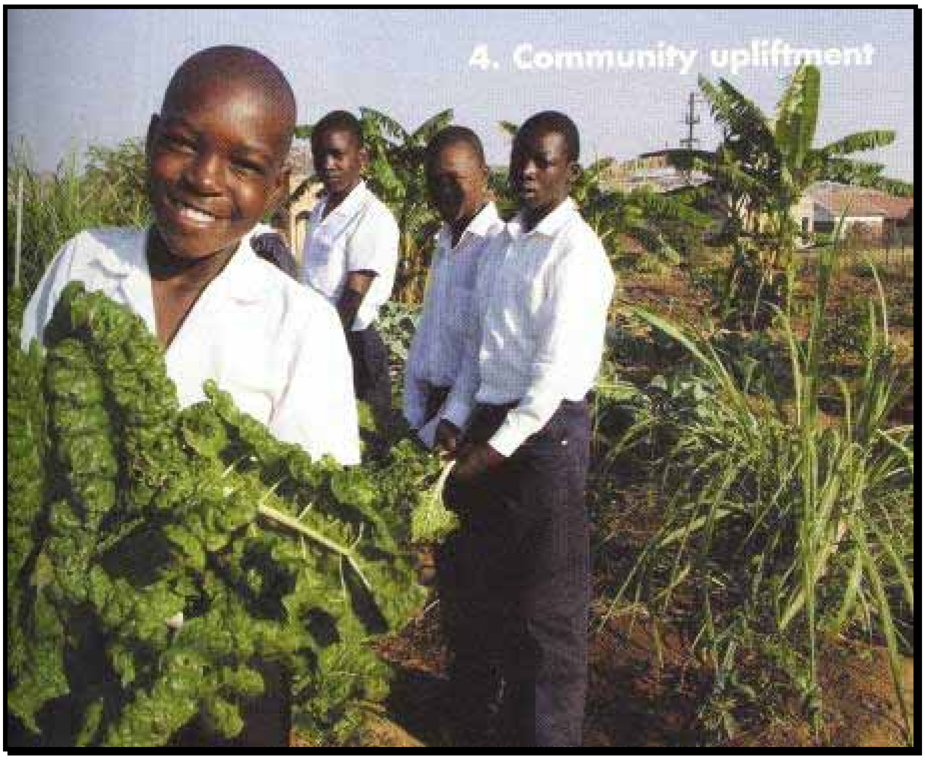



**Figure 6.34: Vegetable growing in low income areas** **(Photo courtesy Food and trees for Africa)**

While the motives of the various government organisations and NGO's such as Food and Trees for Africa are to be highly commended for their efforts and good intentions, there is a problem when the residents use potable water to irrigate the crops using hosepipes. One government Department (Department of Agriculture) has even gone to the extent of providing free hosepipes to residents to help them establish their vegetable gardens – in the same area that DWAF has spent R800 000 on a public education campaign to discourage the use of hosepipes. The situation becomes ridiculous when some residents are happy to use potable water to grow vegetables when many of their neighbours now experience intermittent water supply which can result in typhoid and cholera due to the ingress of sewage into the empty water supply pipes.

### 6.5.2 Johannesburg main water loss contributing areas

Key problem areas include Alexandra; Diepsloot and Soweto. These areas are mainly low cost housing areas with a history of non-payment.

**Alexandra**

The Alexandra district has a consumption of 40.8 Mℓ/day and a minimum night flow of approximately 1000 $m^3$/hr (based on previous logging results). There are 3 distinct zones: Alexander proper, the Jukskei strip (West & East bank), and the Far East Bank.

All three districts are metered individually and have upper and lower zones as well as sub zones) most of which have already been fitted with PRV's). There are no reservoirs or towers with the result that supplies fed directly from Johannesburg (Randjeslaagte system) into Alexandra proper, and from Sandton (Linbro Park system) into the West/East and Far East Bank.

**Diepsloot**

This large area incorporates serviced and unserviced (water tankers) sites. The population is estimated to be in excess of 30 000. There is a single metered supply point into Diepsloot West (fully serviced) with a consumption of 1.3Mℓ/day. The night time pressure at the critical point is 4.7 bar or 47 m. There is an unmetered supply feeding the Diepsloot Reception camp (via water tankers) and Tanganani (fully serviced). The estimated consumption for Tanganani is 0.48 Mℓ/day and the night time pressure at the critical point is 6.7 bar or 67 m. Six PRV installations were installed to reduce the pressures in this area.

**Soweto**

Soweto is the biggest township area in South Africa with average consumption of between 50 and 70$m^3$/household/month. The City of Johannesburg embarked on a major project to reduce losses and increase revenue in this area. Details are discussed in **Section 7.3**.

### 6.5.3 Ekurhuleni main water loss contributing areas

Key problem areas include Tokoza, Benoni Central, Germiston, Daveyton/Etwatwa; Brakpan Central, Vosloorus, Katlehong, Tembisa, Kwa Thema and Duduza.

**Brakpan Central**

Brakpan Central is supplied directly from Rand Water measured through eight Rand Water meters. Two of these meters supply the Brakpan reservoir, which supplies the Brakpan tower through a pump. The area is mostly residential except for the southern part which is industrial. There are five pumps in this zone to boost the pressure to high lying areas. The area has a minimum night flow of 407m$^3$/h and an average of 694m$^3$/h.

**Tsakane/ Langeville**

Langaville, Geluksdal and Tsakane areas are residential areas and are supplied directly from Rand Water and the Tsakane East and West reservoir complexes. The areas have an average flow of almost 1200 m$^3$/h. Unfortunately, the minimum night flow cannot be calculated.

**Phomolong**

Phomolong is mostly residential zone and is supplied from the Chloorkop Reservoir. The area has a minimum night flow of 121 m$^3$/h and an average flow of 227m$^3$/h. The expected minimum night flow is 21m$^3$/h.

**Umthambeka / Entshonalanga**

Umthambeka and Entshonalanga are supplied directly from Rand Water through a pressure reducing valve. The expected minimum night flow was 16 m$^3$/hr and the logged minimum night flow varied between 90 and 160 m$^3$/hr indicating excess night flow of between 78 and 147 m$^3$/hr.

**Germiston Zone 22-2 (Moleleki – East, Zonkiziwe Ext 2, 3, 5 and Southern Areas)**

This zone is supplied by the New Palm Ridge Reservoir. The logged minimum night flow is 353 m$^3$/h and the average 500 m$^3$/h. The expected minimum night flow for this area is 51 m$^3$/h.

**Germiston Zone 6 (Sunny Ridge, Gerdview, Homestead, Primrose, Marlands & Witfield)**

Zone 6 is a mixed residential (60%) and industrial (40%) zone supplied from Rand Water and the Sunnyridge Tower. The expected minimum night flow is 90m$^3$/hr and the logged minimum night flow was 244 m$^3$/hr indicating excess night flow of approximately 154 m$^3$/hr. The industrial night use was assumed at 50m$^3$/hr and was included in the MNF. The average night pressures at the low point and AZP were 104m and 65m respectively. The estimated pressures for these points were 145m and 98m respectively and suggests that there are internal PRV('s) in the zone that are operational.

**Germiston Zone 11 (Driehoek, Jupiter Ext. 3, South Germiston Exts. & Industries West)**

Zone 11 is mixed residential (30%) and industrial (70%) zone supplied from Rand Water through a 150 mm diameter Bermad PRV. The expected minimum night flow is 54 $m^3$/hr and the logged minimum night flow was 220 $m^3$/hr indicating excess night flow of approximately 166 $m^3$/hr. The industrial night use was assumed at 50 $m^3$/hr and was included in the MNF.

**Germiston Zone 3 (Bedfordview – North of Kloof Rd and East of the N3)**

Zone 3 is supplied by the Signal Hill reservoir.as well as a direct supply from RW 0017 (Bedford Fire Meter). The expected minimum night flow is 25 $m^3$/h and the logged Minimum Night Flow was 411 $m^3$/hr indicating an excess night flow of 386 $m^3$/hr. Pressures in the zone are unacceptably high with the low point reaching pressures in excess of 120 m during low flow periods and the critical point as much as 80 m.

**Germiston Zone 19-2 (Motsami, Mopeli, Hlahatsi, Phake, Phooko, Tsolo, Palime, Hlongwane, Moseleke, Imfokeng, Moleleki Ext 4, Hlongwane, Ndhlazi, Mokoena, Monise, Moseleke East**

Zone 19.2 is supplied from the Credi Reservoir. The expected minimum night flow is 52 $m^3$/h. The actual minimum night flow of 354 $m^3$/h. Giving an excess minimum night flow of 302 $m^3$/hr.

**Nigel Central**

Nigel consists of eleven management zones supplied from Rand Water connections. The area includes three towers, nine reservoirs and no PRV's. The logged minimum night flow is 354 m3/h and the average 405 $m^3$/h.

**Vosloorus Tower**

The expected minimum night flow was 90 $m^3$/hr and the calculated minimum night flow was 262 $m^3$/hr indicating excess night flow of more than 170 $m^3$/hr. The MNF was determined by applying the same flow distribution recorded in the Reservoir Zone to the total consumption of the Tower Zone.

**Vosloorus Reservoir**

The expected minimum night flow was 152 $m^3$/hr and the calculated minimum night flow was 375 $m^3$/hr indicating excess night flow of approximately 222 $m^3$/hr. The MNF was determined by applying the same flow distribution recorded at one of the reservoir outlet meters to the entire expected flow from the reservoir.

**Tembisa high level zone (T1)**

Tembisa high level zone is supplied directly from Rand Water, measured through Rand Water Meter RW1744 (600 mm Meinecke). After the Rand Water meter, the pipeline splits into a 400 mm and a 500 mm diameter steel pipeline. These pipelines supply the Tembisa high-level zone directly and the Tembisa reservoirs which supply the low level zone.

**Tembisa reservoir zone (T2)**

The zone is 100% residential and is supplied by the Tembisa Reservoir. Flow from the reservoir is metered through six outlet meters (M8.1 – M8.6) the meters are all operational. The reservoir is supplied by Rand Water metered through Meter RW 1744.

**The following findings were based on the analysis of the logging results.**

The average flow logged through the six supply meters to Tembisa Zone T2 was 1 270m$^3$/hr with a logged minimum night flow of 700 m$^3$/hr, which represents 55% of the average flow. The expected minimum night flow is 188 m$^3$/hr indicating excess night flow in the order of 516 m$^3$/hr. These figures indicate high water loss / wastage in the zone.

Pressure loggings in the zone indicate that the zone is operating within a pressure envelope of 3 – 70m. Pressure loggings also indicate that there are operational PRV's reducing pressures to small areas within the zone.

### 6.5.4 Tshwane main water loss contributing areas

**ODI Region**

The Odi region consists of Ga-Rankuwa, Mabpoane, Hebron and Winterveld. The area has a combined minimum night flow of 700m3/h and expected minimum night flow of 415 m$^3$/h. The average consumption per property is in excess of 30 m$^3$/property/month

**Temba area**

The Temba area consists of Temba, Hammanskraal and most of the Moretele Municipal supply area. The system is characterised by intermittent supply, illegal connections and almost no cost recovery.

### 6.5.5 Emfuleni main water loss contributing areas

**Evaton-Sebokeng**

Flow logging results of the RW2908 and RW1084 metered supply are consistent with normal diurnal trends however; the combined MNF of 2700 $m^3/h$ is 72% of the average (3 775 $m^3/h$) which suggests high night usage, wastage and/or high background leakage. Although these two trunk mains are recorded as being inter-connected at the township boundary, the operating pressures indicate that zoning is being implemented. Full details of the Sebokeng and Evaton pressure management project are provided in **Section 7.2**.

### 6.5.6 Rustenburg main water loss contributing areas

**Thlabane high level**

Tlhabane high level is a residential zone supplied from the Tlhabane upper reservoir complex. The area has a minimum night flow of 61 $m^3/h$ and average flow rate of 95 $m^3/h$ .

**Tlhabane Lower Level**

Tlhabane lower level is a residential zone supplied from the Tlhabane lower reservoir. Flow to the zone is metered through two meters, M843 (Meinecke WP 200) and M217 (Meinecke WPD 250).

**Lethabong**

Lethabong has two bulk supply reservoirs, namely the Lethabong Low Level Reservoir and the newly constructed Lethabong High Level Reservoir. The area is supplied by Magalies Water via the Kortbegrip reservoir. The area has a miimum night flow of 104 $m^3/h$ and average flow of 124 $m^3/h$ .

**Boitekong**

Boitekong is a residential zone supplied from the Bospoort reservoir through a PRV and a 500 diameter WP water meter. The area has a logged minimum night flow of 176 $m^3/h$ and an average flow rate of 242 $m^3/h$ .

### 6.5.7 Matjhabeng main water loss contributing areas

**Thabong**

Thabong consists of approximately 23 600 stands with an average size of 260 $m^2$ of which approximately 18 400 are developed properties. The area operates as a single zone and is supplied directly from Sedibeng Water through two bulk metered connections. There is no form of flow control at these supply points. The area is fully serviced with metered connections at the street front. Meters are read monthly and consumers billed accordingly. Historical consumption figures received from Matjhabeng Municipality indicate an average metered consumption of ±44$m^3$/month/property. Logging results indicate a minimum night flow of 400 $m^3$/h and average of 622 $m^3$/h. The expected minimum night flow is 180 $m^3$/h.

### 6.5.8 Water balance calculations

In order to understand the potential for water savings in each municipality, the first step was to derive a standard annual water balance using the latest International Water Association methodology. While such water balances are very helpful and are now required annually by DWAF, they must be used with caution since certain components are to some extent subjective. For example, the basic water balance will provide a realistic indication of the total Non-Revenue water and the Total Losses. In most cases these two components are almost the same, however, it is often very difficult to split the Total Losses into the Administrative Losses (Apparent Losses) and the Physical Losses (Real Losses). Where possible, this split was undertaken based on information supplied by the Municipality with regard to their own estimates of the quality of their meters as well as the level of water theft in their systems. In addition, many of the municipalities have two different departments covering the technical aspects and the billing aspects of the water supply. In such cases, the billing and cost recovery aspects are managed by Treasury and in many cases, the Treasury departments are not able to provide proper information on the water billed or level of recovery. In such cases, the split between the Real and Apparent losses may not be accurate although this will not influence either the Non Revenue Water or the Unaccounted for Water. The results from the various water audits undertaken for each Municipality are provided in **Figures 4.19 to 4.27.**

Johannesburg has great potential for water savings mainly as a result of Soweto where the monthly consumption is around 60kℓ/property/month. The non-revenue water is 33% of the system input volume

Ekurhuleni has reasonable potential for water savings but not of the same magnitude as Johannesburg. Although the levels of payment is low in the low cost housing areas, the average monthly consumption in most areas are less than 20kℓ/property/month. The non-revenue water is 31% of the system input volume.

The potential for savings in Tshwane lies mainly in ODI and Temba areas. These areas have a history of poor services and non-payment and will take a few years to resolve. The non-revenue water is 26% of the system input volume.

Emfuleni has highest level of non-revenue water of the nine municipalities. This mainly due to the high average monthly consumption in Sebokeng / Evaton of 28kℓ/property/month with no payment. The non-revenue water is 62% of the system input volume.

The non-revenue water in Mogale City is 25% of the system input volume. The non-revenue water in this area is under control with the introduction of pre-paid meters in Kagiso. This is also the first municipality to implement pressure management in South Africa.

The non-revenue water in Rustenburg is 30% of the system input volume.

WATER BALANCE FOR: **CITY OF JOHANNESBURG** 2004 - 2005

| | | |
|---|---|---|
| 1 | Bulk system Input volume | 470.49 |
| 2 | Authorised consumption | 379.62 |
| 3 | Billed authorised | 316.89 |
| | Unbilled authorised | 62.73 |
| | Total losses | 90.87 |
| 4 | % Total losses apparent | 15 |
| | Real losses | 77 |
| | Apparent losses | 14 |
| | Revenue water | 317 |
| | Non-Revenue water | 154 |

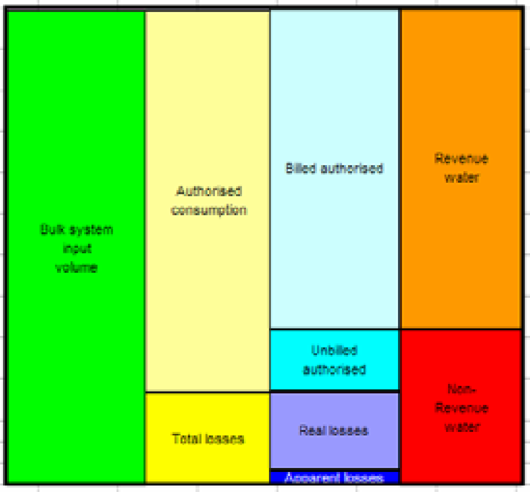



**Figure 6.35: Water balance for Johannesburg (million m$^3$/annum)**

WATER BALANCE FOR: **EKURHULENI** 2004 - 2005

| | | |
|---|---|---|
| 1 | Bulk system Input volume | 291.46 |
| 2 | Authorised consumption | 222.44 |
| 3 | Billed authorised | 200.2 |
| | Unbilled authorised | 22.24 |
| | Total losses | 69.02 |
| 4 | % Total losses apparent | 15 |
| | Real losses | 59 |
| | Apparent losses | 10 |
| | Revenue water | 200 |
| | Non-Revenue water | 91 |

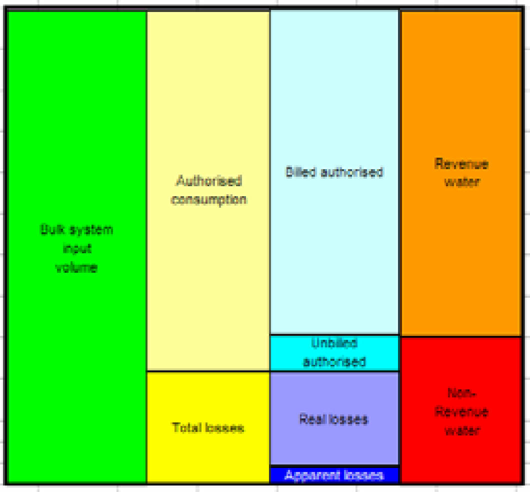
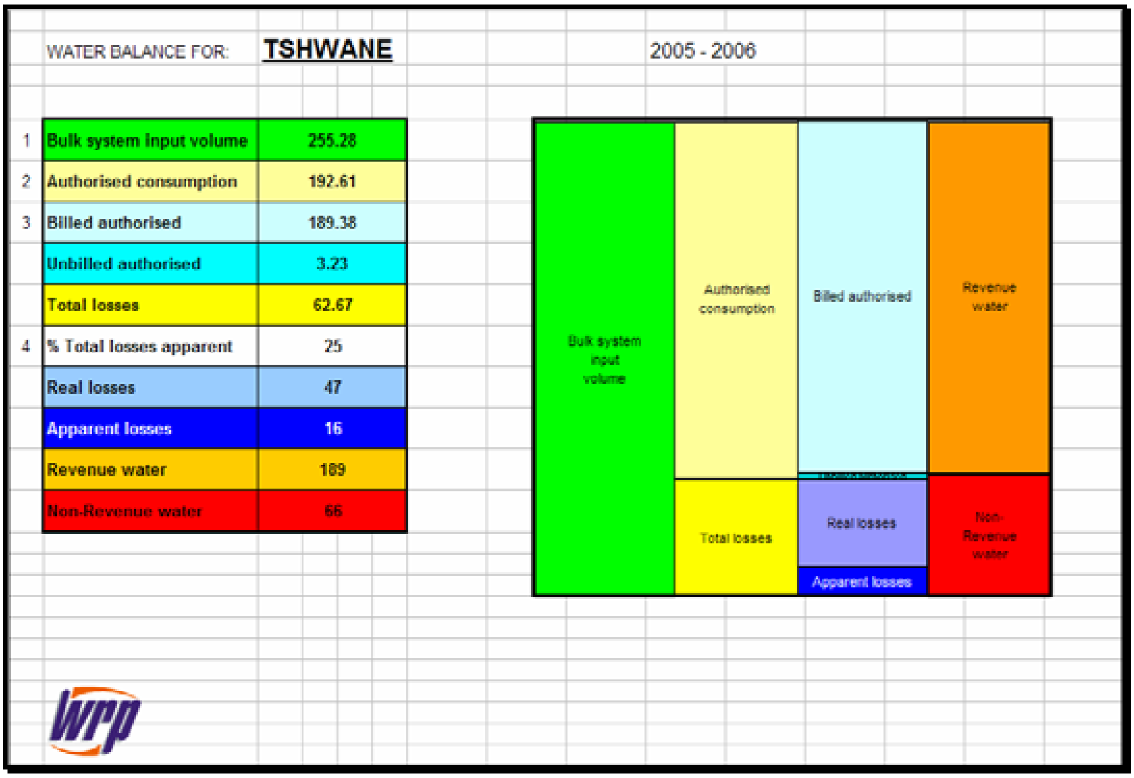



**Figure 6.36: Water balance for Ekurhuleni (million m$^3$/annum)**

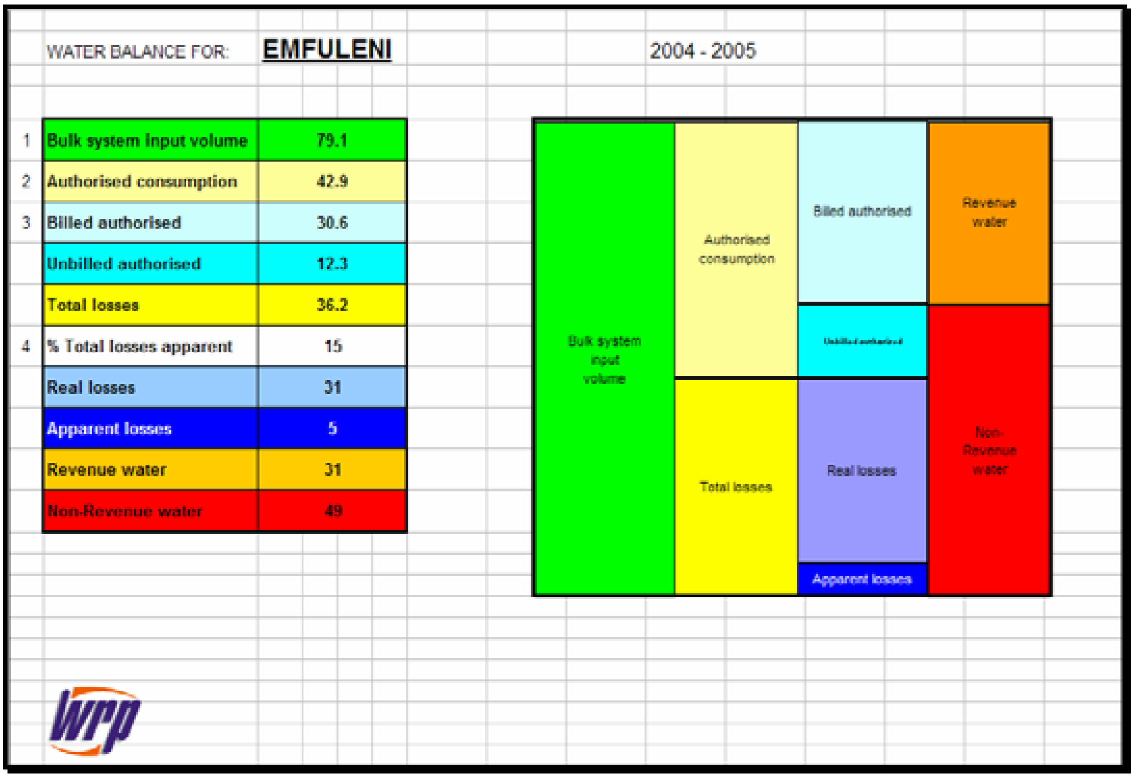


WATER BALANCE FOR: **TSHWANE** 2005 - 2006

| | | |
|---|---|---|
| 1 | Bulk system Input volume | 255.28 |
| 2 | Authorised consumption | 192.61 |
| 3 | Billed authorised | 189.38 |
| | Unbilled authorised | 3.23 |
| | Total losses | 62.67 |
| 4 | % Total losses apparent | 25 |
| | Real losses | 47 |
| | Apparent losses | 16 |
| | Revenue water | 189 |
| | Non-Revenue water | 66 |



**Figure 6.37: Water balance for Tshwane**

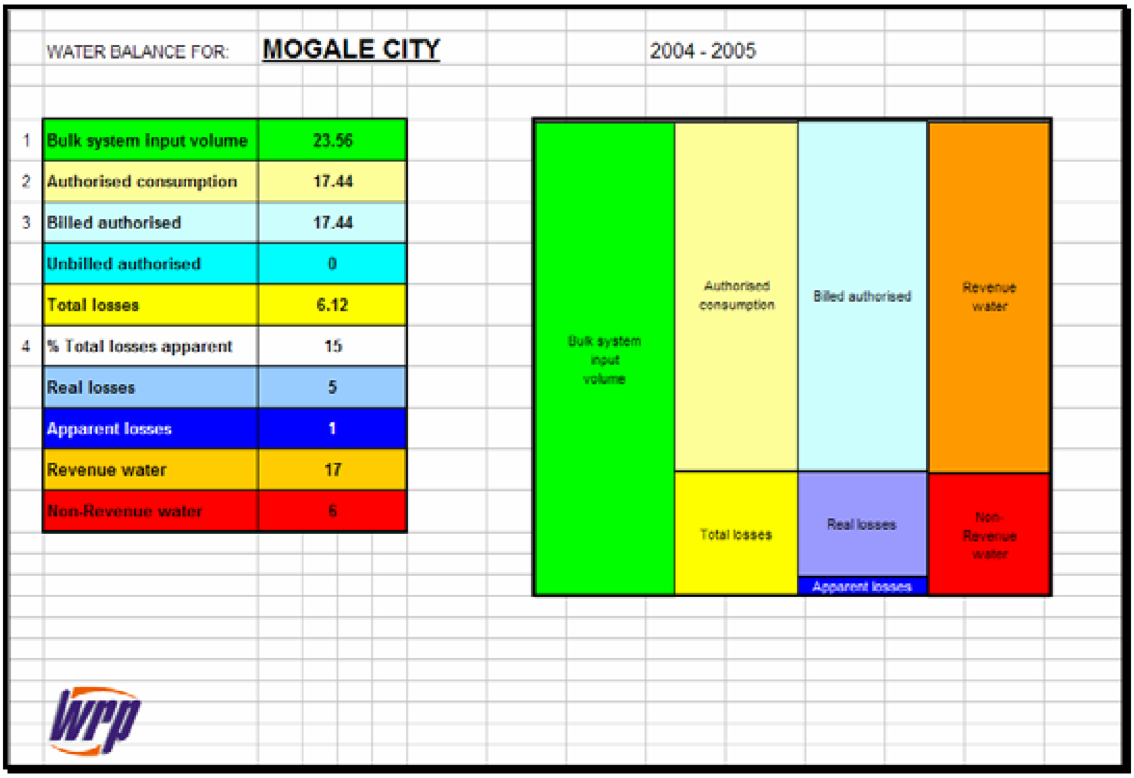


WATER BALANCE FOR: **EMFULENI** 2004 - 2005

| | | |
|---|---|---|
| 1 | Bulk system Input volume | 79.1 |
| 2 | Authorised consumption | 42.9 |
| 3 | Billed authorised | 30.6 |
| | Unbilled authorised | 12.3 |
| | Total losses | 36.2 |
| 4 | % Total losses apparent | 15 |
| | Real losses | 31 |
| | Apparent losses | 5 |
| | Revenue water | 31 |
| | Non-Revenue water | 49 |



**Figure 6.38: Water balance for Emfuleni (million $m^3$/annum)**

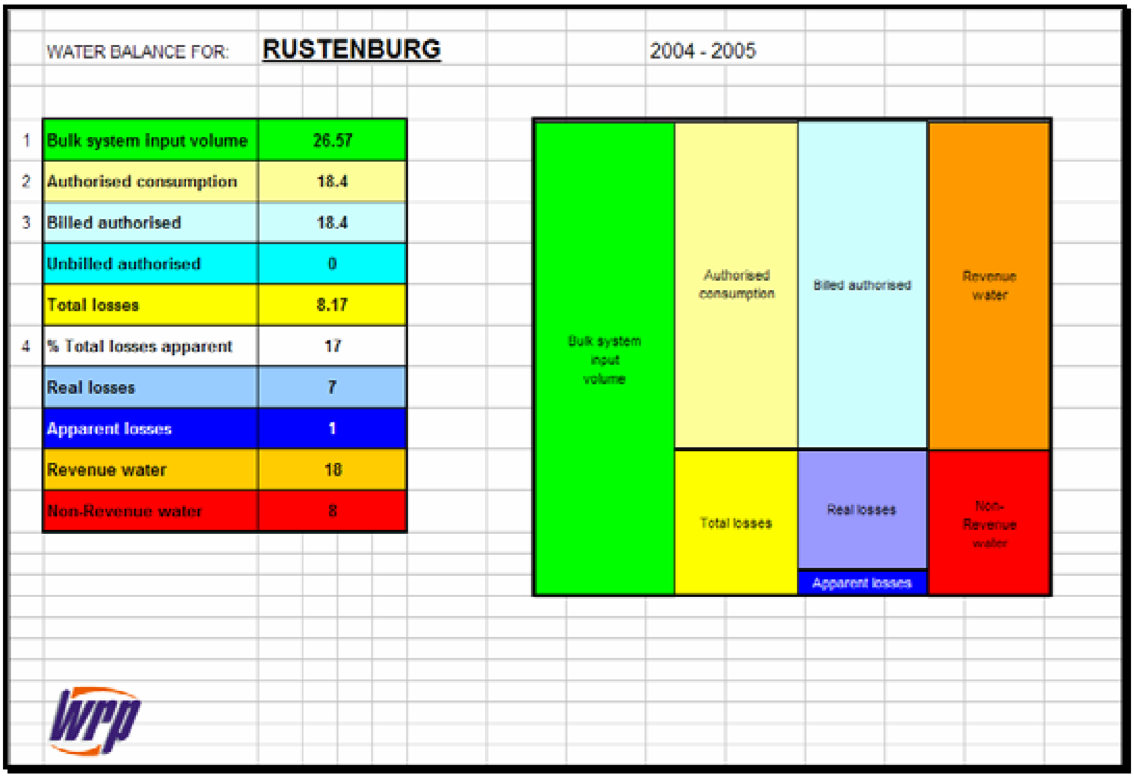


WATER BALANCE FOR: **MOGALE CITY** 2004 - 2005

| | | |
|---|---|---|
| 1 | Bulk system Input volume | 23.56 |
| 2 | Authorised consumption | 17.44 |
| 3 | Billed authorised | 17.44 |
| | Unbilled authorised | 0 |
| | Total losses | 6.12 |
| 4 | % Total losses apparent | 15 |
| | Real losses | 5 |
| | Apparent losses | 1 |
| | Revenue water | 17 |
| | Non-Revenue water | 6 |



**Figure 6.39: Water balance for Mogale (million m$^3$/annum)**

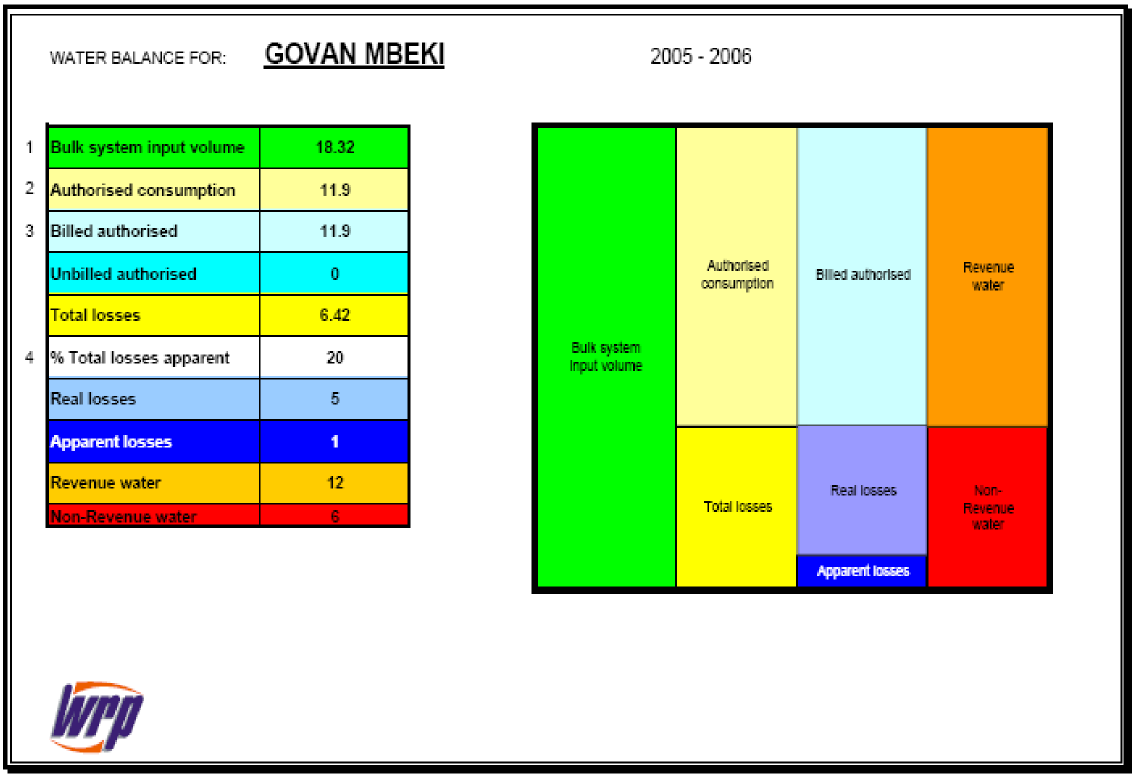


WATER BALANCE FOR: **RUSTENBURG** 2004 - 2005

| | | |
|---|---|---|
| 1 | Bulk system Input volume | 26.57 |
| 2 | Authorised consumption | 18.4 |
| 3 | Billed authorised | 18.4 |
| | Unbilled authorised | 0 |
| | Total losses | 8.17 |
| 4 | % Total losses apparent | 17 |
| | Real losses | 7 |
| | Apparent losses | 1 |
| | Revenue water | 18 |
| | Non-Revenue water | 8 |



**Figure 6.40: Water balance for Rustenburg (million m$^3$/annum)**

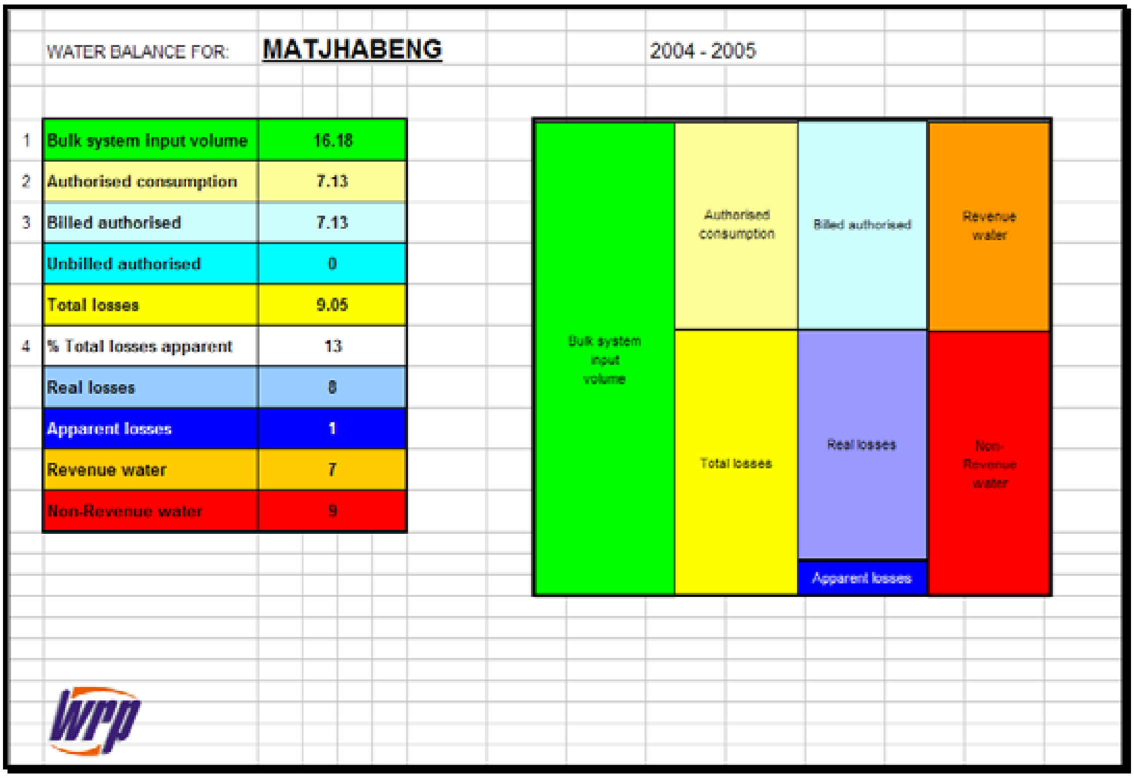


WATER BALANCE FOR: **GOVAN MBEKI** 2005 - 2006

| | | |
|---|---|---|
| 1 | Bulk system input volume | 18.32 |
| 2 | Authorised consumption | 11.9 |
| 3 | Billed authorised | 11.9 |
| | Unbilled authorised | 0 |
| | Total losses | 6.42 |
| 4 | % Total losses apparent | 20 |
| | Real losses | 5 |
| | Apparent losses | 1 |
| | Revenue water | 12 |
| | Non-Revenue water | 6 |



**Figure 6.41: Water balance for Govan Mbeki (million $m^3$/annum)**



WATER BALANCE FOR: **MATJHABENG** 2004 - 2005

| | | |
|---|---|---|
| 1 | Bulk system input volume | 16.18 |
| 2 | Authorised consumption | 7.13 |
| 3 | Billed authorised | 7.13 |
| | Unbilled authorised | 0 |
| | Total losses | 9.05 |
| 4 | % Total losses apparent | 13 |
| | Real losses | 8 |
| | Apparent losses | 1 |
| | Revenue water | 7 |
| | Non-Revenue water | 9 |



**Figure 6.42: Water balance for Matjhabeng (million $m^3$/annum)**

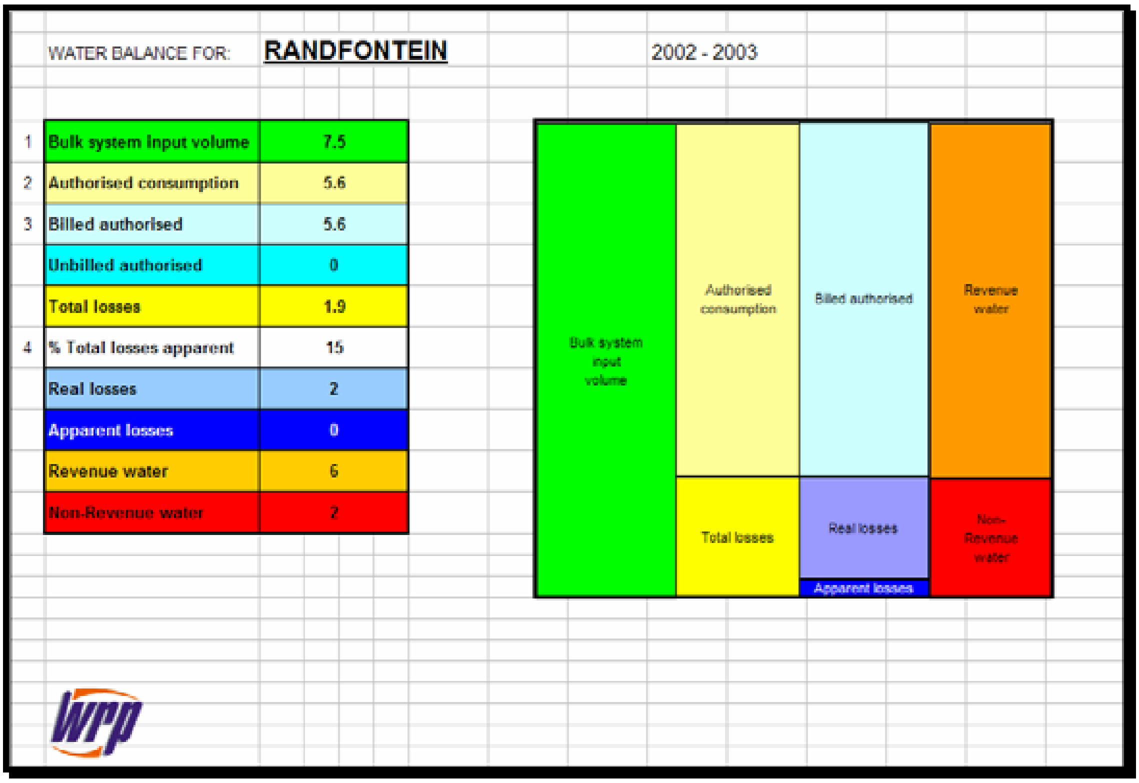



**Figure 6.43: Water balance for Randfontein (million m$^3$/annum)**

### 6.5.9 Summary of ILI Values for major centres

The infrastructure leakage index (ILI) is a performance indicator used to assess the levels of Real Losses in a system. It is very useful in highlighting the areas where losses are relatively high although it must be used with some caution since the value can sometimes be sensitive to certain assumptions used in the calculation. In short, the ILI is a dimensionless indicator where the actual annual real losses (i.e. physical leakage) is divided by the Unavoidable Annual Real Leakage (UARL) and the resulting indicator will vary from around 1 up to over 20 in some areas. A value of 1.0 suggests that the physical leakage from the system is as low as can possibly be achieved in a perfectly managed system. A value of 2 indicates that the actual leakage is twice the possible minimum value and an ILI of 10.0 suggests that the actual leakage is 10 times the potential minimum value. It is rarely possible to achieve a value close to 1 and in the South African situation a value of between 3 and 4 would normally be considered acceptable. A value higher than 4 indicates that there is a leakage problem and action should be taken to address the problem. The higher the ILI value, the greater the leakage problem. It should also be noted that the figures provided in **Table 6.6**, are “lumped” figures for the whole Municipality or Metro. The areas were split into smaller areas and ILI values were assessed individually for each area from which the key problem areas were identified. In this manner it is possible to concentrate efforts in the areas where the most significant gains can be achieved at the least cost.

**Table 6.6: ILI Values for main centres**

| Area | Annual Demand (million m3) | ILI Value (2005) |
|---|---|---|
| Johannesburg | 470 | 7.2 |
| Ekurhuleni | 291 | 4.5 |
| Tshwane | 255 | 5.2 |
| Emfuleni | 79 | 7.3 |
| Rustenberg | 26 | 8.6 |
| Mogale | 24 | 3.4 |
| Govan Mbeki | 18 | 2.6 |
| Matjhabeng | 16 | 8.0 |
| Randfontein | 7 | 4.0 |
| **Total** | 1 186 | |

## 6.6 TASK 4D: WATER SAVING SCENARIOS

### 6.6.1 Introduction

In order to evaluate the potential savings that can be achieved through normal WC/WDM measures, the project team developed 3 scenarios which were provided to the planning team for use in the subsequent system analyses. The three scenarios are labelled Scenario c, Scenario d and Scenario e and they are based on the following :

**Scenario C: 5 Years water loss programme and efficiency**

- water losses can be controlled within the next 5 years (2005 to 2010) and maintained afterwards.
- water use efficiency is implemented by targeting the billed consumption. It was assumed that a 1% per annum efficiency can be gained from 2015 increasing to 30% in the year 2025.

This scenario is the most optimistic with regard to the savings that can be achieved and involves both savings from the Non-Revenue Water as well as savings from the Revenue Water which are assumed to take place over 5 years and 10 years respectively.

The savings from the Non-revenue water concentrate on issues such as leakage detection and repair in areas where consumers have high levels of payment and any losses after the customer meter are basically considered to be part of the customer demand – normally these losses are relatively small since the customer will identify any household leakage and repair the leaks quickly. In the case of areas where the level of payment is very low or is based on a "lump-sum" tariff, the losses tend to be greatest inside the properties after the consumer meter. In many cases, no accounts are sent to the consumers or the accounts are so high that they are generally ignored and payment will never be received by the Municipality. In such areas, the general monthly water demand per property (assuming that there is full 24-hour supply) is usually between 55 $m^3$/month and 35 $m^3$/month. If the water use can be controlled in some manner through proper metering with billing and cost recovery (often using pre-paid meters etc), the water demand tends to drop to approximately 10 $m^3$/month. In many cases, the revenue generated from the water sales is insufficient to justify the expense of metering and billing, however, the real saving to the municipality can be in the order of 40 $m^3$/month which is often sufficient to justify major investment. This is currently the situation in Soweto where over 160 000 pre-paid water meters are being installed and a very similar situation was found in Kagiso where approximately 20 000 pre-paid meters were installed. It should be noted, that the total cost of implementing such pre-payment involves not only the cost of the meter (approximately R1 200 each) but also the continual cost of maintenance as well as a significant cost for consumer education and constant customer support. The associated costs often exceed the basic capital cost of the equipment required.

In the medium and high income areas, the main WC/WDM measures that can be used to reduce wastage (reduction in customer demand is not considered at this stage) concentrated on the reduction in losses from physical leakage before the customer meter. In these areas, most of the water supplied to consumers is both metered and paid for by the consumer and therefore wastage inside the properties tends to be relatively small and is not the serious problem that exists in many of the low income areas. Although the physical leakage is considered to be the main problem issue in the middle and high income areas, the levels of leakage tend to be relatively small compared to the levels experienced in the low income areas and therefore the potential savings that can be achieved are also small.

In Scenario c, it was also assumed that some savings could be achieved through more efficient water practices inside the properties. This typically involves the use of water efficient appliances (washing machines, toilet cisterns etc) as well as low flow shower heads and water efficient gardens where irrigation is either not required or significantly reduced. Typical examples of water efficient gardens are shown in **Figure 6.44** and **Figure 6.45**.

**Figure 6.44: Water efficient garden**


**Figure 6.45: Water efficient gardening at Johannesburg University**

**Scenario d: Reduction in wastage over 5 years**

- Water losses can be controlled within the next 5 years (2005 to 2010) and maintained afterwards.
- No water use efficiency is introduced.

Scenario d is basically the same as Scenario c with the exception that it only addresses the reduction in wastage and does not include any saving from more efficient water practices. This scenario assumes that certain actions can be implemented over a period of 5 years after which the capital costs will decrease and only maintenance costs will remain. This is potentially problematic for the water utilities since their capital costs and much of their operational costs are fixed while the income is dependant on the water sales. To reduce the overall demand can cause problems to the financial viability of a water utility.

**Scenario e: Reduction in wastage over 10 years**

- Water losses can be controlled within the next 10 years (2005 to 2010) and maintained afterwards.
- No water use efficiency is introduced.

Scenario e is basically the same as Scenario d and only addresses the reduction in wastage. This scenario, however, assumes that certain actions can only be implemented over a period of 10 years which is considered to be more realistic than Scenario d based on practical experience gained by the project team from many WC/WDM projects. This is a more favourable and realistic scenario than either of the two previous scenarios.

### 6.6.2 Methodology

In order to make a proper assessment of the potentials savings that can be achieved it was first necessary to obtain basic information for each management area. The basic information was captured in spreadsheets and used in the water balance and potential savings analyses. The basic information captured for each area is summarised in **Table 6.7**.

It should be noted that the basic information was obtained mainly from previous detailed investigations that often included field investigations, loggings, analysis and documentation. Estimated were made when the required detailed information did not exist. This included extrapolating the logging results for the whole area when only parts were logged or assuming the minimum night flow as 50% of the average daily flow if no information existed. Available logging results for the nine municipalities are summarised in

**Table 6.7: Summary of basic information for each management area**

| Information | Unit | Information |
|---|---|---|
| **GENERAL** | | |
| Population (Census 2001) | No | From Census 2001 |
| Households (Census 2001) | No | From Census 2001 |
| Population / property | Pop/prop | Calculated |
| Annual growth rate | % | Census 1996 to 2001 |
| Population (2005) | No | Calculated using Census growth rate |
| Households (2005) | No | Calculated using Census growth rate |
| Free basic water households | No | From municipality |
| Metered connections | No | From treasury |
| Unmetered connections | No | From municipality |
| Standpipe connections | No | From municipality |
| Length of Mains | km | From municipality |
| Density of connections | No/km | Calculated |
| Number of zones | No | From municipality |
| Storage capacity | Ml | From municipality |
| Storage structures | No | From municipality |
| Control valves | No | From municipality |
| Management meters | No | From municipality |
| **SYSTEM INPUT VOLUME** | | |
| Bulk supply connections | No | From municipality |
| Bulk water supplier | Name | From municipality |
| Input volume 1998-2005 | $m^3$/annum | From municipality Jul '98- Jun '05 |
| **BILLED METERED CONSUMPTION** | | |
| Billed consumption for each year | $m^3$/annum | From municipality Jul '98- Jun '05 |
| % of system input volume (2004-05) | % | Calculated |
| **BILLED UNMETERED CONSUMPTION** | | |
| Billed consumption for each year | $m^3$/annum | From municipality Jul '98- Jun '05 |
| % of system input volume (2004-05) | % | Calculated |
| **NON-REVENUE WATER** | | |
| Non-revenue water for each year | $m^3$/annum | Calculated |
| % of system input volume (2004-05) | % | Calculated |
| **RETURN FLOWS** | | |
| System return flows for each year | $m^3$/annum | From municipality |
| % of system input volume (2004-05) | % | Calculated |
| **LOGGING RESULTS** | | |
| Date logged | Date | From previous studies |
| Average pressure @ critical point | m | From previous studies |
| Average pressure @ lowest point | m | From previous studies |

| Information | Unit | Information |
|---|---|---|
| Average pressure @ average zone point | m | From previous studies |
| Maximum system pressure | m | From previous studies |
| Minimum Flow Rate | m3/h | From previous studies |
| Average Flow Rate | m3/h | From previous studies |
| Maximum Flow Rate | m3/h | From previous studies |
| Logged volume | m3/annum | From previous studies |
| Comments | - | |
| **NIGHT FLOW ANALYSIS** | | |
| Date of MNF | Date | From previous studies |
| Measured MNF | m3/h | From previous studies |
| Estimated Background Losses | m3/h | From previous studies |
| Estimated Normal Use | m3/h | From previous studies |
| Total expected MNF | m3/h | From previous studies |
| Excess Night Flow | m3/h | From previous studies |
| Estimated losses | m3/annum | From previous studies |
| **KEY PERFORMANCE INDICATORS** | | |
| 2001-02 (System input volume / population) | l/c/d | Calculated |
| 2001-02 (System input volume / households) | m3/prop/month | Calculated |
| 2004-05 (System input volume / population) | l/c/d | Calculated |
| 2004-05 (System input volume / households) | m3/prop/month | Calculated |

**Table 6.8: Status quo of flow and pressure loggings in various municipalities**

| Municipality | Description |
|---|---|
| Johannesburg | Pressure management study undertaken in 1999/2000. Approximately 20% of area logged with focus on high loss areas. Results extrapolated for whole area. Currently busy with logging of complete system as part of master plan. |
| Tshwane | Water loss study currently undertaken with detailed studies undertaken in Odi and Temba during 2001. Approximately 40% of area logged. |
| Ekurhuleni | Complete system logged and analysed during 2002/2003 |
| Emfuleni | Complete system logged and analysed during 2002 |
| Mogale | Complete system logged and analysed during 2002 |
| Randfontein | Complete system logged and analysed during 2002 |
| Govan Mbeki | Limited logging results are available |
| Matjhabeng | Thabong and Riebeeckstad logged by WRP at own cost in 2002 |
| Rustenburg | Parts of system logged and analysed during 2005. Currently extended. |

The basic information was used to calculate a water balance for each management area as discussed in **Section 6.5.8**. The water balance provides an indication of the possible savings that can be achieved through physical leakage and billed but not paid for consumption.

The potential saving through various interventions such as retrofitting and metering, pressure management, mains replacement and active leakage control can be calculated using case studies and internationally accepted standards. The assumptions made are summarised in

**Table 6.9**.

The potential savings calculated from the water balance and is then compared to the potential savings that can be achieved through various interventions. In each case, these two values should be close in order to establish a realistic potential saving. This methodology is shown in **Figure 6.46.**

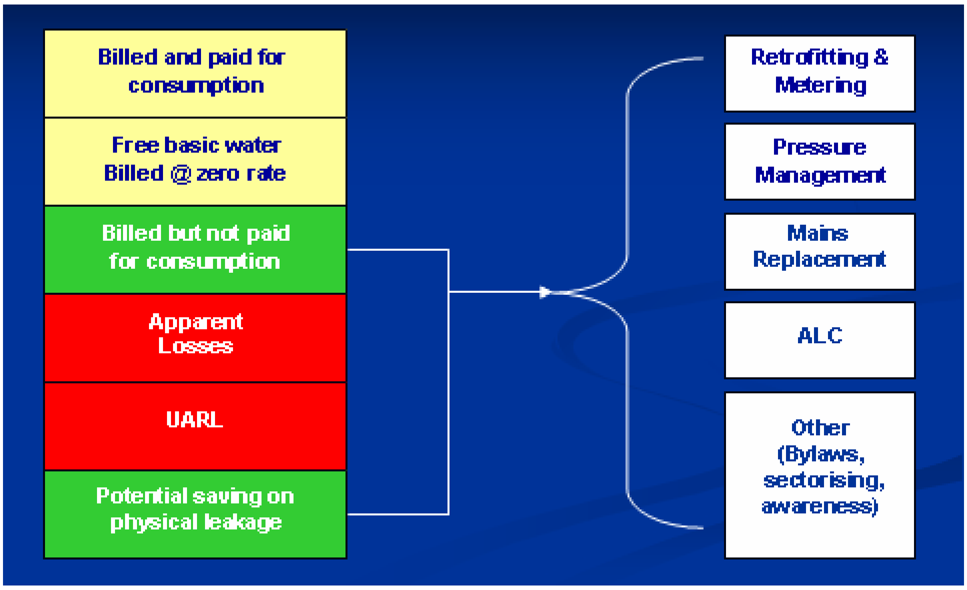



**Figure 6.46: Potential savings methodology**

**Table 6.9: Summary of savings through various interventions**

| Intervention | Potential saving | Comments |
|---|---|---|
| Pressure management | Reducing the estimated minimum night flow by 25% for the area | The minimum night flow is based on actual or extrapolated logging results. Where no logging results exist, it was assumed that the minimum night flow is 50% of the average flow. |
| Mains replacement | 200ℓ/km/hr | An average of 200ℓ/km/hr can be saved through mains replacement. |
| Active and passive leakage control | Estimated 1leak/km/annum running at 1.6m$^3$/hr for one week | |
| Retrofitting | 2 to 15kℓ/property/month with exceptional cases like Soweto where up to 50kℓ/property/month is saved. | These assumptions are based on the Leakage Reduction Projects undertaken by Rand Water (Rand Water, 2002) which indicated an average of 3 to 20m$^3$/property/month can be saved through retrofitting. |
| Sectorisation, water balance, | 1 to 5% reduction in overall consumption. | |

The assumptions made in assessing the potential costs are summarised in and is based on the volume of water saved through the various interventions as previously discussed.

**Table 6.10: Summary of WC/WDM costs**

| Intervention | Budget | Costs |
|---|---|---|
| Sectorisation | CAPEX | Establishment R 20 000 / zone |
| | OPEX | Maintenance at R 5 000 /zone |
| Pressure management | CAPEX | Actual costs or best estimate |
| | OPEX | R 5000 / control valve / annum |
| Mains replacement | CAPEX | Replace 2% / annum @ R 150 /m |
| Active and passive leakage control | OPEX | R 1500 / km |
| Retrofitting & removal of wasteful devices | CAPEX | 5% of properties @ R 1000 / property |
| Meter reading, billing & cost recovery | CAPEX | Consumer meter audit @ R 50 / meter |
| | OPEX | Monthly meter reading @ R 5 / meter |
| Education and awareness campaigns | OPEX | R 5 / consumer / month |
| Water audits / manage KPI's | OPEX | R 1500 / zone / month |
| Management meters | CAPEX | New meters @ R 50 000 / meter |
| | OPEX | Replace 10% / annum @ R 5 000 / meter |
| Consumer meters | CAPEX | New meters @ R 1000 / meter |
| | OPEX | Replace 10% / annum @ R 500 / meter |

### 6.6.3 Results

The detailed summaries for the potential savings are included in **Appendix F**.

**Scenario C: 5 Years water loss programme and efficiency**

The results for Scenario C are summarised in **Tables 6.10 and 6.11 and Figures 6.47 to 6.51.**

**Table 6.11: Scenario c: Summary of potential savings**

| Year | Demand without WC/WDM (mcm/a) | Demand with WC/WDM (mcm/a) | Reduction (mcm/a) | % Reduction |
|---|---|---|---|---|
| 2004-05 | 1 165.8 | 1140.0 | 25.8 | 2% |
| 2009-10 | 1 248.1 | 1063.2 | 184.9 | 15% |
| 2014-15 | 1 337.5 | 1053.1 | 284.4 | 21% |
| 2019-20 | 1 434.6 | 1080.7 | 353.9 | 25% |
| 2024-25 | 1 540.3 | 1109.1 | 431.2 | 28% |

**Table 6.12: Scenario C: Budget requirements**

| Year | CAPEX (R million /a) | OPEX (R million /a) | Total (R million /a) | Savings (R million /a) | CBR* |
|---|---|---|---|---|---|
| 2004-05 | 480.0 | 487.6 | 967.7 | 71.2 | |
| 2009-10 | 402.3 | 487.6 | 890.0 | 510.3 | |
| 2014-15 | 230.5 | 487.6 | 718.1 | 784.9 | |
| 2019-20 | 230.5 | 487.6 | 718.1 | 976.8 | |
| 2024-25 | 230.5 | 487.6 | 718.1 | 1190.2 | |
| **Annual average** | **307.1** | **487.6** | **794.7** | **552.3** | **1.4** |
| 25 year total | 3992.0 | 6339.3 | 10331.4 | 7179.7 | 1.4 |

* Cost benefit ratio (CBR) = Total Implementation Cost / Savings

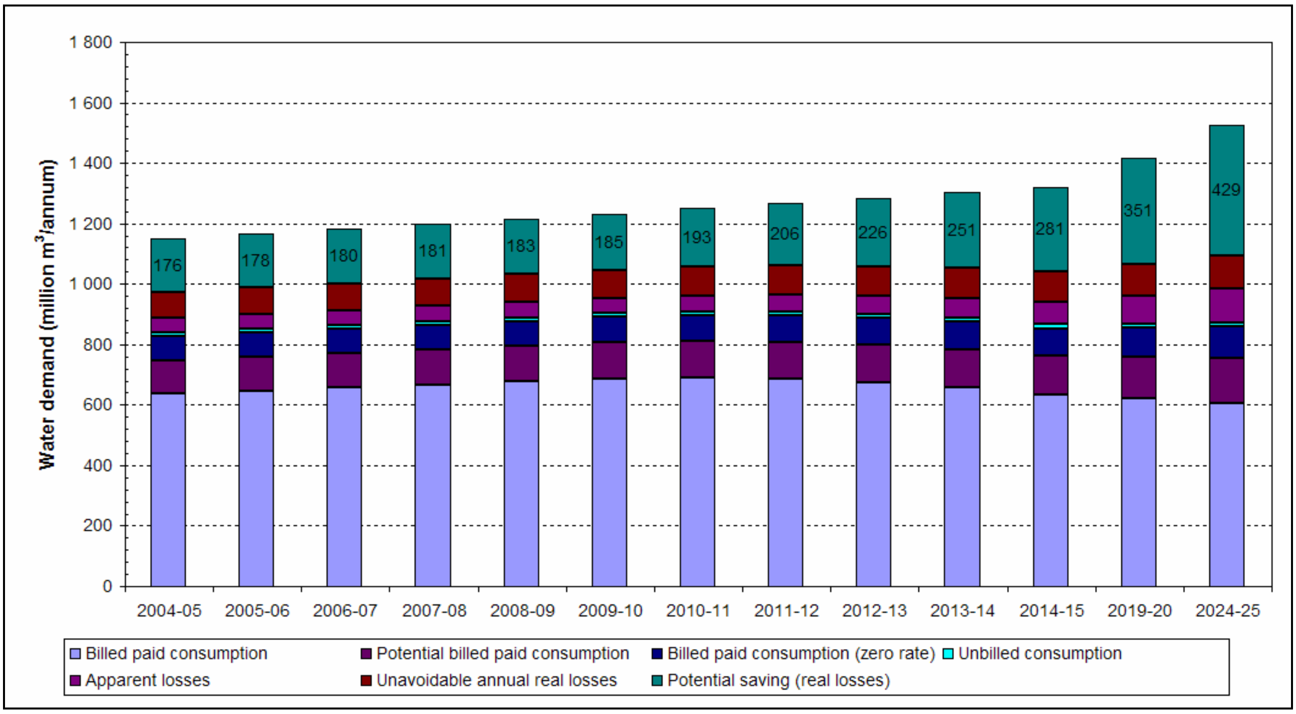



**Figure 6.47: Water balance for the Rand Water supply area**

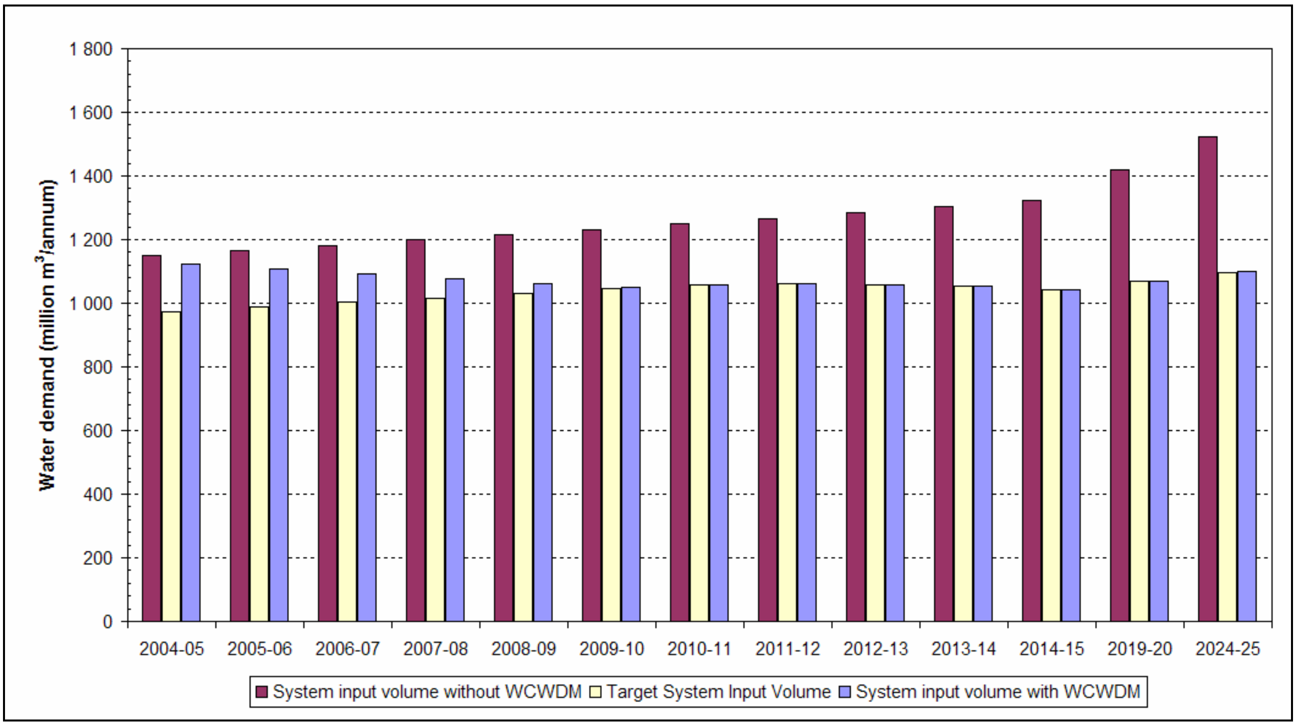



**Figure 6.48: Scenario C - Water demand projection**

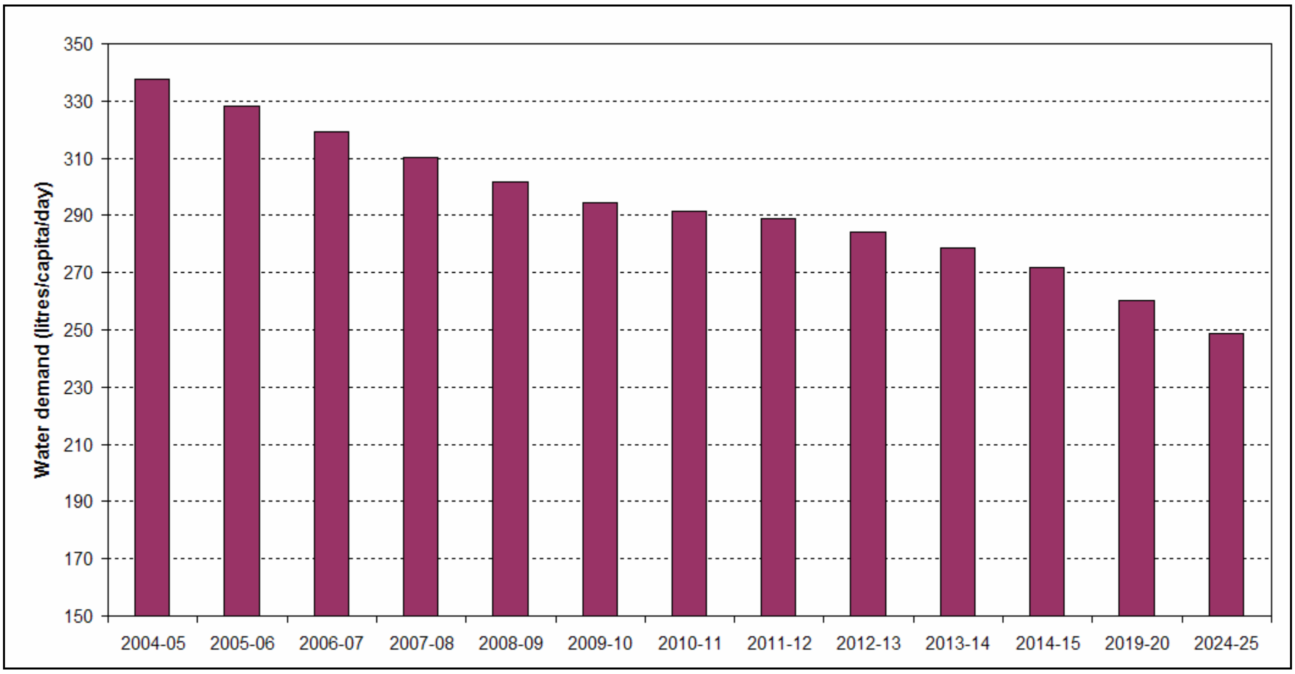



**Figure 6.49: Scenario C - Estimated water consumption in litres per capita per day**


**Figure 6.50: Scenario C - Estimated water consumption in Kl per property per month**

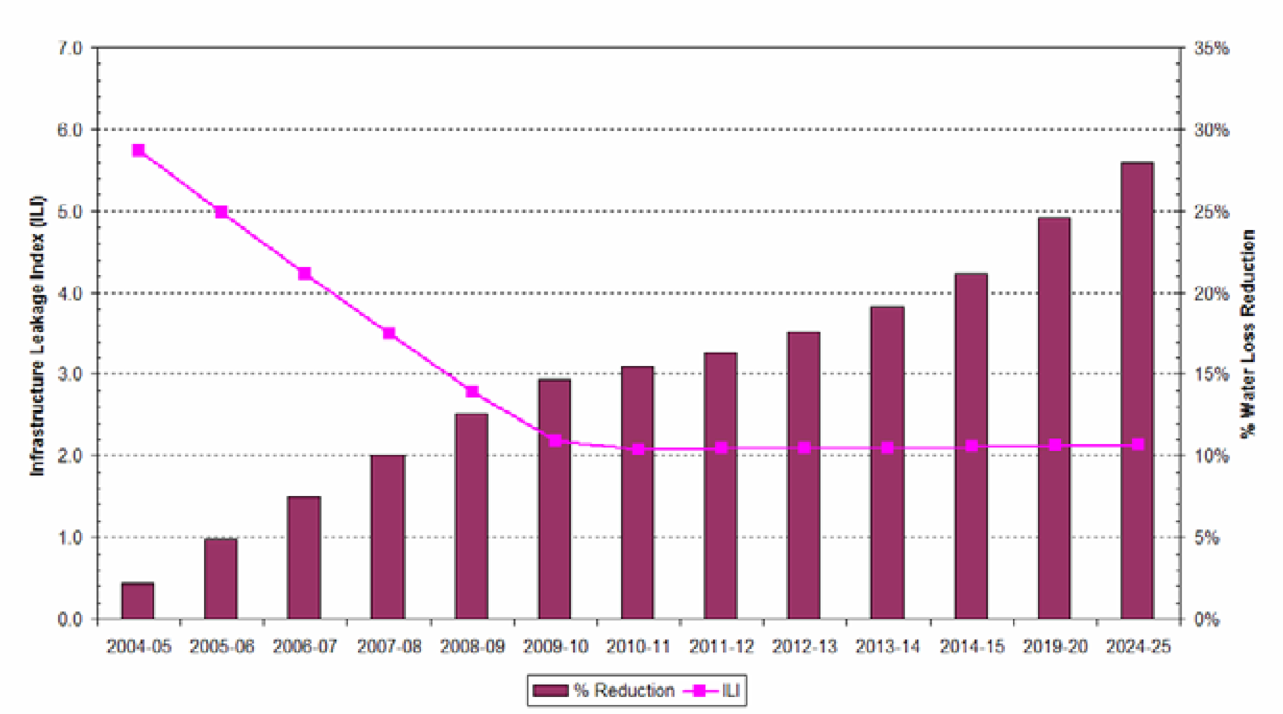



**Figure 6.51: Scenario C - ILI and % saving per annum**

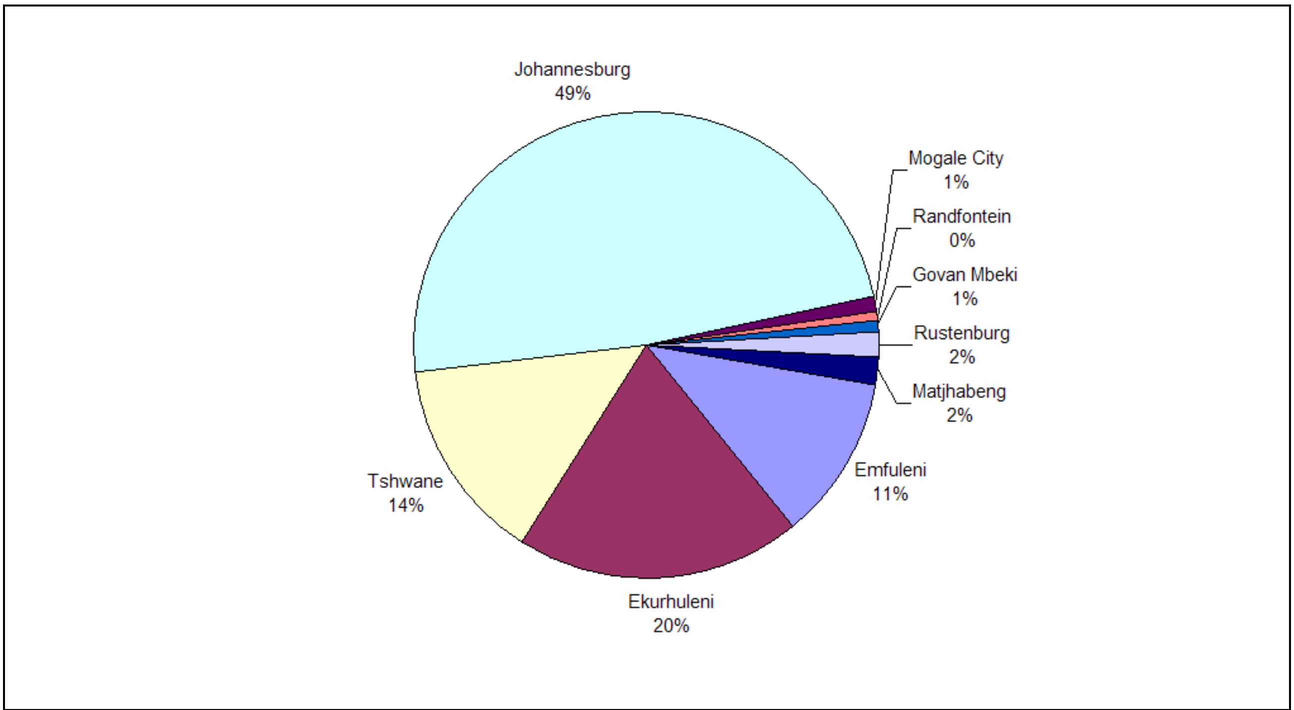



**Figure 6.52: Scenario c: Water savings distribution**

The results from Scenario C indicate a total reduction in demand of approximately 30% or 420million m$^3$/annum year 2025. This reduction will reduce the average consumption per capita per day from 330 to 250l/c/d or the consumption per household from 36 to 26m$^3$/property/month.

It can also be seen that almost 50% of the savings can be achieved in Johannesburg, mainly because of Soweto. The other three focus areas should be Tshwane, Ekurhuleni and Emfuleni. It can also be seen that the potential savings in the other areas is relatively small which can help to prioritise where most funding should be directed to derive the greatest benefit from WC/WDM interventions.

**Scenario D : 5 Year Water Loss Programme**

The results for Scenario D is summarised in **Tables 6.9 and 6.10** and **Figures 6.52 to 6.**

**Table 6.13: Scenario d - Summary of potential savings**

| Year | Demand without WC/WDM (mcma) | Demand with WC/WDM (mcma) | Reduction (mcma) | % Reduction |
|---|---|---|---|---|
| 2004-05 | 1 165.8 | 1140.2 | 25.6 | 2% |
| 2009-10 | 1 248.1 | 1063.5 | 184.6 | 15% |
| 2014-15 | 1 337.5 | 1137.0 | 200.4 | 15% |
| 2019-20 | 1 434.6 | 1224.0 | 210.6 | 15% |
| 2024-25 | 1 540.3 | 1317.6 | 222.7 | 14% |

**Table 6.14: Scenario d : Budget requirements**

| Year | CAPEX (R million /a) | OPEX (R million /a) | Total (R million /a) | Savings (R million /a) | CBR* |
|---|---|---|---|---|---|
| 2004-05 | 489.0 | 500.0 | 989.0 | 70.7 | |
| 2009-10 | 410.6 | 500.0 | 910.6 | 509.6 | |
| 2014-15 | 236.5 | 500.0 | 736.5 | 553.2 | |
| 2019-20 | 236.5 | 500.0 | 736.5 | 581.2 | |
| 2024-25 | 236.5 | 500.0 | 736.5 | 614.6 | |
| **Annual average** | **312.9** | **500.0** | **812.9** | **435.5** | **1.9** |
| 25 year total | 4067.9 | 6500.1 | 10568.0 | 5661.2 | 1.9 |

Cost benefit ratio (CBR) = Total Implementation Cost / Savings

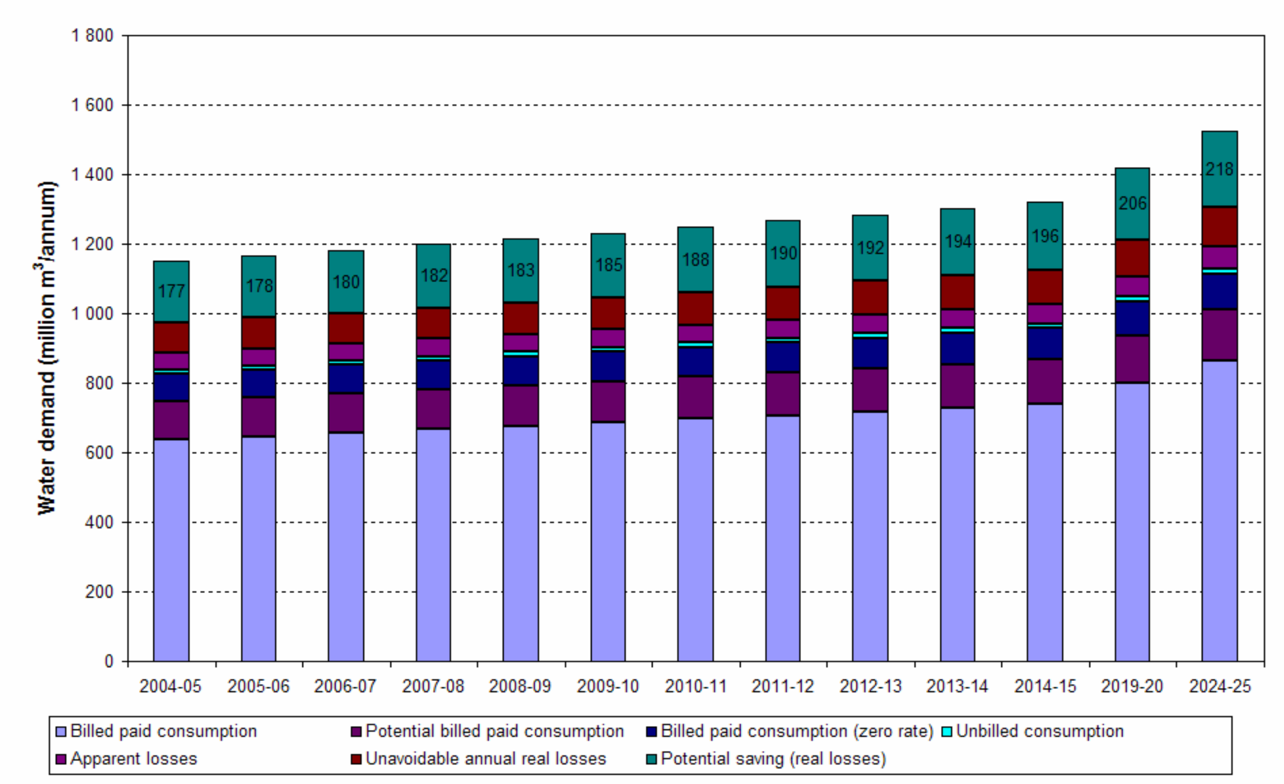



**Figure 6.53: Scenario d : Water balance for the Rand Water supply area**

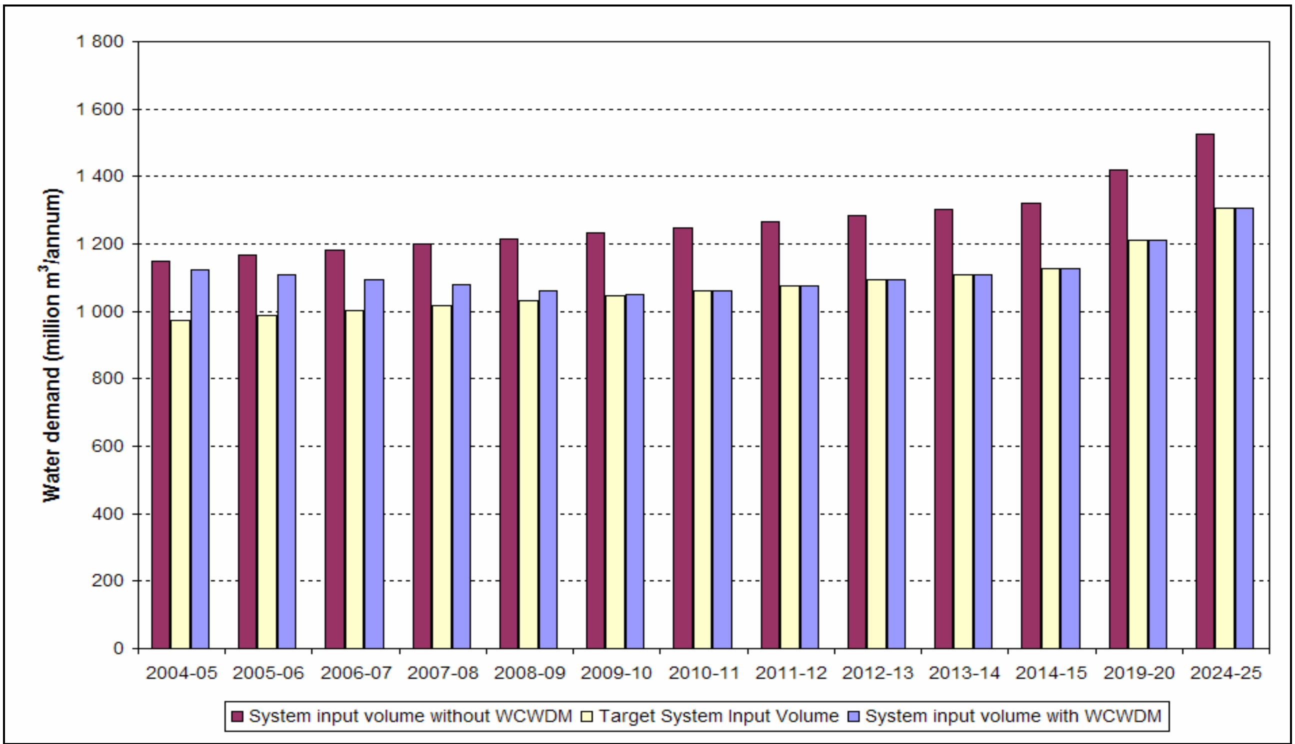



**Figure 6.54: Scenario d - Water demand projection**

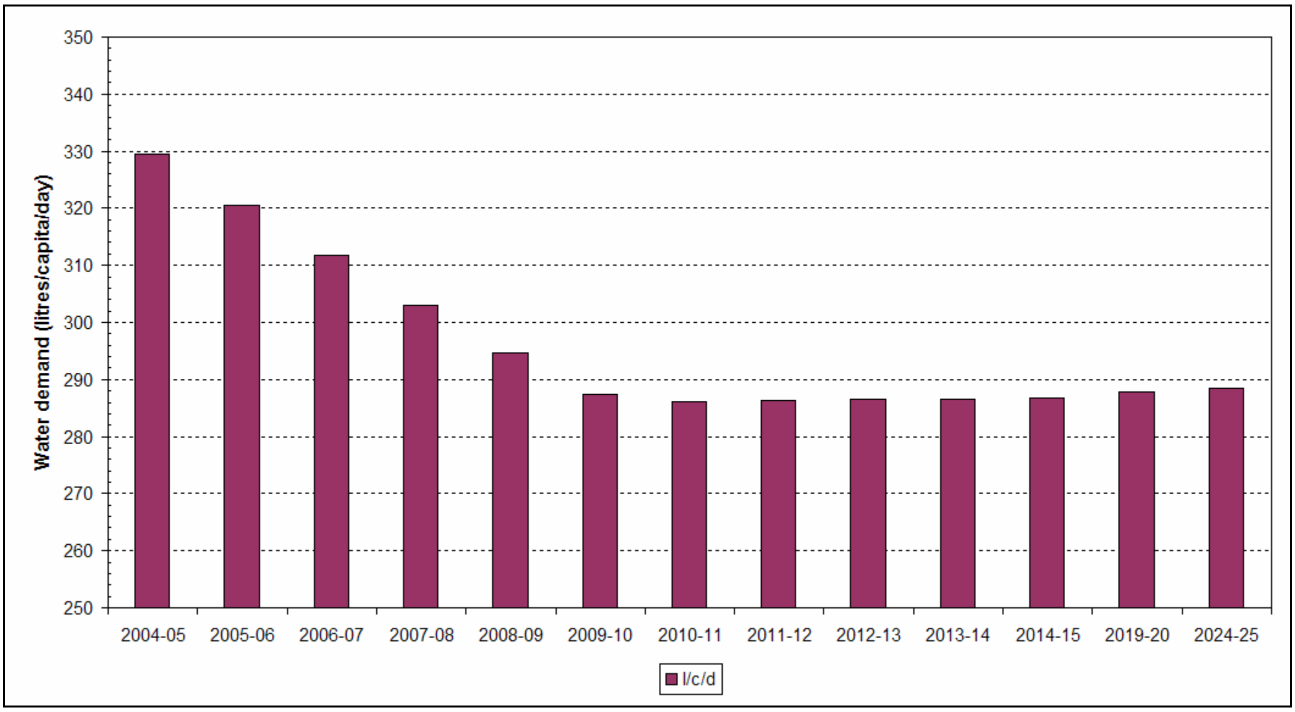



**Figure 6.55: Scenario d - Estimated water consumption in litres per capita per day**

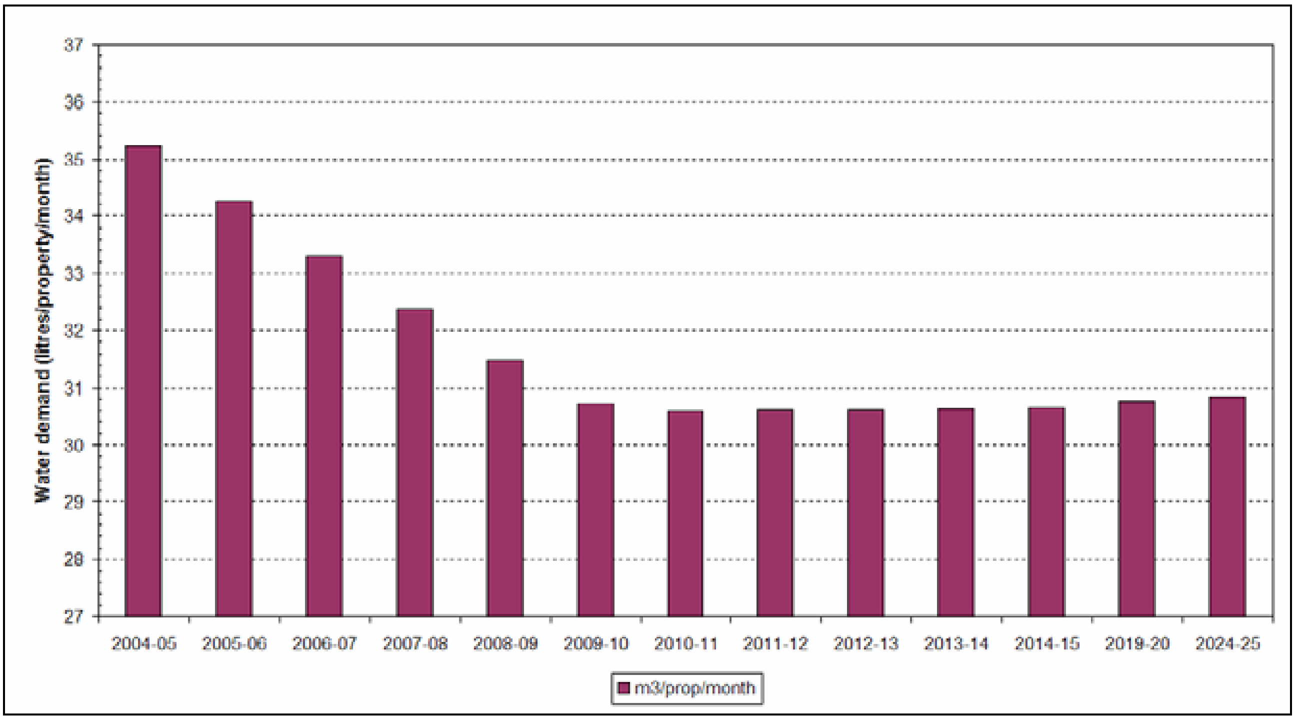



**Figure 6.56: Scenario d - Estimated water consumption per property per month**

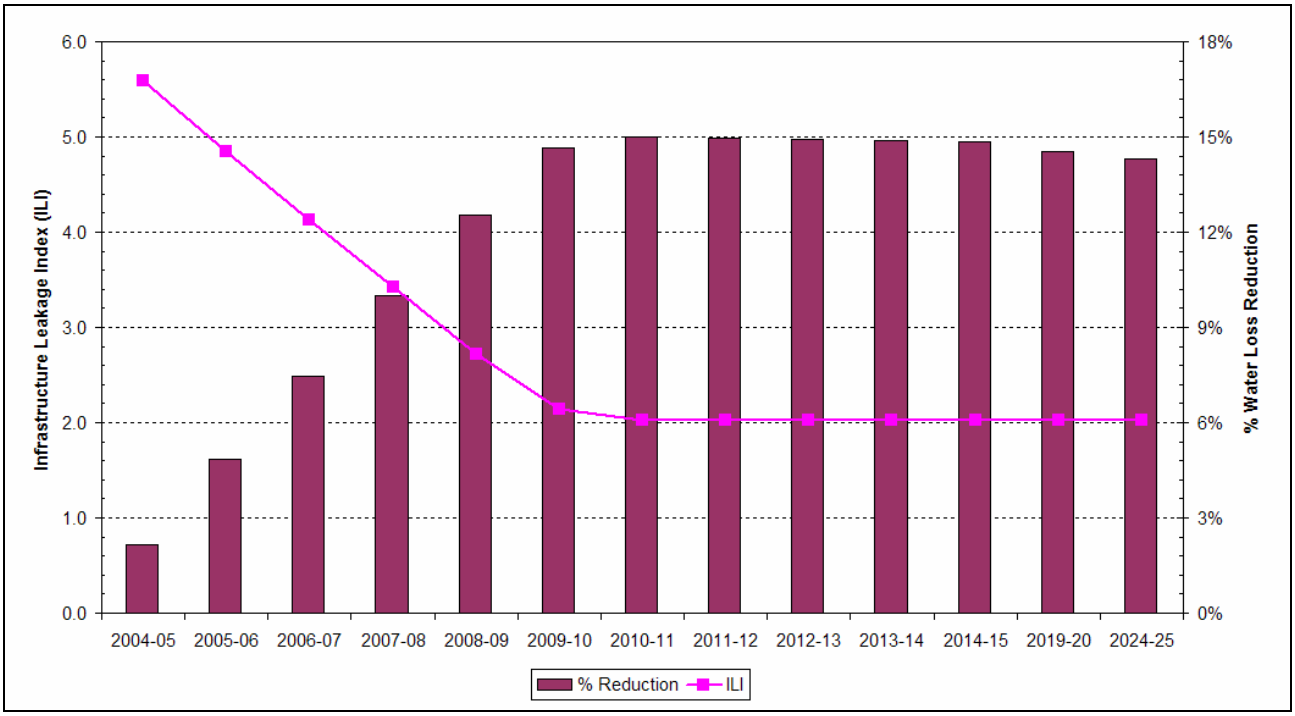



**Figure 6.57: Scenario d - ILI and % saving per annum**

The results from Scenario d indicate a total reduction in demand of approximately 15% or 220million m$^3$/annum year 2025. This reduction will reduce the average consumption per capita per day from 330 to 290l/c/d or the consumption per household from 36 to 31m$^3$/property/month.

**Scenario e : 10 Year Water Loss Programme**

**Table 6.15: Summary of potential savings**

| Year | Demand without WC/WDM (mcma) | Demand with WC/WDM (mcma) | Reduction (mcma) | % Reduction |
|---|---|---|---|---|
| 2004-05 | 1 165.8 | 1140.8 | 25.1 | 2% |
| 2009-10 | 1 248.1 | 1137.4 | 110.7 | 9% |
| 2014-15 | 1 337.5 | 1138.1 | 199.3 | 15% |
| 2019-20 | 1 434.6 | 1224.1 | 210.6 | 15% |
| 2024-25 | 1 540.3 | 1317.7 | 222.7 | 14% |

**Table 6.16: Scenario e Budget requirements**

| Year | CAPEX (R million /a) | OPEX (R million /a) | Total (R million /a) | Savings (R million /a) | CBR* |
|---|---|---|---|---|---|
| 2004-05 | 372.0 | 500.1 | 872.1 | 69.2 | |
| 2009-10 | 431.9 | 500.1 | 932.0 | 305.5 | |
| 2014-15 | 420.5 | 500.1 | 920.6 | 550.2 | |
| 2019-20 | 250.8 | 500.1 | 750.9 | 581.2 | |
| 2024-25 | 232.5 | 500.1 | 732.6 | 614.6 | |
| **Annual average** | **316.0** | **500.1** | **816.1** | **351.9** | **2.3** |
| 25 year total | 4107.7 | 6501.9 | 10609.6 | 4575.0 | 2.3 |

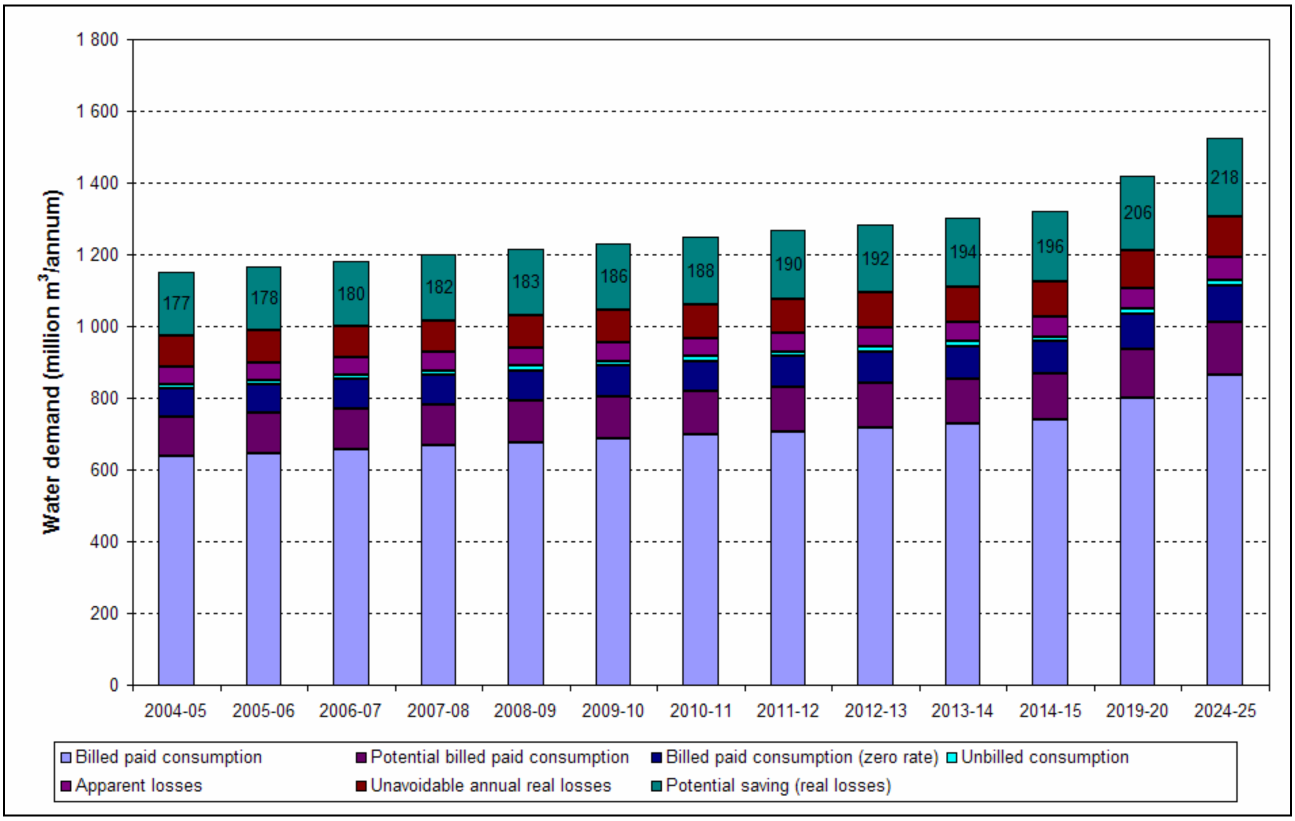



**Figure 6.58: Scenario e : Water balance for the Rand Water supply area**

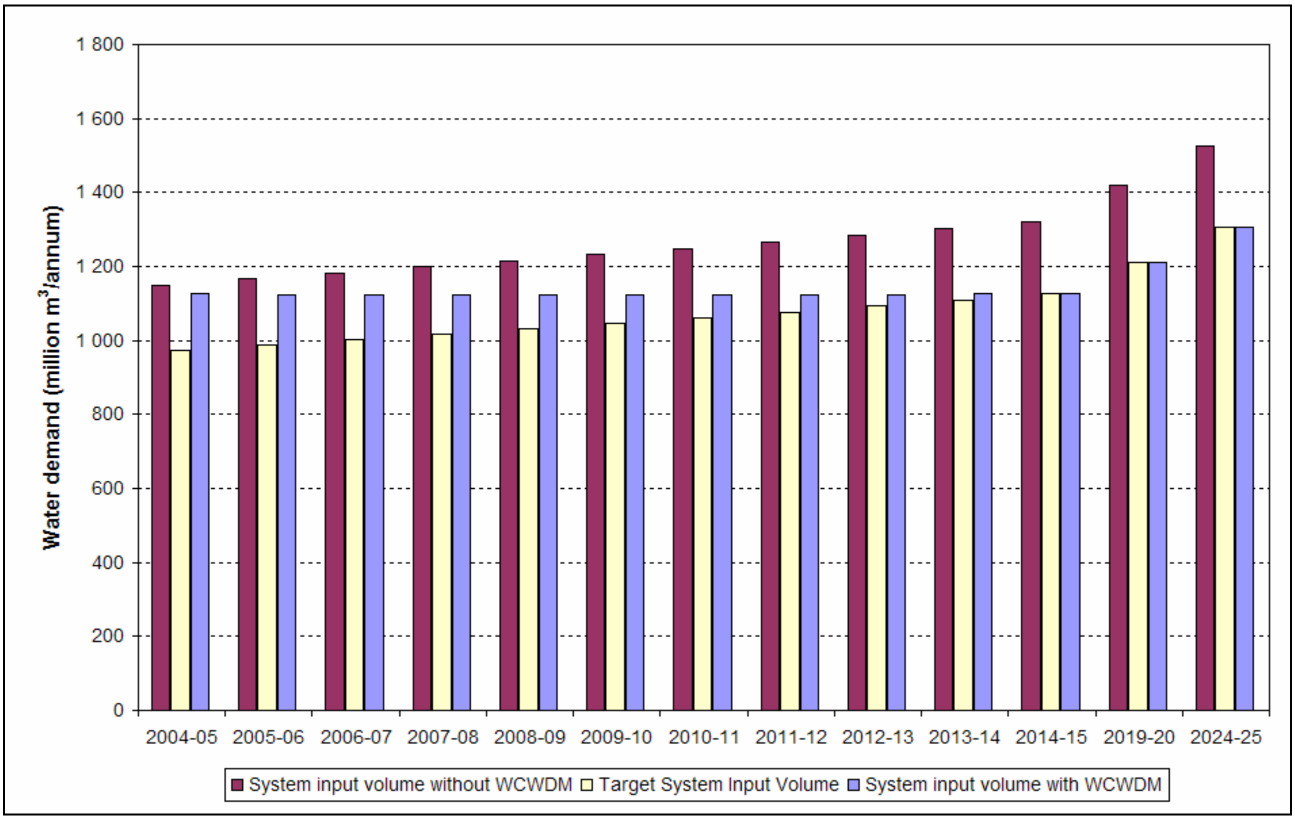



**Figure 6.59: Scenario e - Water demand projection**

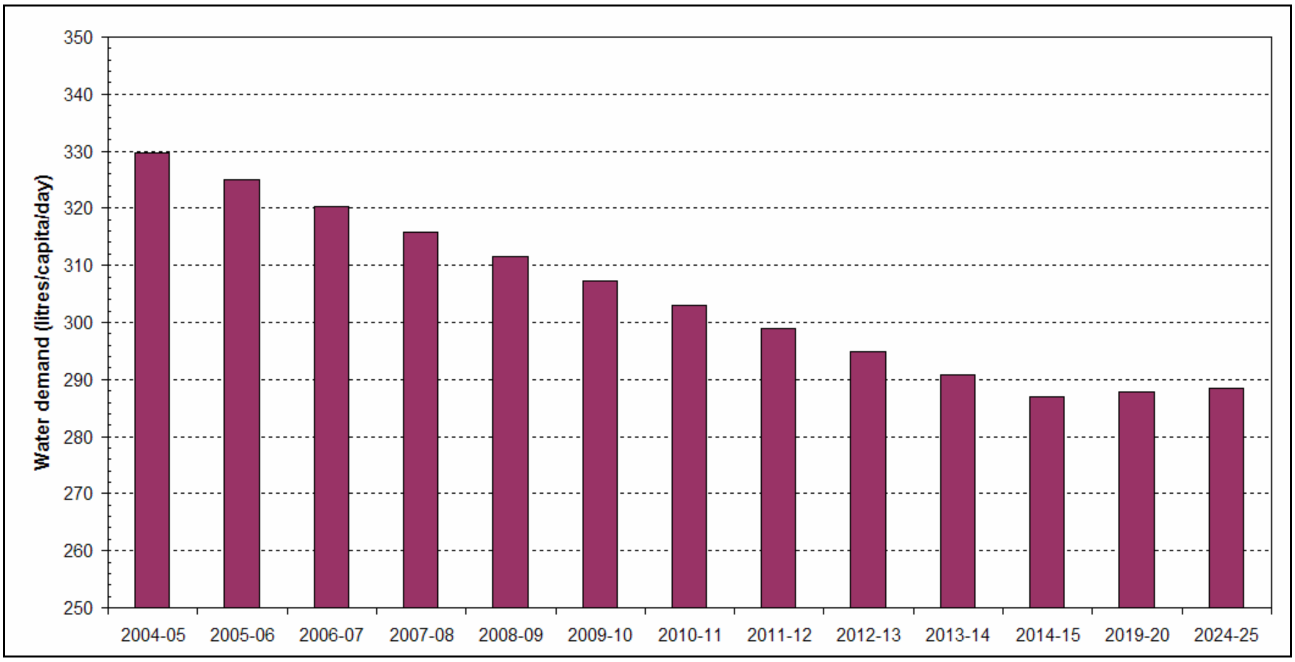



**Figure 6.60: Scenario e - Estimated water consumption in litres per capita per day**

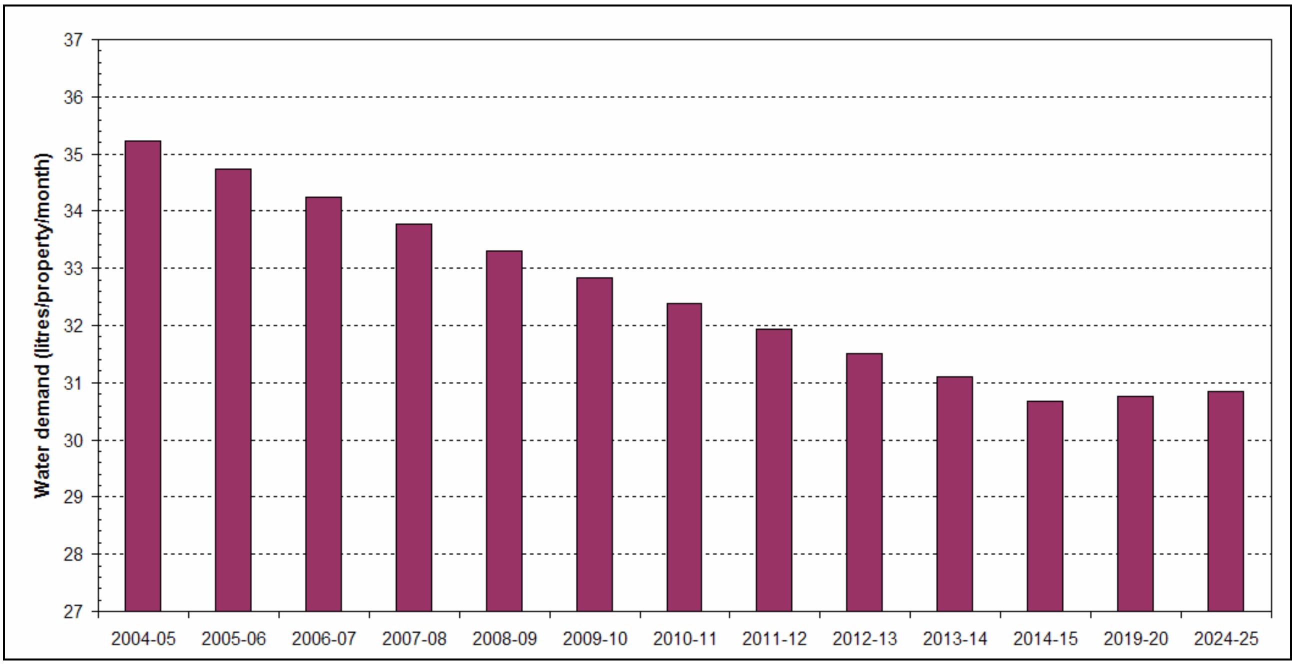



**Figure 6.61: Scenario e - Estimated water consumption per property per month**

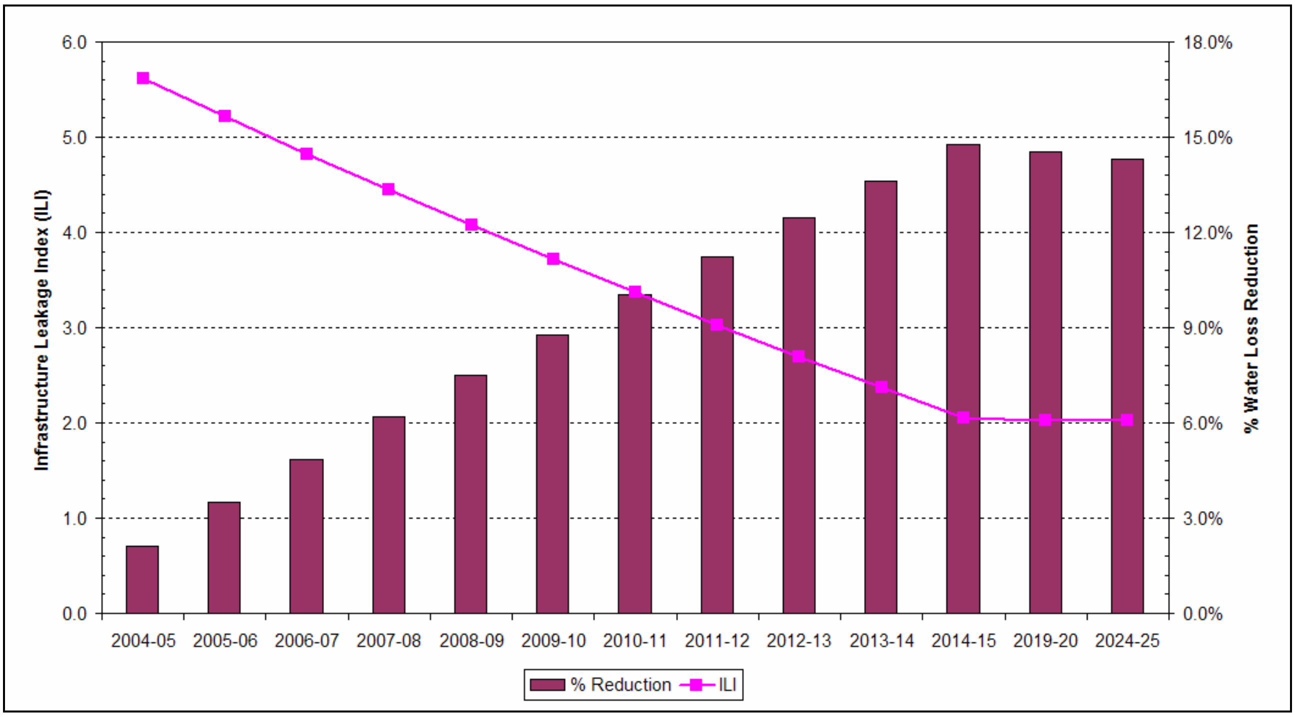



**Figure 6.62: Scenario e - ILI and % saving per annum**

The results from Scenario e indicate a total reduction in demand of approximately 15% or 220million $m^3$/annum year 2025. This reduction will reduce the average consumption per capita per day from 330 to 290l/c/d or the consumption per household from 36 to 31$m^3$/property/month. The results are the same as for Scenario d, except that the savings are realised only after 10 years and not 5 years like in Scenario d.

# 7 CASE STUDIES

## 7.1 SEBOKENG AND EVATON PUBLIC INVOLVEMENT PROJECT

### 7.1.1 Introduction

Water conservation and water demand management interventions have often been criticised for being overly-optimistic and the recorded savings are often difficult to verify. In cases where savings can be motivated, they are normally only measured immediately after the intervention has been completed and very few WC/WDM interventions are reviewed again after 12 months let alone 5 years. Without proper maintenance and continuous sustained effort, any intervention will fail to provide sustainable savings and this has been a key criticism of all WC/WDM activities in many projects. The history of failed WC/WDM initiatives in South Africa far outweighs the successes to the extent that water resource planners often ignore WC/WDM as a viable “resource” which can be used to delay costly augmentation schemes. It cannot be denied however that proper communication between all role players involved and impacted by any intervention or initiative is the key to success and smooth implementation, and while technical solutions are clearly an important component of any water demand management strategy, the support and approval of the communities or inhabitants of the area in which the intervention will take place is by far the single most vital factor that will determine the success and sustainability of any project into the future. Without community support, even the most effective and innovative technical measure will fail. Subsequent to an extensive situational analysis and through much deliberation and discussion, the Department of Water Affairs Forestry initiated and funded the pilot project in Sebokeng and Evaton to address the social dynamics involved in the provision of water. Although the project was funded in part under a separate budget, it forms part of the Pilot Project task which is part of the WC/WDM project for the Upper and Middle Vaal Water Management Areas. For this reason, the key results are summarised in this report.

Emfuleni Municipality is one of the major municipalities in Gauteng and is located approximately 50km south of Johannesburg. The municipality incorporates the towns of Vereeniging, Vanderbijlpark, Sebokeng and Evaton. The Sebokeng and Evaton areas are predominantly low-income residential areas supporting a population of almost 500 000. The combination of low income coupled with high unemployment has resulted in a general deterioration of the internal plumbing fittings over a period of many years. The poor quality fittings both inside the properties and outside (see **Figure 7.1**) cause high levels of leakage which is estimated to be in the order of 80% of the water supplied. The prominent problems in the area include high levels of leakage from taps and toilet cisterns within the properties, excessive garden irrigation and a general lack of understanding among the residents regarding the value of water and hence the conservation thereof. The problems in the area have already been addressed to a limited extent by the introduction of the Sebokeng and Evaton pressure management installation which was commissioned in July 2005 and is already providing significant savings by reducing water pressure and thus leakage during off-peak periods.

**Figure 7.1: Example of leaking tap in Sebokeng**

Limited technical actions can be taken during peak demand periods, due to existing water pressure already being insufficient to provide a full supply in some areas. From a careful analysis of the water demand patterns and water use in the area, it has been found that a major problem during peak demand periods is created by residents through the use of hosepipes and sprinklers (see **Figure 7.2**).

The excessive garden watering in the area is causing peak demand to increase significantly (normally by up to 40%) between the hours of 6am and 5pm with the result that the water pressures drop to below the normally accepted minimum level of service(normally 20m) as can be seen in **Figure 7.3**. Technical interventions are of little value during these periods necessitating the introduction of education and awareness as a key or strategy to address this problem.

**Figure 7.2: Excessive garden irrigation in Sebokeng**

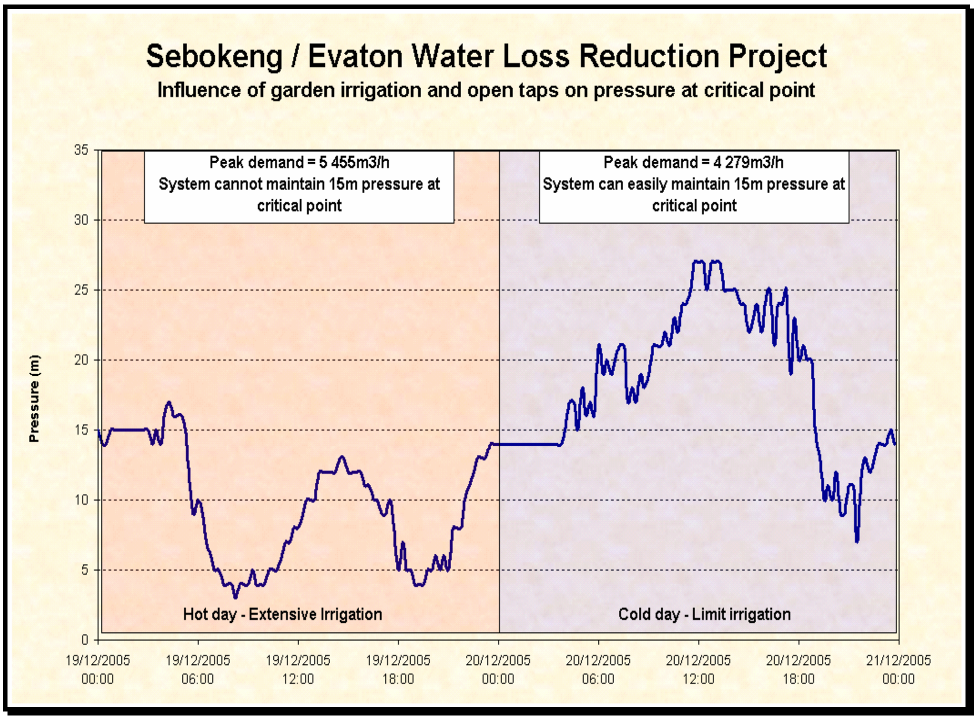



**Figure 7.3: Effect of garden irrigation on pressure during peak demand**

As part of the second phase of the Sebokeng and Evaton leakage reduction project the following interventions were identified:

- A schools awareness campaign
- A leak detection and repair programme

- A community awareness programme

### 7.1.2 The project team

A multi disciplinary team was commissioned for the implementation of this second phase of the leakage reduction project namely water demand specialists, social scientists, and technical personnel from Emfuleni Municipality (Metsi-a-Lekoa), DWAF, WRP and Ayanda Consultants. The diversity of the task team ensures that multiple perspectives are taken into account in order to develop the most practical and sustainable solution. Employment creation opportunities have also been of high priority to the project team and this has been addressed to a large extent by the utilisation of the human resources available in the respective communities in the form of Community Liaison Officers.

### 7.1.3 Leak Detection Programme

Before asking the residents to save water and limit wastage in their homes and gardens, it was first necessary to eliminate as much as possible the visible leaks present on the roads and pathways. If the water utility is not seen to take leakage seriously, the residents could not be expected to exercise restraint. The leak detection programme was therefore one of the first interventions to be introduced. A three day training programme was held in March 2006 in which 4 personnel from the Municipality were trained (see **Figure 7.4**) in the use of basic leak detection equipment by members of the project team who have extensive experience in this field. The theoretical component of the training was presented in the offices of Metsi-a-Lekoa and the practical field work was undertaken in Johandeo and Boitumelo – two relatively large discrete areas in Sebokeng and Evaton. The initiative from the municipality's side highlighted to the community that the water utility is trying to eliminate water wastage wherever it occurs and serves as the first step towards forming a partnership with the community to encourage water conservation.

**Figure 7.4: Leakage detection training in Sebokeng / Evaton**

### 7.1.4 Community Awareness Programme

Empowering people with knowledge and alerting them to the areas of deficit stimulates mobilisation of the available assets within the community to combat the problems. People need to be made aware of the problem of water wastage in order to alter wasteful behaviour. Visual materials and information pamphlets have been developed by the authors and have been tailored to suit the local environment rather than simply using existing materials developed elsewhere. The materials that have been developed under this project focus on several key issues such as:

- garden irrigation;
- fixing of basic household leaks
- water wise household use and
- water use in schools.

A second component of the community awareness programme involved the training of community liaison officers selected from the community, who are responsible for door to door evaluation and monitoring of water consumer behaviour as well as the overall education of the community. These are people equipped with interpersonal skills and basic technical knowledge. They assist the community where water related problems are encountered such as the changing of tap and cistern washers and fixing of basic leaks which result in a substantial loss of water over a period of time. In short, community awareness constitutes the bulk of the initiative and serves to disturb the equilibrium of wasteful behaviour present in the communities. Various posters were produced by the project team and distributed throughout the community including all schools in the Pilot Area as well as public bill-boards (see **Figure 7.5**).


**Figure 7.5: Community liaison officers at work in Sebokeng / Evaton**

### 7.1.5 Schools Awareness Programme

Schools have been identified as one of the key problem areas with the greatest scope for improvement where saving water is concerned. Children are amongst the most receptive target population. Simple educational materials have been developed to educate the children about efficient water usage and serves to train them to be water wise. The schools programme includes training and mentorship of Vaal University students operating as interns for Metsi-a-Lekoa. The objective of their involvement was to afford young up-coming engineers the opportunity to gain practical experience in the field of water demand management and to broaden their knowledge and skills base as a means to increasing the chances of quality service delivery in the future. The interns undertook a schools audit at Crystal Prince Secondary school in order to establish the status quo with regards to water use in the schools. The prominent problems identified in the course of the audit were:

- Vandalism of taps and toilet cisterns
- General lack of hygiene and care for the schools environment

Having looked at the prevailing problems it appeared appropriate to launch the schools programme by educating the educators as the gate keepers to the children to whom they impart knowledge. The water conservation workshops were held at Crystal Prince Secondary School on the 1st of June 2006 and at Letsemeng Primary School on the 13th of June 2006 where the teachers were informed about the education and awareness initiative undertaken by Metsi as well as various issues and debates surrounding provision and use of water (see **Figure 7.6**).

**Figure 7.6: Schools plumbing repair training**

The topics dealt with in the course of the workshop were:

- Where our water comes from – water transfer schemes
- Treatment of water
- The importance of water
- Wasting of water: Leaks, vandalism, garden irrigation etc.
- Pressure management
- Why we cannot afford to waste water
- Misconceptions related to water
- CLO's and the role of education
- What can be done to save water

The teachers were encouraged to serve as examples to the children in terms of proper utilisation of water and to remind the children that what they waste today they will lack tomorrow. The workshops met with much enthusiasm and the educators suggested the establishment of an environmental youth group in the communities with the help and support of the municipality. Further workshops have been planned for the month of September in honour of spring when the children are excited and consequently waste a lot of water while celebrating. These will serve to raise their awareness to the role that they can play in bringing about a solution to the problem of increasing scarcity of our water resources. Through sponsored incentive stationary packs and various other equipment, the children will be encouraged and enthused to conserve water. A schools competition has already been held where school children were encouraged to design a “water-wise” design for the large Sebokeng/Evaton Pressure Management installation. The winning entry was used to decorate the large valve chamber and total prize money of R18 000 was presented to the schools and pupils responsible for the winning designs (as shown in **Figure 7.7**). This competition helped to create awareness not only of the pressure management installation but also for the issue of conserving water and reducing wastage within the Sebokeng/Evaton community.


**Figure 7.7: Schools WDM awareness project - prize giving**

### 7.1.6 Summary of Progress

In summary various activities have taken place with regards to the community awareness and education initiative within the designated communities. In terms of training the following has been undertaken:

- Leak location training for four Metsi personnel

- School audit training and basic plumbing training for Vaal University students
- Basic plumbing and interpersonal skills training for the Community Liaison Officers

The CLO's commenced with their duties on the 5th of May 2006 and the Leak locators likewise on the 8th of May 2006. Thus far 729 houses have been visited in Johandeo and 2007 in Boitumelo making a total of 2736 houses to date. All houses visited are recorded by the Community Liaison Officers in a log book and a mini audit is carried out by them in order to ascertain the common problems faced by the residents and the audit forms have been retained for utilisation by the municipality in future strategic planning. The common problems identified and that require attention are:

- Leaking taps with worn washers (see Figure 7.8)
- Poor quality household fittings that cannot be fixed but need replacing
- Leaking toilet cisterns
- Stolen taps

Other problems are related to inconsistent metering and billing in the areas specifically in Johandeo as well as broken or non existent meters which is presently being addressed by a meter audit that has been undertaken by Metsi. A clinics workshop is held by the CLO's on a weekly basis in order to reach as many people as possible. The bulk of the CLO's duties rests upon maintaining visibility with the communities as well as building relationships with the community members (as shown in **Figure 7.9**). The majority of their time is spent talking to individuals in the households and on the streets, distributing educational pamphlets and encouraging water wise behaviour. As part of their duties the CLO's are required to demonstrate practically how to fix basic household leaks particularly changing of tap washers for which they received practical training in the field with a highly experienced plumber and member of the project team. This effort has proven successful and met with much approval from the residents of the area.

**Figure 7.8: DWAF plumbing repair project**

**Figure 7.9: DWAF CLO's interacting with community**

The identified pilot areas were selected due to the fact that they have been ring fenced and loggers were installed to obtain information pertaining to flow and pressure and thus water consumption in the area. It is unfortunate however that these designated areas and Sebokeng as a whole have experienced many technical problems particularly due to poor infrastructure and various equipment but looking at the logging results obtained from Boitumelo it can be deduced that:

- The profile of the flow has stabilised over the month that the community awareness campaign has been in operation
- The average consumption was ±11 $m^3/h$ and has dropped to ±8$m^3/h$ meaning that the average consumption has been decreased by ± 3$m^3/h$ (see graph of Boitumelo North Meter below).
- Logging results will be reviewed to ensure validity

It has also been noted that further pressure management at zone level is necessary as the pressure at night remains unacceptably high and can be linked closely to the problem of high leakage of internal household fittings. This will be addressed by an installation of a PRV in the designated areas.

#### 7.1.7 Results to August 2006

To conclude an initiative of this nature requires sustained effort as altering long standing faulty behaviour and perceptions cannot be achieved in a matter of days. It means that individuals in many respects must discard their previous behaviour towards the use of water and become "water wise". This process cannot be achieved overnight and requires a sustained effort, monitoring and evaluation. Although the initiatives will continue after the conclusion of the WC/WDM project, some initial results are shown in **Figure 7.10** for Boitumelo where it was possible to measure the savings. It should be noted that the savings on both Johandeo and Boitumelo will be carefully examined and monitored over a period of years to evaluate the level of success due to the awareness programme. This type of initiative is rarely monitored properly and as such it is usually impossible to gauge the success or pay-back for this form of WC/WDM intervention.

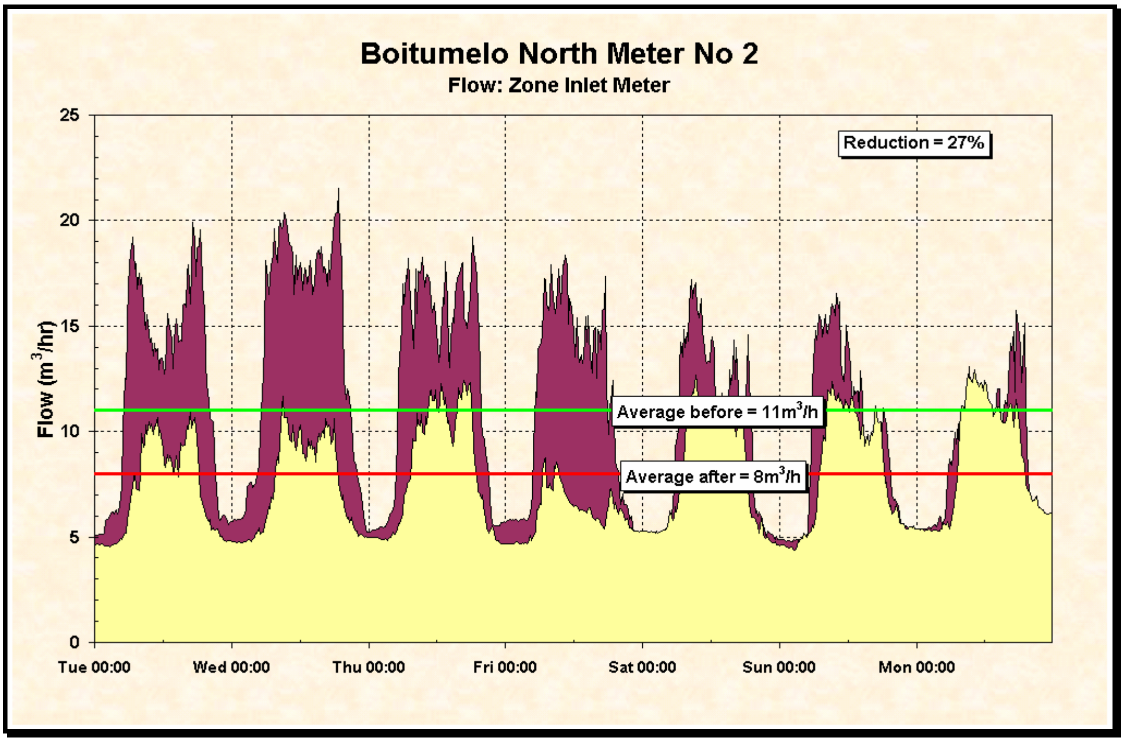



**Figure 7.10: Results from portion of Boitumelo**

### 7.1.8 Conclusions

It is imperative to note that with the implementation of any socially orientated intervention; it is inevitable that numerous challenges will be encountered. There is undoubtedly a discrepancy between theory and application and an important lesson learnt in the course of this particular study is the uniqueness of every community and the flexibility required in the approach of the implementing agent in making the necessary adjustments even sacrificing to some extent a small measure of structure for the sake of effectiveness. With the commencement of this study, it soon became apparent that numerous water provision related matters had to be resolved before the education component of the project could continue. This lesson was illustrated clearly when it was discovered that the area of Johandeo had been experiencing intermittent water supply for several years due to pipes which were ill equipped to cope with the growing water demand in the area. In this instance the awareness component of the project remained key as the municipality had to maintain open channels of communication in order to bring clarity to frustrated residents and to retain the support of the community in their efforts because only when a community receives an adequate service are they likely to take cognisance of water conservation measures and likewise payment for services. When speaking to a number of the residents; it was clearly expressed that while economic factors play a big role in payment for municipal services arranging for means of payment is not entirely impossible if payment would be for a service that was in fact received and that the community was satisfied with. The problem of intermittent supply was subsequently addressed and with this development came greater responsiveness and a greater willingness by the residents of Johandeo to be educated about water conservatory behaviour.

Parallel to the above dilemma in Johandeo was what appeared to be a sewerage overflow problem in the low lying areas of Boitumelo. The residents have been living in suspected sewerage water for a period of nine years and this has done little good for the morale and cooperation of the community. Due to the recent openness from all the stakeholders and role players in Emfuleni and the community, an inter-departmental site visit was arranged to evaluate the extent and magnitude of the problem and to determine the measures that could be taken to address this problem. For the first time the plight of the residents living under these conditions is being treated with the necessary degree of seriousness and currently an in depth investigation is being undertaken to establish concrete solutions including tests that are to be run on the water flooding the area to determine the quality of the water and whether or not the affected residents should be relocated.

While the time spent investigating the problems was of great value, it is vital that the strategies devised do not simply end with the investigations but are taken further to concrete action. For a meaningful partnership to be established tangible evidence of efforts made to improve the quality of life for the communities is required and the appreciation of this efforts will undoubtedly show itself in full support and cooperation of the community for the municipality.

### 7.1.9 Recommendations

Since the commencement of the leak reduction project in 2005 many lessons have been learnt. Pressure management has resulted in great water savings by reducing burst leaks and leaking household fittings and has proven to be a noteworthy avenue in water demand management not just for the present moment but into the future. In addition to the technical interventions involved in water demand management, community awareness and education has also been identified as a vital component of any water conservation programme. Of crucial importance is the involvement of all role players and institutions such as the educational institutions as well as all community members in making the initiative a success. Promotion of continuous water wise behaviour can ensure availability of resources into the future for all. It is also essential to solicit support from municipal officials as well as other government officials since without such political support no progress can be made.

## 7.2 SEBOKENG AND EVATON PRESSURE MANAGEMENT PROJECT

### 7.2.1 Introduction

Emfuleni Local Municipality is located some 50 km south of Johannesburg in the industrial heartland of South Africa and incorporates, amongst others, the towns of Vereeniging, Vanderbijlpark, Sebokeng and Evaton. A separate water utility called Metsi-a-Lekoa was established several years ago to manage the supply of potable water to the residents of Emfuleni Local Municipality which are estimated to total over 1.2 million of which approximately 450 000 are located in the Sebokeng/Evaton areas. The water utility is wholly owned and managed by the Municipality and operates within the normal municipal structures.

The water supply systems in Sebokeng and Evaton have suffered through several decades of neglect due to various historical factors whereby low-income areas received little attention compared with their more affluent counterparts. As a result, the reticulation system serving Sebokeng/Evaton was gradually collapsing and the levels of service to the communities it served was poor. Many large water pipes in the system were in desperate of need of repair and most of the valves were either leaking or broken or could not be located due to the fact that they were buried under decades of rubbish and rubble. To compound the problems, the “as-built” drawings for the reticulation system were often inaccurate leading to serious problems when trying to isolate sections of the network for emergency repairs. Another key problem concerned the poor quality internal plumbing fixtures used in the properties which is a clear case of “penny-wise and pound foolish”. Most of the properties in the area experienced leaking taps and/or toilets which most residents simply accepted as the norm due to a lack of understanding of the value of water and a lack of resources to make the necessary repairs. The problem of high internal plumbing leakage was not limited to Sebokeng and Evaton and remains one of the key factors behind the high levels of wastage in most low-income areas throughout South Africa.

As a result of the various problems mentioned above, the water reticulation system in Sebokeng /Evaton experienced very high levels of leakage and/or wastage. It was estimated that the wastage in the area before the project was commissioned was in the order of 80% of the water supplied to the area which in turn represented an annual water bill of approximately R120 million per year ($20 million) for Sebokeng and Evaton alone.

In 2004, the Municipality requested proposals from suitable qualified teams through an open tender process to propose measures to address the leakage/wastage problems in Sebokeng and Evaton. Several proposals were received and one of the successful proposals involved a small scale public private partnership in which the Project would be funded completely (both capital works and professional services) through the savings generated from the remedial measures proposed by the Project Team. The proposed project involved no financial input from the Metro and even the initial capital costs were borne in total by the Project Team with the bulk of the savings being returned to the Metro. The project was, in effect, a small scale Public Private Partnership involving a simple risk-reward project.

The main objective of the Sebokeng/Evaton Leakage Reduction Public Private Partnership was to reduce water leakage (and thereby also reduce pumping energy costs) and levels of wastage in the Sebokeng and Evaton water distribution systems through a Public Private Partnership between Metsi-a-Lekoa (for Emfuleni Local Municipality) and the WRP/DMM joint venture. The project was one of the first of its type in South Africa where the project Team (i.e. the Consultant) took on 100% of the financial risk through an extremely complex Public Private Partnership (PPP) involving no fewer than 12 key role players.

While the technical aspects of the project are clearly noteworthy (since it is currently the largest installation of its type in the world), the project was also unique in the manner in which it was managed and commissioned in a 3 month period which few, if any, believed could be achieved. The rapid implementation resulted in huge water savings being achieved at the earliest possible date which in turn has resulted in massive financial benefits to the water supplier and local community.

The project represents a significant advancement in Public-Private Partnerships (PPP's) and clearly demonstrates that small scale Public Private Partnerships can be viable despite the general view that this type of project is confined to larger projects. The remainder of this paper provides details of the processes involved in setting up and implementing such a project. The paper concludes by suggesting that the model used by the Project Team to address leakage in Sebokeng and Evaton can be adapted for use in other areas and other applications to improve service delivery throughout South Africa.

### 7.2.2 The Project Area

The Sebokeng and Evaton areas form part of the Emfuleni Local Municipality (see **Figure 7.11**) which is located to the south of Johannesburg – the main industrial centre of South Africa. The areas are predominantly low-income residential areas supporting a population of almost 500 000. There are approximately 70 000 household connections in the area, each of which is supplied with an individual water supply as well as water borne sewage. The combination of low income coupled with high unemployment has resulted in a general deterioration of the internal plumbing fittings over a period of many years. The poor quality fittings cause high levels of leakage which was estimated at the start of the project to be in the order of 80% of the water supplied to the area.

The leakage at the start of the project was extremely high as indicated by the high minimum night flow (MNF) in the order of 2 800 $m^3$/hr as shown in **Figure 7.12** which represents the situation before the project was initiated. This is one of the highest MNF's recorded anywhere in the world and represents almost two Olympic sized swimming pools of water every hour during a period when demand for water should be minimal.

It should be noted that there is virtually no storage in the Sebokeng and Evaton areas, either at bulk reticulation level or domestic property level. The high MNF is therefore almost completely due to leakage, most of which occurs inside the properties and is therefore not evident from normal visual inspection . It should also be noted that since most of the leakage occurs inside the households, the leaking water returns through the sewer network which is often overloaded to the extent that spillages of raw sewage into local river courses are a common occurrence in this area.

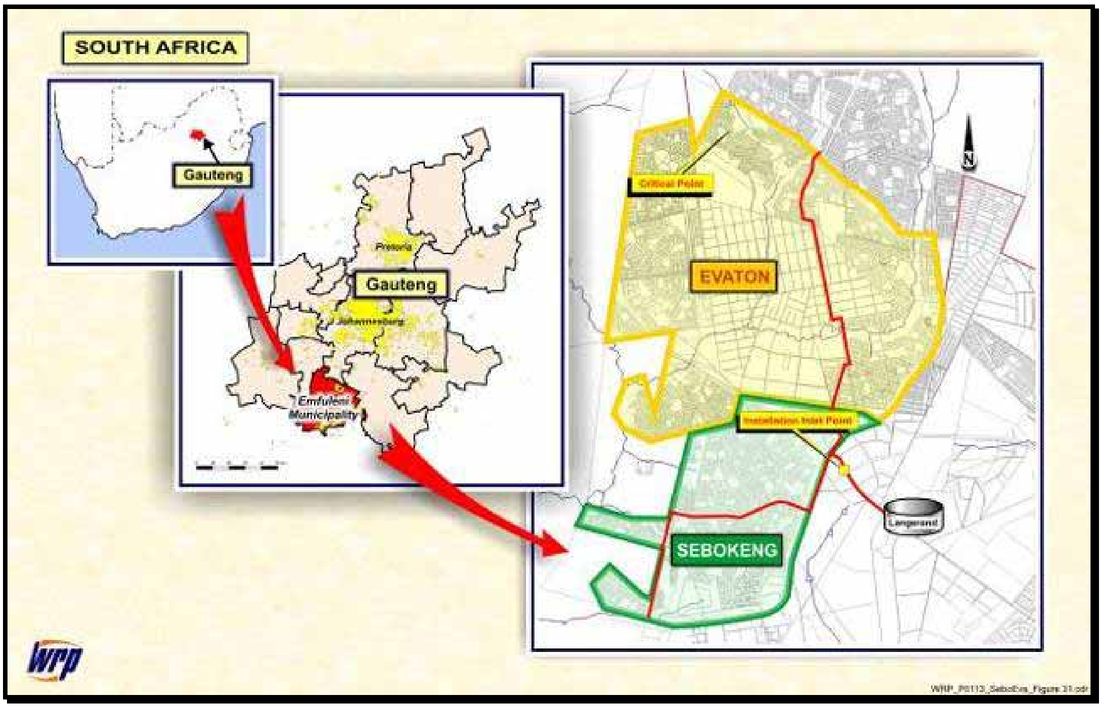



**Figure 7.11:Sebokeng and Evaton location plan**

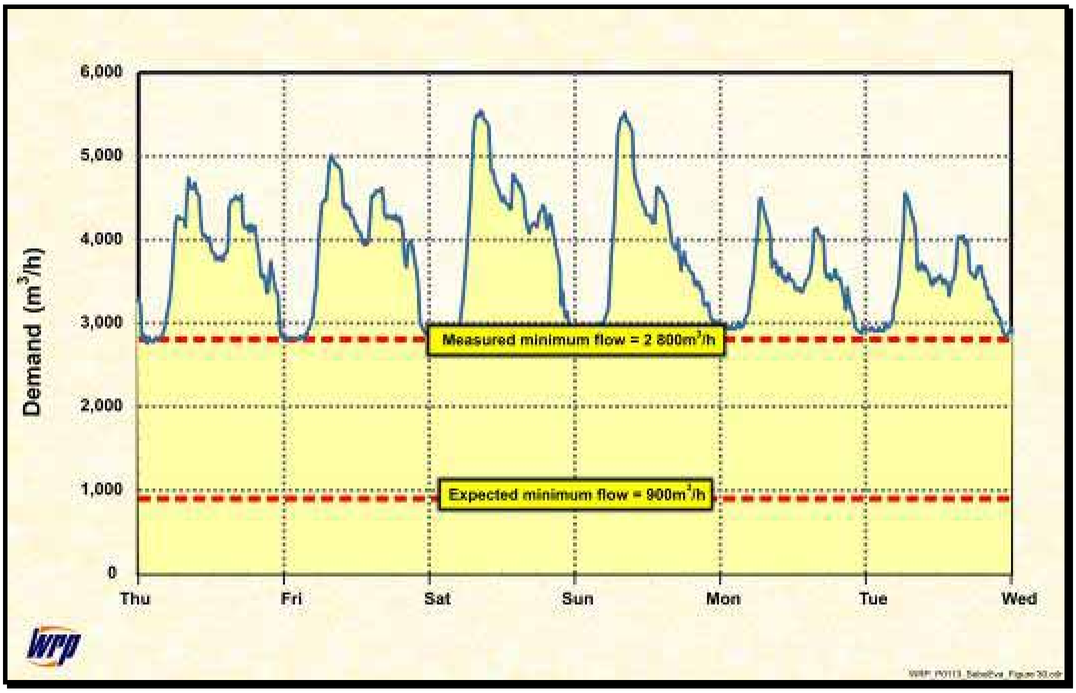



**Figure 7.12: MNF entering Sebokeng/Evaton before and after intervention**

### 7.2.3 The Project

High internal household leakage is usually caused by a combination of poor quality fixtures, high water pressures and poor maintenance. The most effective method of addressing this problem is to replace all leaking fixtures with new high quality fixtures after which they must be properly maintained by the residents. In addition, the water pressure in the system should be limited to the appropriate level whereby a proper level of service can be provided without damaging the fixtures. Unfortunately, the process of repairing and replacing plumbing fittings tends to be relatively expensive and time consuming with the result that few Municipalities can afford to direct sufficient budget to this issue. An alternative approach, however, involves lowering the water pressure in the system during "of-peak" periods when demand for water is low and the system pressures are higher than required. While this approach does not actually address the repair of any leaks, it can often provide very significant savings, both in terms of reduced leakage as well as financial savings to the water utility. The savings can then be used to fund subsequent leakage reduction activities such as plumbing repairs and general road and connection leaks.

The advantage of adopting pressure management as the first intervention is that, under certain circumstances, the costs are minimal and the resulting savings tend to be very significant. This is particularly valid in areas such as Sebokeng and Evaton where the bulk of the leakage is inside the properties and the levels of wastage/leakage are extremely high. The method has been tried and tested in many areas and spectacular results have been achieved by the Project Team in very similar circumstances. The project discussed in this paper was therefore the first phase of a long term project and involved the design, construction and commissioning of what is thought to be the largest single advanced pressure control installation in the world.

The basic concept is very simple and yet remarkably effective. By controlling the pressures during the off-peak periods it is often possible to significantly reduce the losses without identifying or repairing a single leak. Only after the excessive pressures have been addressed, can the other measures such as repairing leaking pipes and/or retrofitting be tackled.

### 7.2.4 Project Team

Unlike previous pressure management projects undertaken in South Africa, the Sebokeng-Evaton project was completed as a small scale Public Private Partnership between the Consultant and the Client. The project involved a complex jigsaw involving no less than 12 key role players as shown in **Figure 7.13**.

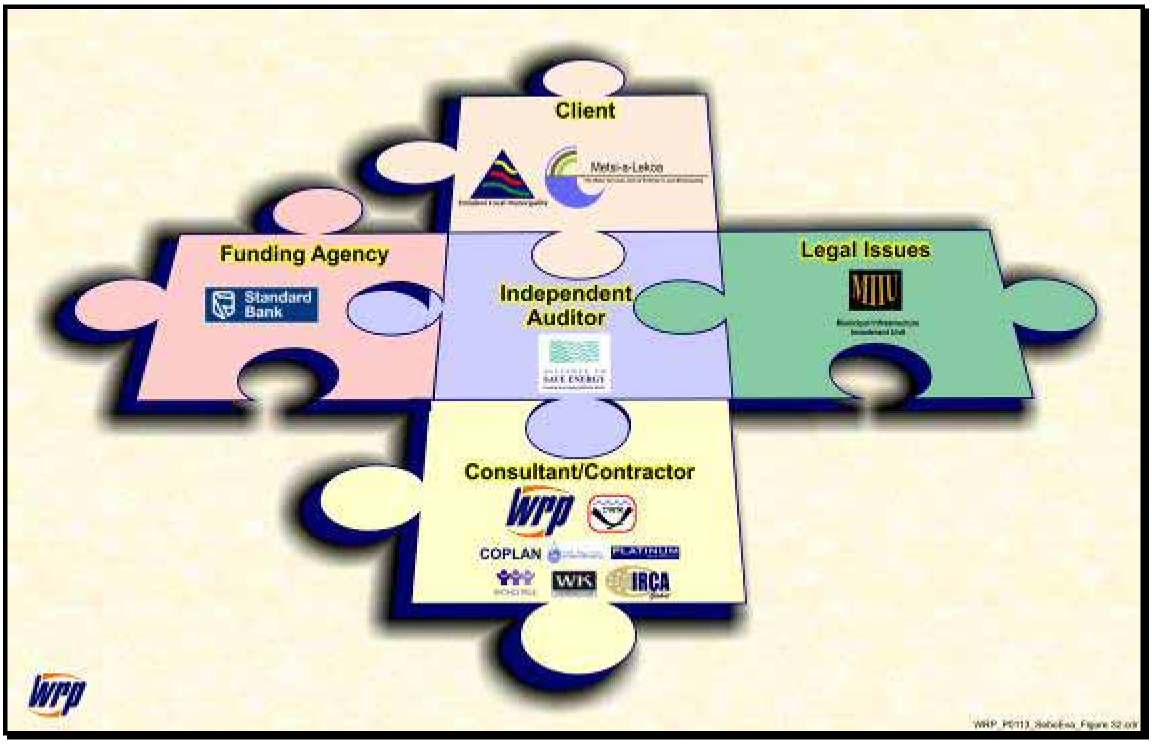



**Figure 7.13: Public Private Partnership model used for the Sebokeng/Evaton project**

### 7.2.5 The Installation

The installation is a large “house-sized” valve chamber which was constructed on top of the two existing water mains of diameter 1000 mm and 675 mm which supplied Evaton and Sebokeng respectively.  After constructing the basic infrastructure, two sections of the pipes were removed and replaced with several sections of smaller diameter pipes together with the necessary, meters, strainers, isolating valves and pressure reducing valves as shown in **Figure 7.14** and **Figure 7.15**.

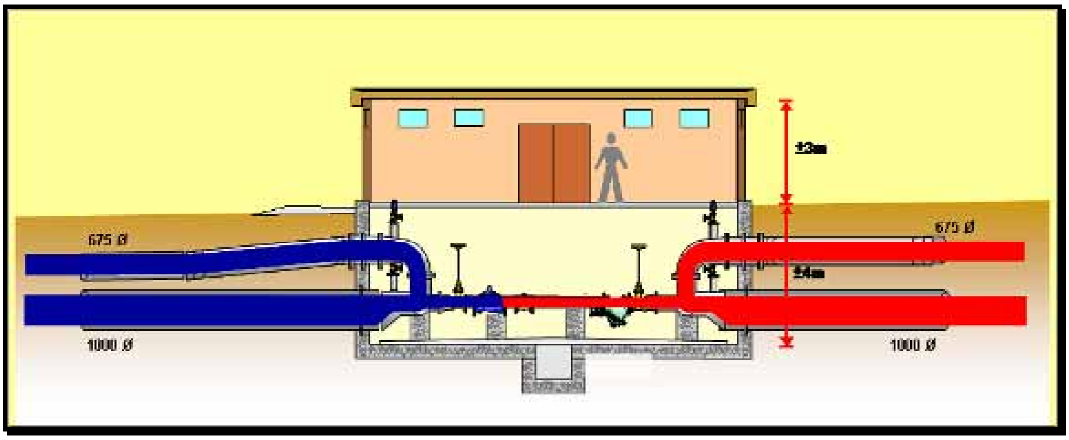



**Figure 7.14: Elevation layout of the Sebokeng/Evaton Installation**

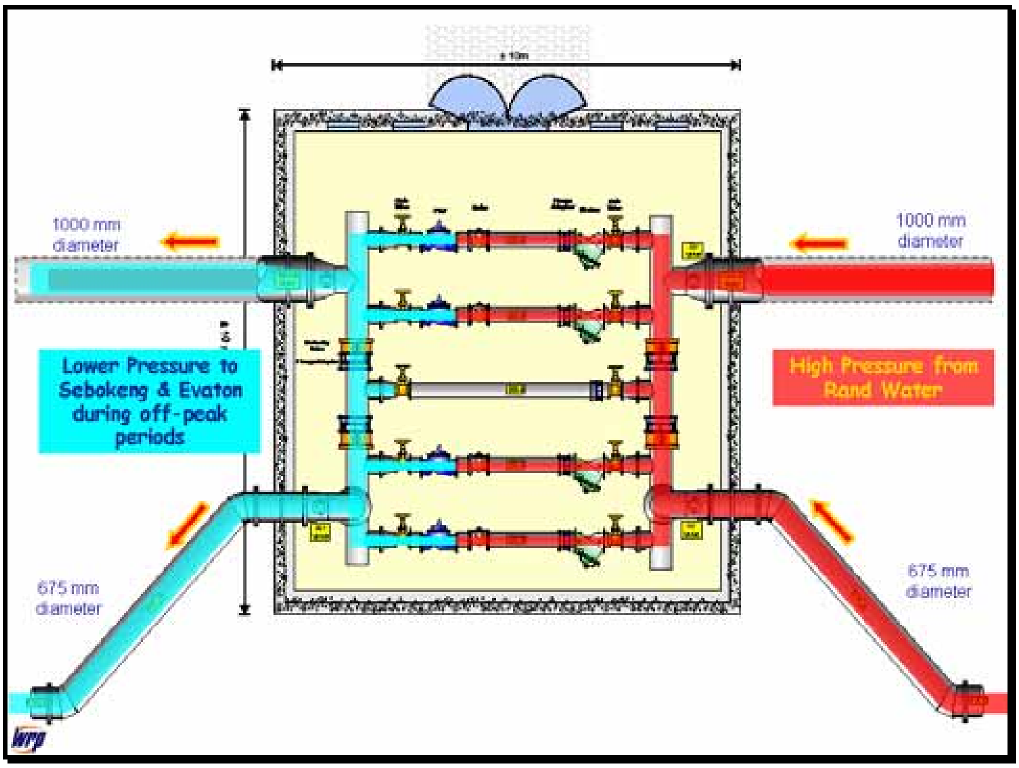



**Figure 7.15: Plan layout of the Sebokeng/Evaton installation**

### 7.2.6 Financial Model

Unlike many other projects, even the funds required to cover the capital costs were provided by the project team through a normal bank loan sourced from Standard Bank. Payment to the Project team is made by the Client on a monthly basis and in accordance with the savings made. In this particular case, the payments made to the Consultants Team are based on a small percentage of the savings achieved and the results from the first year of operation indicate that the average payment will be in the order of 10% to 15% of the savings achieved with the balance accruing to the Municipality. It is important to note that the Consultant’s Team must operate and maintain the installation for a period of 5 years and that the savings paid by the Municipality to the Project team will cease after the 5-year period has elapsed.

### 7.2.7 Results to February 2007

The project was initiated on 1 April 2005 and was operational by 30 June 2005 – only 3 months later. The actual construction was only finalised in September 2005 when the installation was officially opened by the Major of Emfuleni and the Director General of the Department of Water Affairs and Forestry as shown in **Figure 7.16**.


**Figure 7.16: Opening of the installation by the DG of DWAF and Mayor of Emfuleni**

The extremely short construction period was to some extend forced upon the Project Team by a very stringent legal contract which included severe financial penalties if the project was not operational by 1 July 2005. The Municipality was very anxious to achieve savings at the earliest possible date and the actual savings achieved during the first year of operation exceed R24 million which represents a 3-month "Pay-Back". The savings are reflected in **Figures 8.17 and 8.18.** The actual values and savings are provided and detailed in **Table 1**.

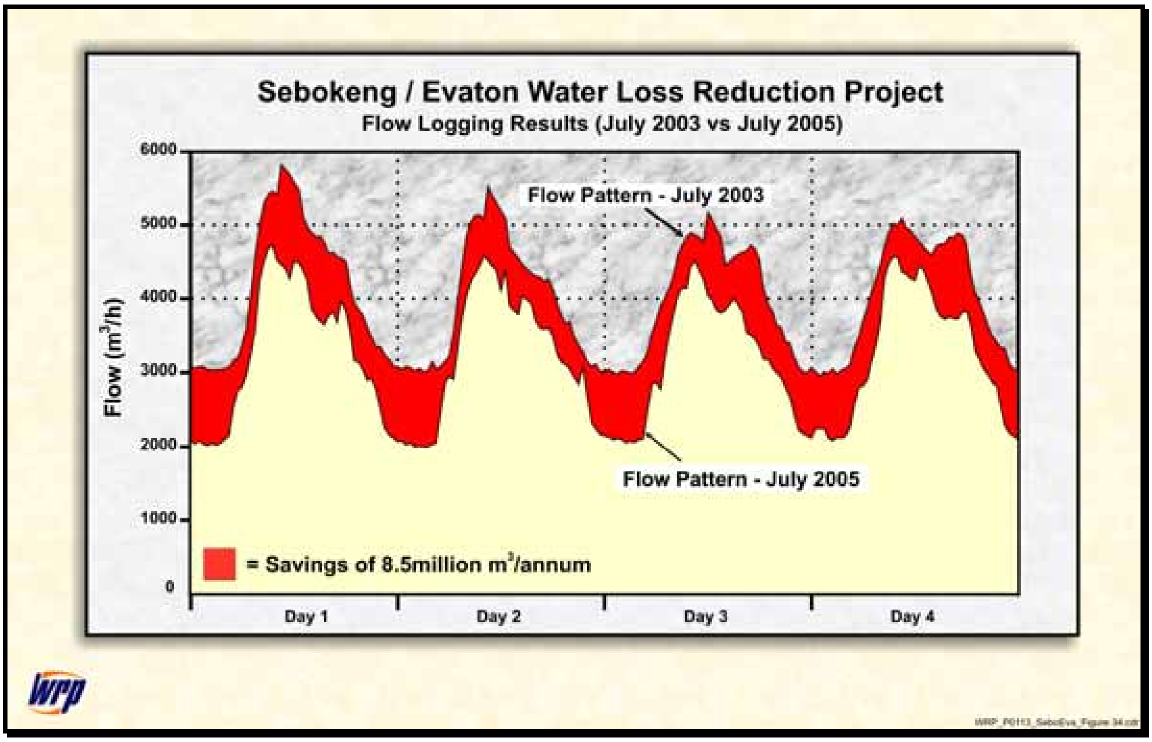



**Figure 8.17: Initial Savings from the Sebokeng/Evaton Project**

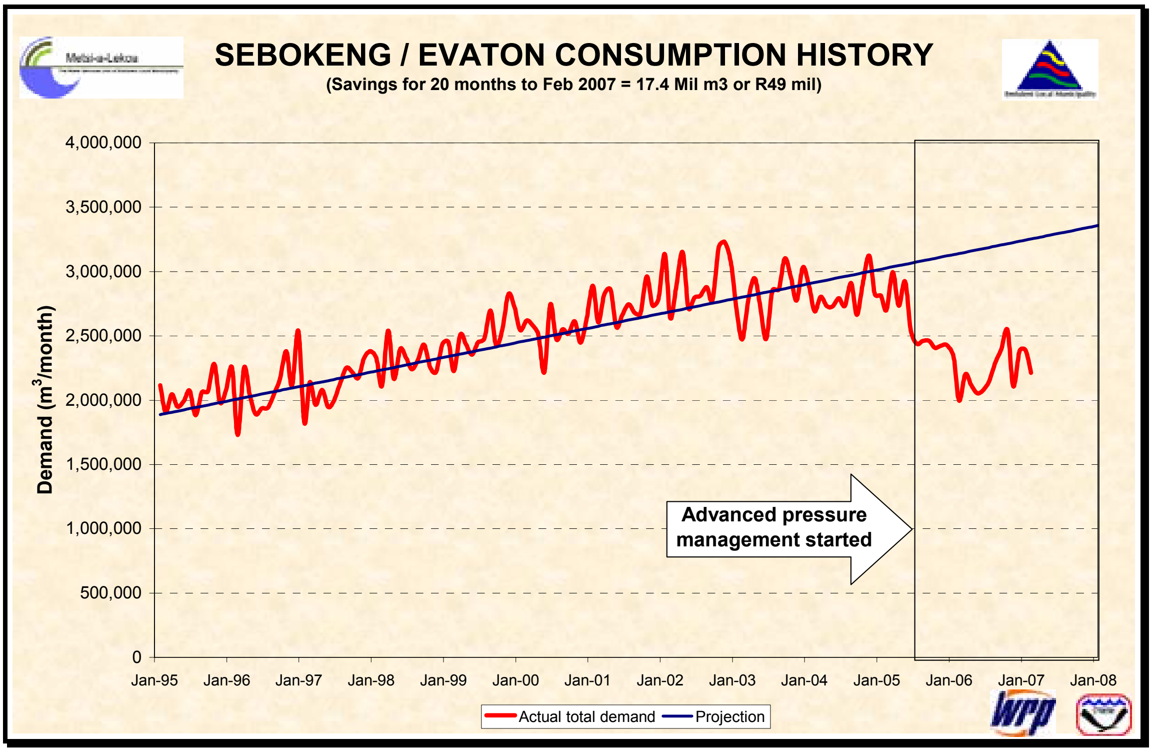



**Figure 8.18: Historical water consumption in Sebokeng and Evaton**

**Table 1: Summary of Savings from July 2005 to February 2007 ( 20 months)**

| Month | Water Use (m3) | | Savings | | |
|---|---|---|---|---|---|
| | Expected | Actual | m3 | Rands | US$ |
| Jul-05 | 3,074,241 | 2,438,310 | 635,931 | 1,755,170 | 292,528 |
| Aug-05 | 3,083,840 | 2,460,620 | 623,220 | 1,720,088 | 286,681 |
| Sep-05 | 3,093,130 | 2,459,070 | 634,060 | 1,750,005 | 291,668 |
| Oct-05 | 3,102,729 | 2,406,260 | 696,469 | 1,922,254 | 320,376 |
| Nov-05 | 3,112,018 | 2,421,960 | 690,058 | 1,904,561 | 317,427 |
| Dec-05 | 3,121,618 | 2,427,780 | 693,838 | 1,914,992 | 319,165 |
| Jan-06 | 3,131,217 | 2,337,020 | 794,197 | 2,191,983 | 365,331 |
| Feb-06 | 3,139,887 | 1,997,250 | 1,142,637 | 3,153,678 | 525,613 |
| Mar-06 | 3,149,486 | 2,200,560 | 948,926 | 2,619,036 | 436,506 |
| Apr-06 | 3,158,776 | 2,118,830 | 1,039,946 | 2,870,250 | 478,375 |
| May-06 | 3,168,375 | 2,055,280 | 1,113,095 | 3,072,142 | 512,024 |
| Jun-06 | 3,177,664 | 2,076,990 | 1,100,674 | 3,037,861 | 506,310 |
| Jul-06 | 3,187,263 | 2,149,000 | 1,038,263 | 3,010,964 | 501,827 |
| Aug-06 | 3,196,863 | 2,296,197 | 900,666 | 2,611,930 | 435,322 |
| Sep-06 | 3,206,152 | 2,393,860 | 812,292 | 2,355,647 | 392,608 |
| Oct-06 | 3,215,751 | 2,545,230 | 670,521 | 1,944,511 | 324,085 |
| Nov-06 | 3,225,041 | 2,107,670 | 1,117,371 | 3,240,375 | 540,063 |
| Dec-06 | 3,234,640 | 2,384,830 | 849,810 | 2,464,449 | 410,741 |
| Jan-07 | 3,244,239 | 2,387,810 | 856,429 | 2,483,644 | 413,941 |
| Feb-07 | 3,252,909 | 2,212,620 | 1,040,289 | 3,016,839 | 502,806 |
| **Total** | **63,275,839** | **45,877,147** | **17,398,692** | **49,040,379** | **8,173,396** |

### 7.2.8 Conclusions and Recommendations

The Sebokeng-Evaton Public Private Partnership has exceeded all expectations and many lessons were learned during the project as mentioned below:

In the first 20 months of operation the project has saved over 17 million m$^3$ of water resulting in direct financial savings to the Municipality in excess of R49 million.

The project had a financial payback on the total cost of the project of only 3 months.

According to the Alliance to Save Energy’s calculations (internal document sent to World Bank), the project is providing annual energy savings associated with pumping of water by the bulk water service provider in excess of 14 000 MWh which in turn is equivalent to reduced Green House Gas emissions of 12 000 tonnes per annum.

Public Private Partnerships need not be “mega-projects” and can be successful with relatively small projects if they are properly planned and implemented.

Sourcing the initial funding for a small project will remain a problem in South Africa since most financial institutions are not interested or willing to provide such small scale funding. Unfortunately very few private companies are willing or able to provide the necessary funding with the result that many projects which are technically sound cannot be taken forward.

A proper legal contract is essential and unfortunately once again this can cause many problems and long delays – it took almost 6 months to prepare the legal contract compared to 3 months to implement the project !

Many project teams consider that a Risk-Reward contract should be based on a 50/50 split of the savings achieved. This need not be the case and in the example, a split closer to 90/10 in favour of the Client was considered appropriate. Both Client and Project Team were satisfied with the outcome.

By introducing a 5-year operation and maintenance period, the Client effectively ensures that the savings will be maintained for a pre-agreed period. The 5-year period also allows time to transfer the knowledge and operational skills to the Client – an important and often neglected issue.

In summary, the project demonstrates that pressure management is possibly one of the most under-rated aspects of Water Demand Management in areas experiencing unusually high levels of leakage. In South Africa, such areas tend to be the lower income areas where leakage levels are known to be high due to various historical factors and the use of low cost fittings within the properties. The initial pressure management project is only the first phase of a long-term leakage reduction initiative and subsequent phases will include the replacement of all leaking taps and toilet cisterns within the properties as well as the replacement of household meters and selected pipes. It is strongly recommended that only high quality fittings (including meters and pipes) should be used which are capable of withstanding the high useage levels experienced in such areas. The use of low quality taps, toilet cisterns, meters and pipes will simply aggravate what is already a very dire situation.

## 7.3 OPERATION GCIN'AMANZI

### 7.3.1 Introduction

The object of the Gcin'amanzi project is to substantially reduce water wastage both on private properties and within the municipal water network in Soweto near Johannesburg. It is projected that this project will lead to savings of up to R158 million a year to the City of Johannesburg as well as drastically reducing the water and sanitation bill to individual households. The current situation in Soweto is that most of the households are either not receiving accounts or are being billed based on a deemed consumption of approximately 20 kl/month. The reality of the situation is that the average monthly consumption is estimated to be in excess of 50 kl/month. The main aim of the Gcin'amanzi Project is to reduce the average monthly consumption to approximately 12 kl/month and ensure that all water used is both metered and paid for based on the actual consumption. This is being achieved through the implementation of Pre-paid metering and the project is considered to be the largest project of its type to be undertaken anywhere in the world.

The water losses in the deemed consumption areas (deemed consumption is a fictitious average monthly per property consumption amount" calculated as the annual volume of water purchased from Rand Water divided by the number of formal properties for the area under consideration) has been calculated to be 82 000 Mℓ/annum or 225 Mℓ/day with approximately 83% of these losses amounting to 187 Mℓ/day occurring in Soweto. Since Soweto accounts for approximately 90% of the total volume of water purchased for deemed consumption areas, targeting Soweto for the implementation of a Water Conservation and Water Demand Management project is expected to yield significant savings in future water purchases.

Operation Gcin'amanzi (OGA), was initiated in July 2003, as an enabling tool to drastically reduce the abnormally high levels of non-revenue water in Soweto. The project which is programmed for completion in 2007, represents a R560 million investment in present value (with a four year payback period) and will benefit 160 000 households. OGA is seen as a key component of Johannesburg Water's Financial Turnaround Strategy.

There are a suite of technical and social interventions that support the OGA project. Some of the key technical interventions are the renewing of the mid-block system, installation of prepayment metering and retrofitting of plumbing in private households.

### 7.3.2 Operation Gcin'amanzi gains momentum in Soweto

The implementation of Operation Gcin'amanzi, a multi-million project to upgrade municipal water infrastructure, continue to gain momentum in Soweto. This follows the successful completion of the Phiri prototype project where 99% of residents have opted for the installation of free-payment meters (free-6000 litres of water first and only start paying for consumption above 6000l).

The project was launched in August 2003 with the intention of reducing the severe water losses which amounts to about 7 billion liters of water a month in Soweto alone. As part of the project the following interventions have been implemented:

- Replacing and upgrading the water reticulation pipes
- Repairing of leaking household plumbing fixtures
- Metering of properties with a free-pay meter to allow for the monthly dispensing of free 6000 l per stand and then payment based on actual consumption thereafter
- Creation of employment opportunities to assist in the roll out of these measures and provide skills

An intensive education and awareness programme is part and parcel of the project to ensure community understanding of the project and instil awareness on customer rights and obligations, within the context of the project. More than 365 community facilitators from the affected communities have been employed and trained to carry out door to door consultation with home owners prior to the installation of free-pay meters. This compliments the community and wards meetings that are held regularly by local ward councillors.

The education and consultation interventions are paying off:

- To date more than 21 000 households are now equipped with free-payment water meters.
- Water, supplied to each stand has dropped from 66 000 litres per month per stand to about 11 000 per month per stand.
- Approximately R10,6 million has been saved on water losses.
- 4,016,221 kl (over 4 billion) litres of water has been saved to date
- And 1 527 employment opportunities created for local labourers.
- Average water consumption and payment levels in the areas are that 57% of customers are using more than the free 6kl basic water allocation, and only spending R40.56 per month.
- Further benefits of the project include the debt write-off and the indigent's policy that has recently been introduced by the Executive Mayor of the City of Johannesburg. Plans are already underway to prepare for the next phase of the macro project targeting a further 30 000 households.
- As the project roll-out gains momentum, the after-care support programme will be intensified to ensure that a more efficient customer care and complaints handling process is in place.
- Johannesburg Water remains committed to its objective of bringing Johannesburgs "liquid gold" under better control and improving service delivery in general. With measures like these, it is the customers who are sure to be the main beneficiaries, in this case Soweto customers.

- Residents in Phiri were in the past being billed for water and sanitation based on the assumption that they consumed 20 Kilolitres of water. This bill amounted to R134.00 a month. With the Pre-Pay system, residents are only billed for what they consume over and above the first 6000 litres which is provided by Johannesburg Water free of charge each month. The average cost to residents in Phiri is now between R20 and R24 per month.

The initial results from the project are reflected in **Figure 7.17** as supplied by Johannesburg Water.


**Figure 7.17: Water demands in the Soweto area from July 2001 to April 2006 (supplied courtesy JOWAM)**

## 7.4 KAGISO PRE-PAID METERING PROJECT

The Kagiso Pre-paid metering project was initiated before the Soweto project and was at the time, the largest pre-paid project of its type. The area is situated near Krugersdorp and involves the installation of approximately 20 000 pre-paid meters in the Kagiso area.

Results from the Kagiso pre-paid metering project are shown in **Figure 7.18 and Figure 7.19.** It can be seen Mogale City has managed to keep this initiative sustainable despite the technical and management problems experienced.

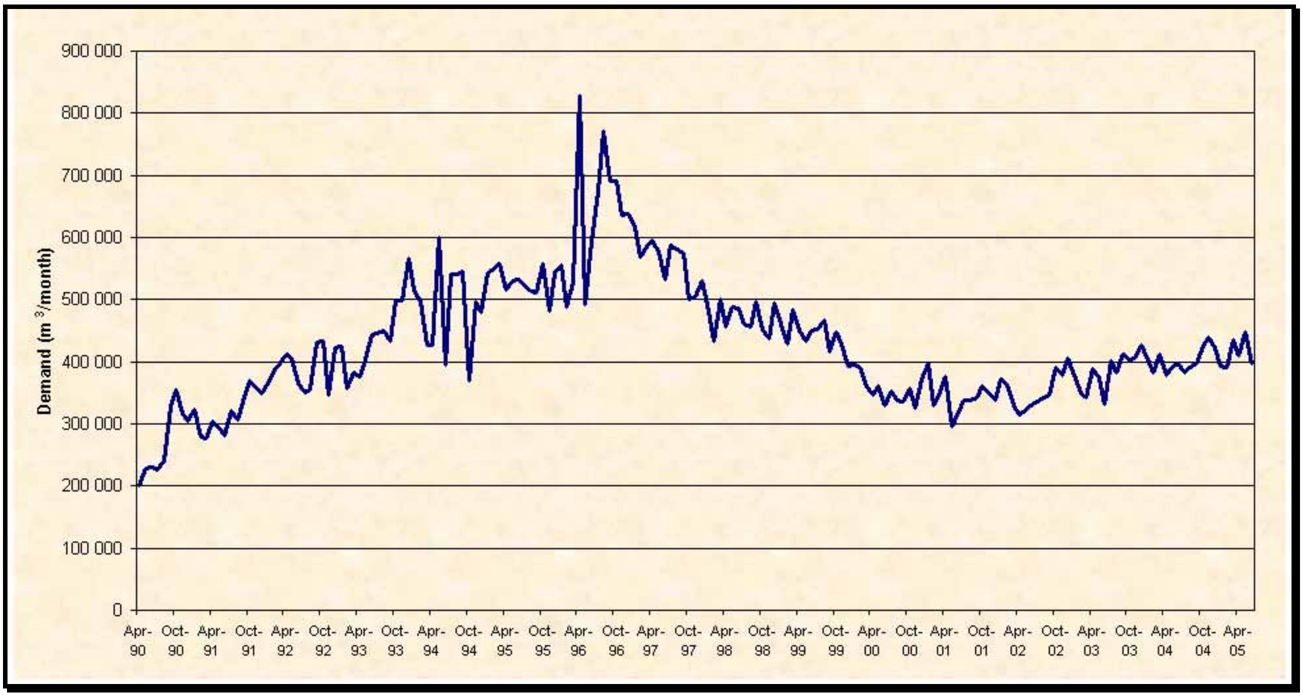



**Figure 7.18: Water consumption figures for Kagiso from 1990 to 2005 (supplied courtesy M Rabe)**


**Figure 7.19: Increased revenue collection in Kagiso from 1999 to 2005 (supplied courtesy M Rabe)**

# 8 CONCLUSIONS AND RECOMMENDATIONS

## 8.1 INDUSTRIAL, MINING AND POWER SECTOR

### 8.1.1 Industrial sector

The major motivational factors for water demand management and water conservation prevalent in the Industrial sector include:

- Sustainability Standards Set by Clients (Regular Inspections - Food, Pharmaceutical & Beverage)
- “Specific Water Consumption” per product is monitored and comparisons with international benchmarks generally compare favourably
- Obtaining relevant ISO accreditation is a priority for a number of consumers
- Part of Large International Organisation (Benchmarked)
- High operating Costs (Water and Energy)
- Quality of Abstracted Raw Water (Steel)
- Quality of Effluent Discharged (National Water Act - DWAF) / Discharge Tax

The stumbling blocks to implementing water demand management and water conservation are:

- Cost of implementing projects prohibitive (pay-back 2 years or less)
- Energy costs significantly higher that water, therefore main focus for improved efficiencies

Potential measures for water demand management and water conservation for the industrial sector include:

- Most large companies are implementing Sustainability / Environmental Policies regarding water
- Water Audits/ Water balance – Although prevalent amongst most large consumers, many medium sized and smaller consumers due not have adequate systems in place. There is subsequently significant potential through improved monitoring and control of water used for various industrial processes. Monitoring of processes and equipment ensures that they are operating within optimum water usage limits.
- Organisations targeted by the study stated that retrofitting/ replacement of existing dated equipment with more efficient equipment would results in a reduction in consumption.
- “Specific Water Consumption” per product is not monitored in all industrial sectors. Industries should be encourage to do so as part of water audits (even if only internal benckmarks are

established). Comparisons with international benchmarks are often not considered applicable as type of product and process may vary.

- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage. Limited uptake of water efficient devices for domestic usage was found.
- Recycling of effluent through treatment. Discharge of waste water with little or no recycling was found to be common practice amongst industrial consumers.
- Retrofit or eliminate once through cooling systems. Options include: re-circulation of cooling water, air cooled systems, discharge to other applications.
- Proper operation and maintenance of hot water and steam systems. Options include: Active leak detection and maintenance, return steam condensate to boiler, discharge blow down through expansion tanks, insulate steam, condensate, hot water pipes and storage tanks.
- Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the industrial sector.
- Major drivers moving forward are legislation and the cost of water. The most common reason for organisations not implementing water demand measures is financial. Most organisations will only consider capital project with a return on investment period of two years or less.
- A major concern amongst large consumers is growth in demand due to deterioration in water quality.

### 8.1.2 Mining

The major motivational factors for water demand management and water conservation prevalent in the mining sector include:

- Quality of Effluent Discharged (National Water Act - DWAF)
- International Standards – ISO 14 001
- Part of Large International Organisation – Annual SHE targets set (Benchmarked against other operations)
- Security of supply – Alternatives to potable water are used due to supply limits
- Operating Costs (Water and Energy)

Potential measures for water demand management and water conservation for the mining sector include:

- Current legislation (National Water Act - DWAF) is likely to have an ongoing impact on use within the mining sector.
- Scope exists to implement Water Demand Management/ Water Conservation measures for Domestic Usage (including retrofitting of water saving devices)
- Education and Awareness Programs. Promotion of improved water use practices and general awareness regarding the importance of water conservation is not prevalent within the industrial sector.
- Operating Costs (Water and Energy).
- Non-potable use including partially treated effluent. Additional scope exists for suitably situated mines to make use of partially treated effluent from municipalities for process water.
- Improved efficiency of Effluent Treatment Plants (Reverse Osmosis).
- New technology/ retrofitting. New mining techniques that are specifically suited to water scarce regions are being developed. Upgrading of older workings and equipment will result in a reduction in water consumption.
- Co-operation with other local users (Current legislation/ By-laws may be an obstacle). Mines are investigating the viability of recycling of process and decant water through treatment for supply to other mines/ industrial users as well as municipalities. The use of dual reticulation systems by towns in municipal areas has been implemented on a limited scale to date.

### 8.1.3 Power sector

Motivation to Implement WDM/ WC

- Operating Costs
- Target of Zero Effluent Discharge
- Current legislation (National Water Act - DWAF)

Potential measures for water demand management and water conservation for the power sector include:

- Significant improvements in efficiency achieved 1980 – 2001 through implementation of Dry Cooling.
- Future improvements in efficiency dependant on technology breakthrough.

- Demand Side Management (DSM) Program implemented in 1994 has continued potential (Currently Working with Dept Energy and Minerals).

## 8.2 IRRIGATION SECTOR

Efforts have been made to identify the causes of water losses in the six schemes in the Vaal catchment in the irrigation sector, and hence to propose achievable water conservation and demand management initiatives. The study reviews the extent of data gaps in the catchment, which, at this stage, presents a stumbling block in water use auditing in the catchment. Analysis of the water balance data obtained from DWAF indicated significant conveyance loss in the catchment. Most of the conveyance losses in the catchment are attributed to operational losses, which can be easily alleviated by equipping water bailiffs with tools which can assist them to release the right amount of water at the right time. The conveyance loss in the Vaalharts scheme, unlike the other schemes, is mainly attributed to canal evaporation and seepage from canals. The high evaporation is reckoned to be due to the length of the channel. The high seepage loss, as people from the area indicated, especially from the North Canal, is due to improper construction.

The potential for water saving by implementing latest technologies has been investigated based on theoretical irrigation application efficiency values. A 2% improvement in each of the six selected schemes would provide a 7.3 million $m^3$/a saving. This can irrigate an area of 948 ha assuming 7700 $m^3$/ha/a water requirement. Similarly if the irrigation application is improved by 5% in each of the schemes, 18.0 million $m^3$/a water, which can irrigate 2 340 ha, which is equivalent to the entire Schoonspruit government water scheme. There are savings in operational costs which can offset the capital costs of improving efficiencies. These are however, closely linked to the types of crops that are being farmed.

As mentioned, while a quota allocation system is in place and while farmers are not using their full allocation, there is little incentive for farmers to implement more efficient irrigation systems, despite the fact that it can be shown that there are sufficient offsets in operational cost savings . It should, of course, be borne in mind that under utilization also serves as a buffer for the risk to farmers of impending drought periods. It would appear reasonable to link the water tariff to assurance of supply, as this is likely to provide the kind of incentive to encourage farmers to balance their risks of supply against using more efficient irrigation systems.

A four-year project titled ” Standards and Guidelines for improved irrigation efficiency from dam wall release to root zone application” is running by a consortium of ten people funded by WRC. The objective of this project is to develop benchmarks for all aspects of irrigation. These benchmarks are imperative to assess irrigation efficiency and hence to quantify the benefits of different water conservation and demand management efficiencies.

There is also huge potential for saving by improving the water management. However, the existing water monitoring system in the whole catchment has to be improved in order to give reliable information, to assist in identifying management problems and to quantify the benefits.

The success of water conservation and demand management initiatives mainly depends on the awareness and, responsibility and accountability of water control officers and the end users. As in Australia, a shift from thinking of productivity in the traditional way, from yield per hectare to yield per $m^3$ can bring about a substantial improvement in water use.  Thus huge efforts are required to address these shortcomings.

## 8.3 URBAN SECTOR

From the assessment of the scope for WC/WDM in the Upper and Middle Vaal River Basin several key issues were identified from which the following conclusions and recommendations were made:

- WC/WDM can provide a significant reduction in the water demands in the area if the measures are implemented properly and maintained indefinitely. The cost of implementing WC/WDM measures is often less that the maintenance costs which are often overlooked with the result that the WC.WDM interventions fail within a year or two of being implemented.
- The projected Rand Water demand in the year 2024-25 is estimated to increase from its current value of approximately 1 200 million $m^3$/annum to more than 1 500 million $m^3$/annum in the event that no WC/WDM measures are implemented. The potential savings that can be achieved in the study area range from a maximum optimistic estimate of approximately 400 million $m^3$/annum (Scenario c) in the year 2024 ( i.e. demand drops to approximately 1 100 million $m^3$/annum) to a more conservative and possibly realistic estimate of 200 million $m^3$/annum – i.e. demand drops to approximately 1 300 million $m^3$/annum (Scenario e).
- Savings are extremely limited in Mogale and Govan Mbeki as indicated by the relatively low ILI values of 3.4 and 2.6 respectively. In contrast the ILI values for Johannesburg, Ekurhuleni,

Tshwane and Emfuleni are 7.2, 4.5, 5.2, and 7.3 which indicate relatively high levels of leakage/wastage in these systems. Rustenberg also has high leakage/wastage as indicated by its ILI value of 8.6 as does Matjhabeng with an ILI of 8.0.

- WC/WDM can be effective and sustainable as has been shown by several large projects undertaken in the study area including:
    - The Sebokeng/Evaton pressure management project
    - The Soweto leak repair, retrofitting and pre-paid metering project;
    - The Kagiso pre-paid metering project.

- Garden irrigation using potable water is a huge problem issue in many low income areas where indiscriminate use of hosepipes and potable water is creating both supply and pressure problems. The use of hosepipes must be either banned completely in such areas or the use restricted to an hour or two every 2nd day during off-peak periods. Irrigation during the hottest part of the day (from 10h00 to 18h00) should be prohibited simply on efficiency grounds.
- Government Departments must co-ordinate their efforts with regard to WC/WDM. The efforts of DWAF where the Department is spending large budgets to educate consumers on the evils of hosepipe irrigation is being undermined by the efforts of the Department of Agriculture where it is providing free hosepipes to the same consumers to grow vegetables. Those wishing to grow vegetables in such areas should be provided with buckets or watering cans which can still be used with good effect without causing the system problems mentioned previously. Alternatively, roof tanks should be provided to capture rainwater which is ideal for such irrigation.
- DWAF should encourage WDM activities – e.g. fund projects like Sebokeng, provide subsidies for roof tanks and low flush toilets etc. The Department should not encourage use of low quality fixtures in township retrofitting projects and should rather use the highest quality pipes, meters and fittings for poor areas since the taps and toilets in these areas experience highest use and lower quality fittings will not last.
- Lack of maintenance will result in many systems deteriorating into intermittent supply if action is not taken quickly – particularly in township systems where lack of maintenance has occurred over past 30 years.
- Municipalities should be encouraged to combine technical and financial services into a single unit – current trend of separate billing/treasury from water supply/technical is causing major problems and a proper water audit is often not possible since the split between Real and Apparent losses cannot be established with confidence.

# 9 REFERENCES

## 9.1 IRRIGATION SECTOR

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