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LESSON SERIES
May 2015

REDUCING WATER LOSSES IN MUNICIPALITIES

Key Issues and Pointers to Implementation

WATER RESEARCH COMMISSION

ABOUT THIS PUBLICATION

This publication contains extracts from the Water Research Commission (WRC) Research Report entitled *Guidelines for Reducing Water Losses in South African Municipalities* (WRC TT 595/14) by R S McKenzie. The *Guidelines* are practical and extremely useful. They are based on work over a period of 20 years in about 20 countries.

This document has a primary focus on section 2 of the *Guidelines* which provides a comprehensive and easy to understand overview of the key issues in reducing water losses in municipal water supply systems. It is intended to give decision makers, managers and implementers of water supply in municipalities a vision for dealing with water losses in cost effective and uncomplicated ways.

You are strongly encouraged to access the full *Guidelines* to use in implementing water demand management. The full *Guidelines* have a number of Appendices to support its practical implementation.

To obtain the full WRC Report No. TT 595/14 contact:
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Cover photograph courtesy of City of Cape Town: Khayelitsha installation after “face lift”

CONTENTS

ACRONYMS

ALC	Active Leakage Control
BABE	Burst And Background Estimate
CAD	Computer Aided Design
DWS	Department of Water and Sanitation
GIS	Geographical Information System
GPRS	General Packet Radio Services
GSM	Groupe Spécial Mobile (Global System for Mobile Communications)
ILI	Infrastructure Leakage Index
IWA	International Water Association
MIS	Management information system
NRW	Non-Revenue Water
PI	Performance Indicator
PRV	Pressure Reducing Valve
UARL	Unavoidable Annual Real Losses
UK	United Kingdom
WDM	Water Demand Management
WRC	Water Research Commission

1 INTRODUCTION

Saving water and water demand management (WDM) in general can be quite confusing to a municipality wishing to embark on some form of water loss reduction activities. A lot of work has taken place in South African and internationally to support water loss reduction in order to save money. While immediate savings cannot usually be expected, municipalities are encouraged to plan for a five (or preferably ten) year programme. The savings may be difficult to achieve, and possibly more difficult to sustain, but one thing is certain – **if no action is taken to reduce water losses, the losses will continue to increase.**

There is no single WDM intervention that will always provide the best savings at the least cost. Every water supply system is unique, and will have its own specific problems. In reality, reducing water losses is not complicated. But it does require a dedicated and methodical approach if real and sustainable savings are to be achieved. It is often similar to detective work where the first step in the process is to identify and understand the problem before trying to solve it. Too often, water loss reduction interventions are introduced that are inappropriate to the problems experienced in the reticulation system. The interventions must be selected to address the most serious problems to have a real chance of success.

There are a great many different interventions that can help to reduce water losses as can be seen in Figure 1.

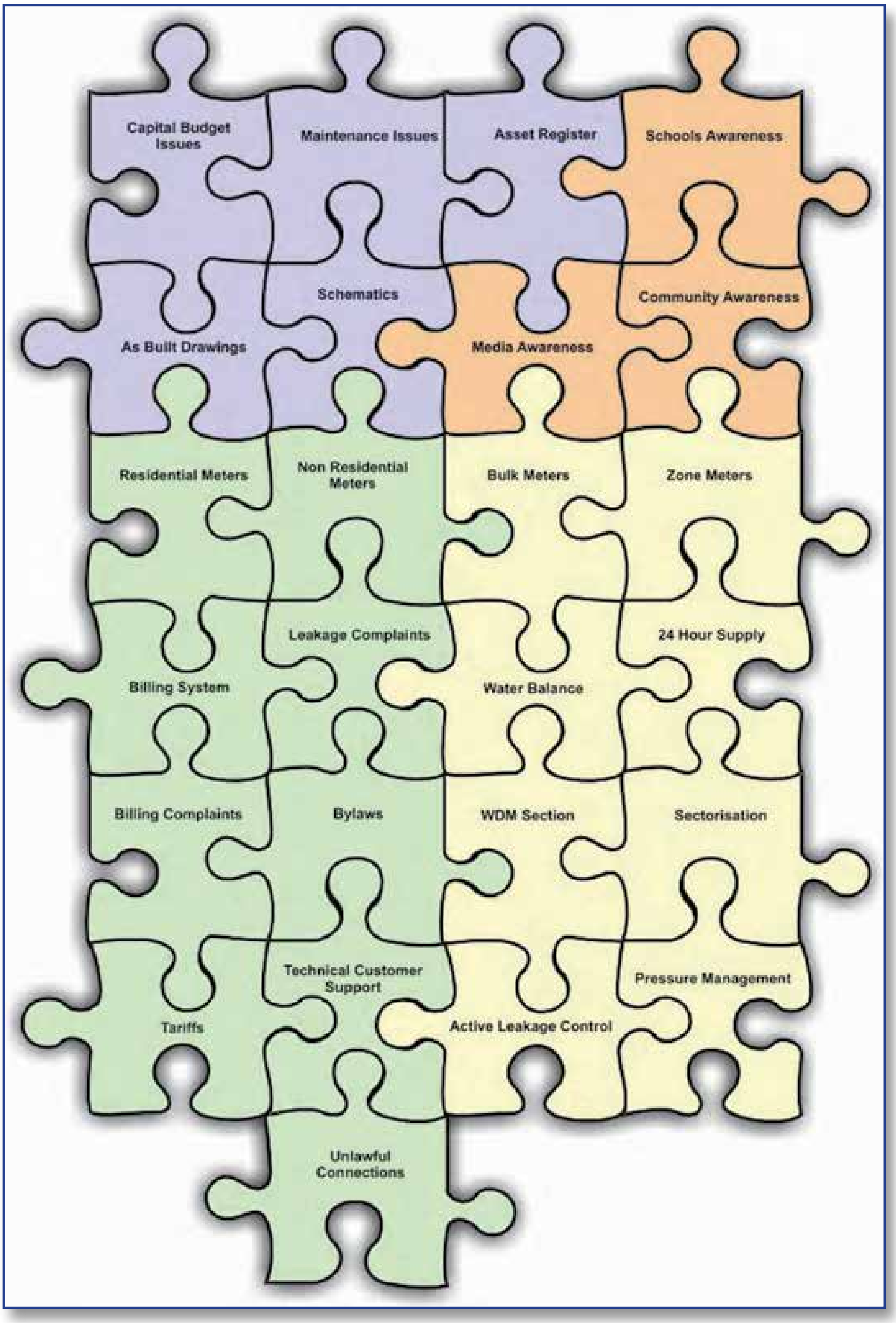


Figure 1: Some possible WDM Interventions and issues

The key issue is to decide which interventions are the most appropriate to a specific area and how best to implement them. The most common mistake is to believe that water loss reduction is achieved only through leak detection and repair. In such cases, large budgets are often used to search for unreported leaks using the latest hi-tech and expensive equipment. If the water losses are due to inaccurate metering or even background leakage, the leak detection activities will yield little or no results. Before starting any major water loss reduction intervention it is therefore necessary to spend some time and effort to examine the problems and to identify the root causes of the water losses. Once the real problem issues have been identified, the solutions are often obvious, and the way forward becomes clear.

2 KEY ISSUES

2.1 Addressing the obvious

Many municipalities struggle to appreciate the necessity and benefits of dealing with water losses. Council officials will often debate at length over a budget allocation of a few thousand Rand when a road leak may run unattended for weeks or months, and can run up a bill of hundreds of thousands of Rand. Based on the existing situation in many municipalities, there are a few key issues regarding water loss reduction that need no explanation or detailed analyses which are basically nothing more than common sense. Unfortunately they require a budget and real effort from the municipality often involving excavation of pipelines and repair, where necessary. Until these basic issues have been addressed, there is little benefit in introducing some of the more expensive and sophisticated measures such as pre-paid metering and automatic meter reading, for example.

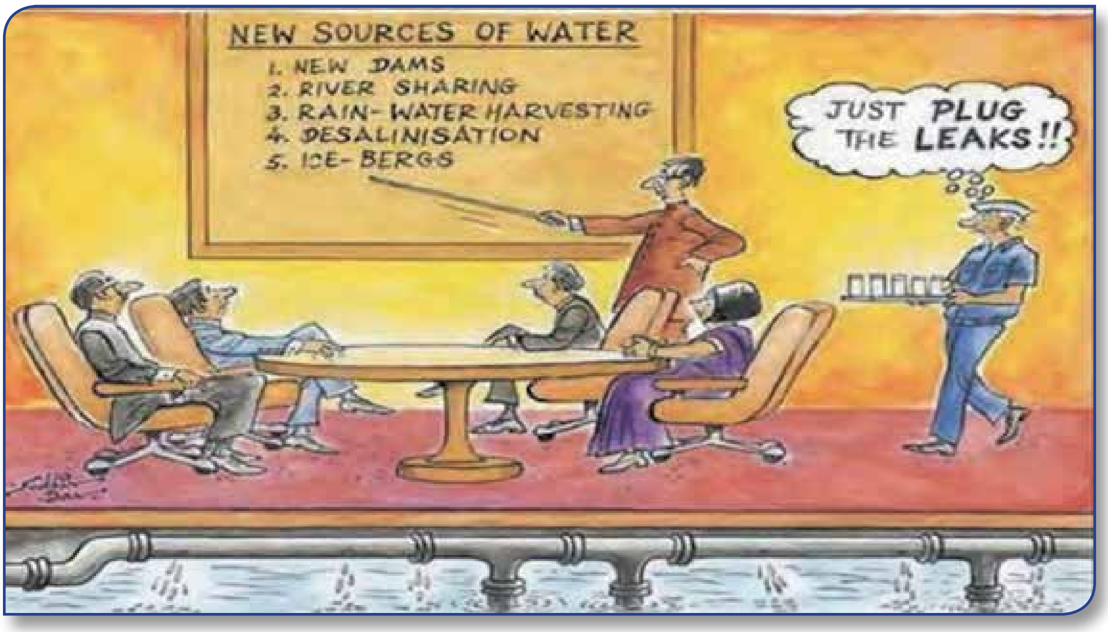


Figure 2: Fix the obvious! (Courtesy World Bank: Water and Sanitation Sector)

Addressing the basics correctly will always be cost-effective and should be considered as a pre-requisite for future water loss reduction interventions. The basics are addressed in section 2.1.

2.2 Key water loss reduction (water demand management) issues

The following key water loss reduction issues are discussed to give you a sense of what the issues are, and how to go about implementing water loss reduction:

1. Network schematics
2. Leak location and repair
3. Pressure management
4. Sectorising
5. Logging and analysis of minimum night flows
6. Bulk management meters
7. Bulk consumer meters
8. Domestic metering and billing
9. Pipe replacement and repair
10. Cooperation between technical and financial departments in municipalities
11. Basic water balance
12. Community awareness and education

2.2.1 Network schematics

Before any work can be considered in a water supply network it is important to understand the basic layout of the network. Some water utilities and municipalities have already developed comprehensive computer aided design (CAD) drawings which show every pipe and valve in the system which are very useful. However, they are normally too complicated and detailed for the purpose of gaining a basic understanding of how the system operates.

In order to understand how a particular system operates, it is recommended that the first task is to develop a high-level system schematic. Such a schematic is shown in Figure 3 for the water supply to a small town. The schematic is not drawn to scale. It is designed specifically to show the key components in the system including master meters, reservoirs, purification plants etc.

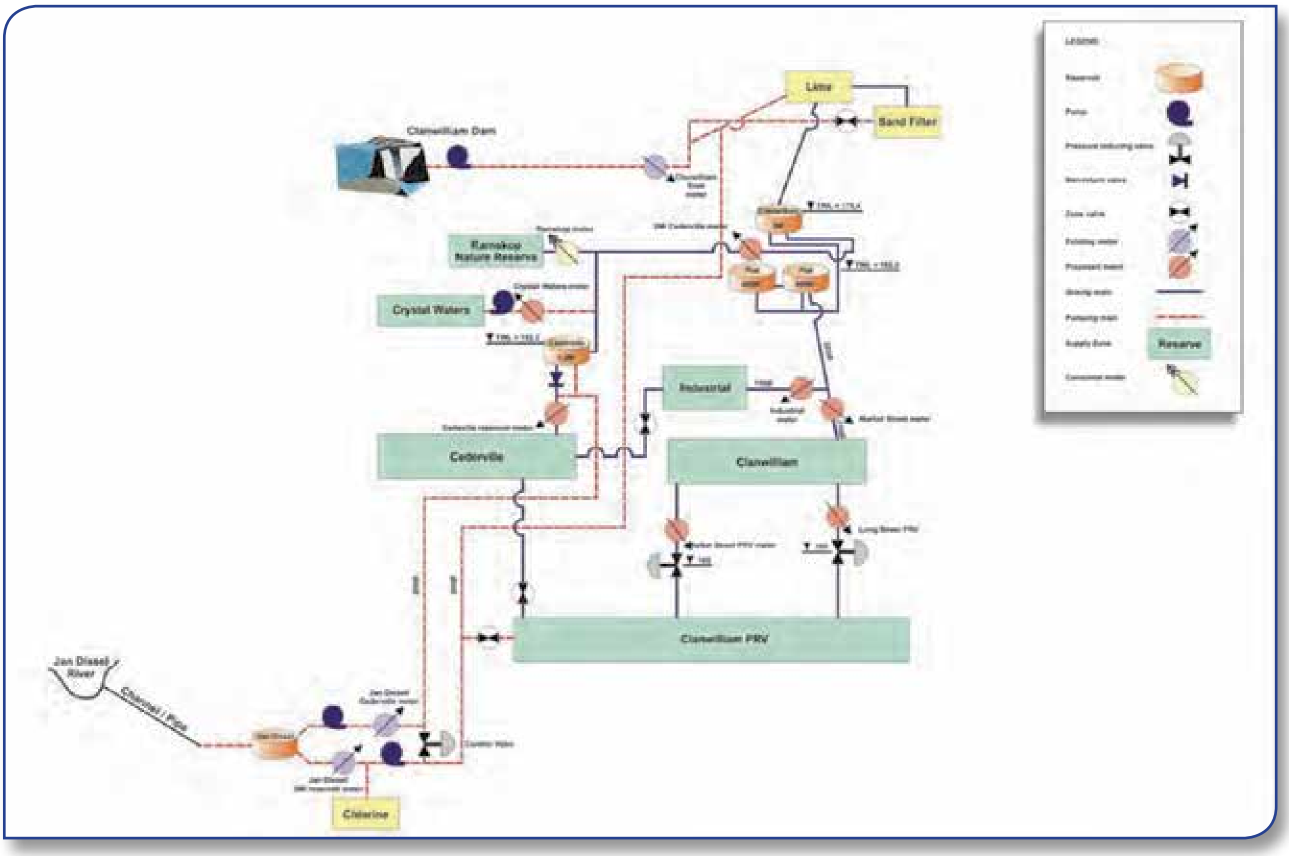


Figure 3: Typical high level system schematic

The schematic is a relatively simple system and, in the case of larger towns, the schematic may become more complicated. In some cases, it may be necessary to split the schematic into various components with a high level schematic together with several more detailed schematics.

2.2.2 Leak location and repair

Identifying and repairing leaks is often what most people think of when addressing water losses. While in some areas it can be very important, in other areas it is not the main problem. Throwing big budgets at leak location and repair may be futile if the underlying problem is high water pressure or a network which is no longer viable.

Repairing visible and reported leaks (preferably within 24 hours of being reported) is without doubt one of the most obvious and basic interventions that should be implemented. The repair of leaks needs no financial justification or preliminary assessment to determine if it is worthwhile. No municipality can expect its customers to save water and pay for services if it allows visible leaks to run for weeks or months without being repaired. Repairing visible leaks is the most basic and obvious water loss reduction intervention that can be implemented.

Spending time and effort searching for unreported leaks (those below the ground that are not visible) with some form of leak detection equipment is referred to as active leakage control (ALC). This may or may not be cost effective depending upon the level of leakage in a specific area. If an area is known to have high leakage (the area will have high minimum night flow) and the network is known to be in a poor condition, it may be worthwhile to send in a team of leak locators to identify unreported leaks. It must always be noted that all visible leaks should be repaired before any leak location activities are undertaken to search for new and unreported leaks. It should also be noted that the equipment used to identify the unreported leaks need not be the most expensive or most sophisticated. In most cases, a well-trained experienced leak detector with a basic listening rod will often find more leaks than a poorly-trained leak locator with the most expensive equipment. Figure 4 shows some leak location equipment in action.

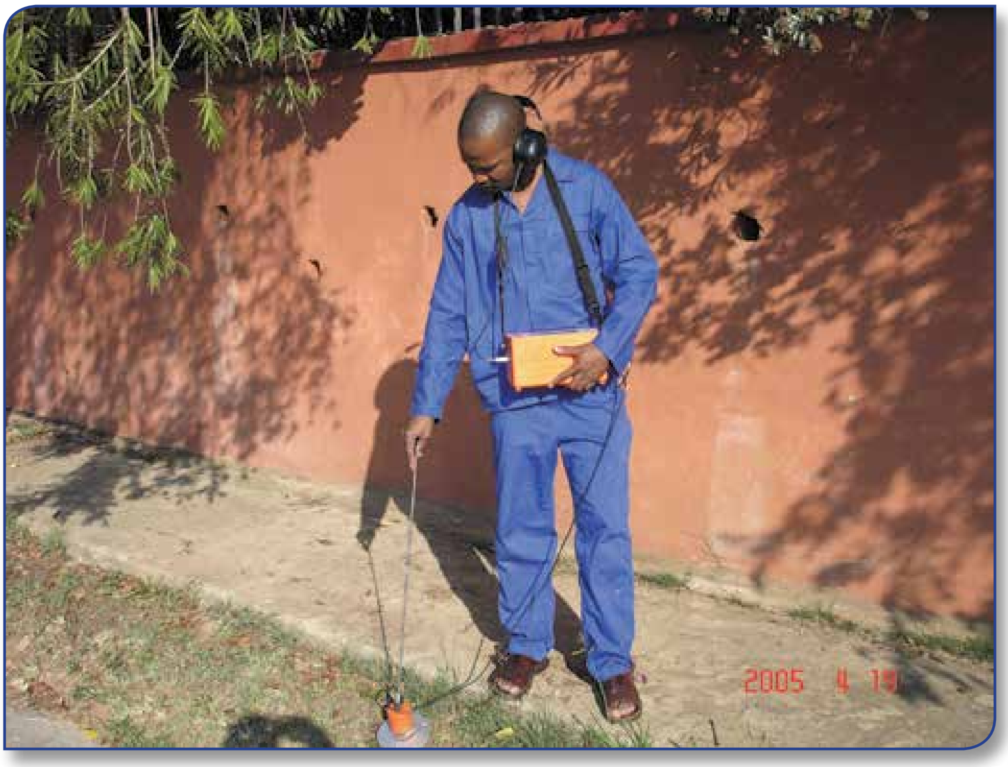


Figure 4: Leak location using sounding equipment

2.2.3 Pressure management

Leakage is driven by pressure. Many municipal water supply systems in South Africa are operated at unusually high pressures and, as a result, pressure management is often one of the most important WDM interventions that can be implemented. Pressure management can take many forms ranging from the basic fixed outlet pressure control to some form of more sophisticated hydraulic or electronic control which is often referred to as "smart control" or "advanced pressure control".

South Africa was one of the first countries in the world to adopt the principles of advanced pressure control initially developed in the United Kingdom (UK) for the UK water industry back in the early 1990s. The techniques used in the UK were first presented in South Africa in 1997 and following a series of small pilot projects, the full-scale Johannesburg Pressure Management Project was completed in 1999 involving the design and commissioning of almost 50 advanced pressure control installations. Around the same time, both City of Cape Town and Drakenstein Municipality recognised the benefits of pressure management and introduced measures to lower pressures in their water supply systems. Cape Town currently boasts the lowest level of non-revenue water (NRW) (around 20%) for any Metro in the country, while Drakenstein now has one of the lowest levels of NRW for any municipality in the country (around 11%). Pressure management is a key component of the WDM interventions implemented in both cases.

Following the success of the Johannesburg project, one of the most ambitious pressure management projects undertaken anywhere in the world was designed and commissioned in 2001 in Khayelitsha for the City of Cape Town. At the time, this was the largest installation of its type in the world and was the forerunner to the even larger installation located in Emfuleni Local Municipality – both of which have received national and international recognition.

The most recent large-scale advanced pressure management installation in South Africa was commissioned in Mitchells Plain for the City of Cape Town in November 2008 and was the 3rd large-scale pressure management installation of its type to be constructed in South Africa. Each of these three installations controls the supply of water to approximately 500 000 residents from a single supply.

Water supply systems worldwide are generally designed to provide water to consumers at some agreed level of service, which is often defined as a minimum level of pressure at the critical point which is the point of lowest pressure in the system. In addition, there may be certain fire-flow requirements which can override the normal consumer requirements. The systems are designed to accommodate these pressure and flow requirements during the period of peak demand which would normally occur at some specific time of the day and during a particular month in the year. In other words, the systems are designed to provide the appropriate supply volumes and pressure during a very short period in the year and for the remainder of the time the systems tend to operate at pressures significantly higher than required. Even within the same system, there will be areas of high pressure due to topography and/or distance from the supply point with the result that many parts of a supply area will operate at pressures significantly higher than required in order to ensure that there is sufficient pressure at the one critical point.

Managing water pressures in a supply area is not a simple issue, and there are a great many items to consider. The common factor in every system is the fact that leakage is driven by pressure and, if the pressure is increased, the leakage will also increase.

In order to reduce leakage through pressure management it is necessary to reduce the water pressure without compromising the level of service with regard to the consumers and firefighting. If the water pressure in a system can be reduced, even for a short period during times of low demand, water leakage from the system will be reduced.

In effect, there are long periods when there is significant scope for pressure reduction, and this is the basis on which pressure management interventions are designed. Reducing the water pressure in a system can be achieved in many ways ranging from simple fixed outlet control valves to a variety of electronic or hydraulic controllers. However, ensuring that boundary valves are closed or open on a regular basis as per the network design is of greater importance than any pressure controller, which in any event will not operate properly when a pressure management zone has been compromised by unauthorised opening or closing of boundary valves.

The key to success rests with sorting out the pressure zones and making sure that they remain discreet. Most of the savings achieved through pressure management originate from the basic fixed outlet pressure reducing valve (PRV). The most serious problem facing municipalities in South Africa is ensuring that the pressure zones are operating properly and have not been compromised through an unauthorised opening or closing of valves. Unfortunately sorting out the zones is often tedious and thankless work. It is, however, the key to any successful pressure management installation.

It must always be remembered that pressure management does not eliminate leaks or repair any existing leaks. All leaks in the network before the introduction of pressure management remain as leaks after the pressure management installation has been commissioned. The benefits of pressure management are mainly through the fact that the leaks will run at a lower rate at any time where pressure has been lowered as can be seen in Figure 5 and Figure 6.

In addition, the lower pressure regime will lower the rate at which new leaks develop and, in many cases, the incidence of new bursts can be reduced significantly – sometimes by 90% or even more. The financial benefits of the reduction in new bursts and prolonging the life of the reticulation system are rarely included in the financial analyses despite the fact that they dominate the financial viability of most pressure management projects. Pressure management will usually provide very attractive pay-back on the initial investment.

2.2.4 Sectorising

Sectorising is simply the process of cutting a big area into smaller more manageable areas that allows the water manager to identify problem areas. The process of sectorising is well known as a critical element of any water loss reduction programme. The International Water Association's (IWA's) recommendations on a maximum zone size of approximately 2 000 connections has been embraced throughout the world to the extent that this is often considered a pre-requisite to any other WDM intervention. Unfortunately, while it is recognised that sectorising is very important, it is equally important to recognise that sectorising is only a means to an end and not an end itself. What is often overlooked when considering the sectorising of a large system is the fact that every new sector created must be maintained indefinitely if it is to remain effective. The costs and effort required to maintain new zones is often neglected. These costs are rarely added to the operational budgets of the municipality with the result that any zones created tend to be breached soon after establishment. It is therefore often better to concentrate on a smaller number of larger zones that can be properly maintained rather than too many small zones that are not maintained.

Figure 5: Underground leak running at low pressure (Ken Brothers)

Figure 6: Underground leak running at high pressure (Ken Brothers)

It should also be noted that in areas where small zones have not been established, it is still possible to use the concept of sectorising to identify problem areas, albeit on a temporary basis usually referred to as step testing. Through the use of step testing it is possible to identify the key problem areas despite the fact that there may be few if any permanent zones. Step testing is the process of closing internal boundary valves in order to isolate or cut-off portions of the network. By simultaneously monitoring the night flow during the sectorising process, small zones of high leakage can be identified.

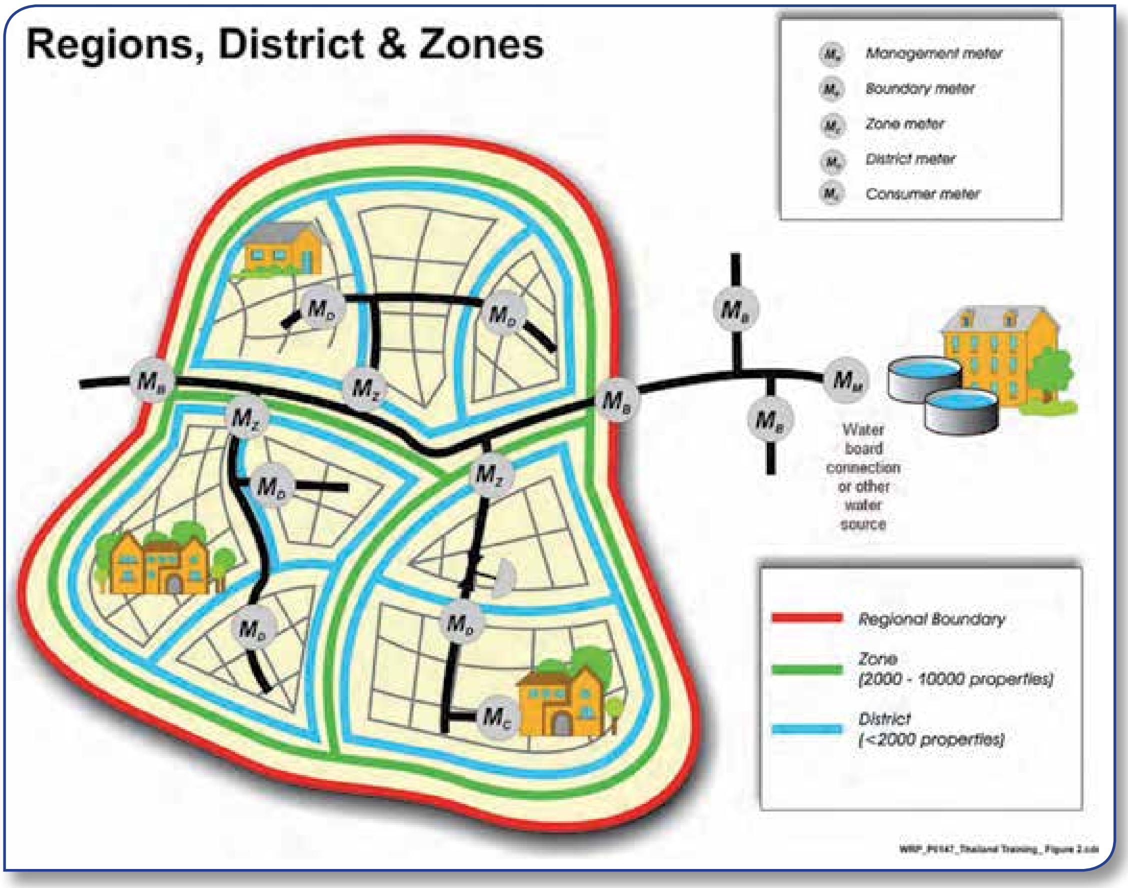


Figure 7: The concept of sectorising

2.2.5 Logging and analysis of minimum night flows

The logging of pressures and flows in a water reticulation system is a bit like a doctor measuring the pulse and blood pressure of a patient to see how healthy s/he is. This monitoring process is effectively the intervention that supports the sectorising process as discussed in the previous section. After zones have been established, the flows and pressures can be monitored in order to identify specific problem areas. So much can be determined from the examination of the logging results that it is surprising how few municipalities in South Africa have a logger let alone understand how to interpret the logging results. With the advent of the Internet and availability of Groupe Spécial Mobile (GSM) (Global System for Mobile Communications) and General Packet Radio Services (GPRS) communications, it is now possible and highly cost-effective to use loggers which automatically transmit the data directly to a receiving platform where the results are immediately available to anyone with a smart phone or other mobile device.

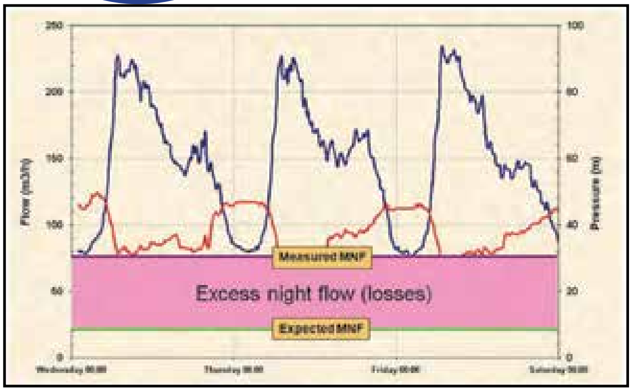


Figure 8: Example of a basic flow and pressure logging

2.2.6 Bulk management meters

Bulk management meters are sometimes considered an unnecessary luxury by water reticulation managers who don't appreciate the need to continually monitor the pressures and flows throughout their networks. Such meters are not used to generate accounts to anyone, but are specifically to help the water supply managers monitor and understand the water supply network. Bulk management meters are therefore essential for the proper operation and management of any reliable and well-managed water supply system. A typical example is shown in Figure 9.

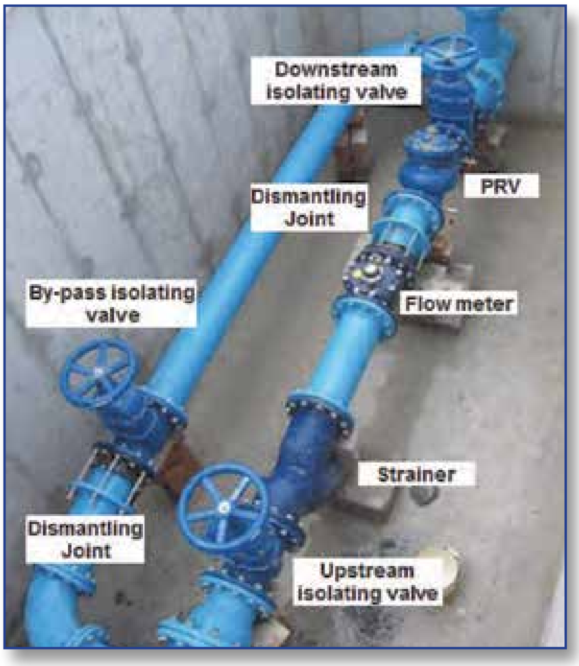


Figure 9: Typical bulk management meter in pressure reducing valve (PRV) chamber

Ideally, bulk management meters should be installed at the entrance to every zone in the system (see Figure 10). The old saying that "…to measure is to know " cannot be over emphasised. It is the bulk meters throughout the water supply system that are used to measure and quantify both water supplied to an area as well as the level of leakage in a specific area. Such bulk meters are an essential component of any efficient management process and they should be properly maintained and used to help identify problems. Ideally there should always be an option for measuring the water pressure at the same time as the flow into an area is measured. Knowing both pressure and flow helps to explain some of the problems that regularly occur. Once again, it is important that the water supply manager is able to understand the flow and pressure logging results.

Figure 10: Some bulk meters in Johannesburg

2.2.7 Bulk consumer meters

Industrial customers demand and expect a reliable water supply from their water services provider. No company in the world will invest billions on a new manufacturing facility if the water supply is likely to be unreliable. Industries pay their water accounts and do not expect to receive free water. Most municipalities charge an "industrial water tariff" which is usually higher than the domestic tariffs. In addition, they often charge a higher sewage tariff due to the fact that the industrial effluent can be problematic from a water quality perspective.

Since industries tend to use large quantities of water, often through a single connection, they often represent a very significant component of the water supplier's total annual water income. It is for this reason that industrial water users should receive special attention to ensure they are properly metered and billed. This is one of the most important issues that a water supplier should address when dealing with the "commercial losses" component of its water balance. In many municipalities the metering and billing of large consumers is poor, with numerous meters buried or broken or old and many un-metered connections. To deal with this issue a project was recently undertaken by the Ekurhuleni Metropolitan Municipality (see section 3.1).

The bulk consumer meters for bulk customers can effectively be considered a cash register for the municipality. The metering of large consumers is therefore of critical importance to the water supplier as it is a key element of their revenue stream and the revenue generated from a small number of large industrial consumers can often exceed the remaining revenue generated from the residential customers. It is much easier to monitor, bill and control the water supplied to a small number of bulk customers compared to a large number of smaller domestic water users.

Figure 11: Typical bulk industrial consumer meter in Ekurhuleni

2.2.8 Domestic metering and billing

The metering and billing of domestic consumers is a serious problem in many areas. Currently, there appears to be insufficient political support to enforce payment, and the issue of nonpayment is likely to remain a problem throughout South Africa for years to come. Once a customer has taken the decision not to pay for their water use there is no incentive for them to use water efficiently, and so the levels of leakage and general wastage become significant. With low payment levels, the municipality will eventually become bankrupt or have to reduce the funds spent operating and maintaining the water supply system that will deteriorate over time, and leakage levels will continue to increase. The level of service delivery will therefore decrease, visible leaks will become more common, and the image of the municipality will be damaged. Residents experiencing the poor service levels will not be willing to pay their water accounts and thus the cycle continues in a downward spiral.

A word of caution when considering domestic metering and billing concerns the recent trend in the use of smart metering, which has been very successful in some parts of the world. Such metering often eliminates the need for meter readers and, through the use of electronic meters and/or meter reading devices, will also eliminate many of the meter and billing inaccuracies. If implemented properly, this technology offers great potential for improved metering and billing, but there are a number of important issues to be considered before embarking on the use of such equipment.

The most critical issue is the need to engage with the community in advance and secure a commitment from consumers that they are willing to accept the new system and pay their water accounts. If this is not fully resolved before such metering systems are implemented they will fail completely. In many cases, the reasons for withholding payment are linked to underlying issues such as poor levels of water supply or very high levels of household leakage. If these are the reasons for poor payment levels, no new smart metering system will help and it will, in fact, aggravate an already dire situation.

Another consideration is the high initial cost of the equipment as well as the potential loss of employment opportunities for existing meter readers. In many water supply systems throughout South Africa there is already insufficient budget to maintain and repair the network in order to provide a reliable and safe water supply. In such cases it may be considered unacceptable by customers to spend hundreds of millions of Rand on new meters. And, given that there is already such high unemployment in most parts of South Africa that any job losses will be very unpopular.

2.2.9 Pipe replacement and repair

When to repair and when to replace is a question that many water distribution managers struggle to resolve. Pipe replacement is often the most expensive water loss reduction intervention. At some point in the life of a pipeline, however, the repair of the pipe becomes impractical (see Figure 12), and the only solution is to either reline or replace the pipe – both of which are expensive options. There are currently two main schools of thought when it comes to pipe replacement in South Africa. One approach that was implemented in the eThekwini Metro was the "blanket replacement" approach where all pipes of a certain type and/or age were replaced. In this case, it was decided to replace all of the asbestos cement pipes in the network. This was a massive undertaking involving pipe replacement of mains at an estimated cost of almost R1 billion.

Figure 12: A case where pipe replacement is clearly appropriate

An alternative approach has been introduced in Tshwane Metro in which certain types and age of pipes are replaced according to the incidence of burst pipes as recorded and monitored on the municipality's management information system (MIS). This approach involves the replacement of pipes as they deteriorate to a level where the occurrence of new leaks becomes so high that the pipes are effectively no longer suitable for use. This approach requires the collection and analysis of all burst information which is part of a sophisticated Geographical Information System (GIS)/MIS. Such information and statistics on pipe bursts is invaluable when used to determine whether or not it is time to replace a section of pipe and is one of the factors contributing to the lower than average leakage experienced in Tshwane Metro.

Both of the above approaches are supported by the respective water managers who operate and manage large water reticulation systems. In cases where funding is a major constraint, then the option of selective replacement will most likely be the appropriate route to follow since there will be insufficient funds available to complete a full replacement of pipes.

Great care should be taken when considering any large-scale pipe replacement project and it is recommended that some form of pilot area should be tested before embarking on any full-scale project. Numerous pipe replacement projects have been undertaken where the leakage has, in fact, increased after long lengths of pipework have been replaced. Pipe replacement is the most expensive water loss reduction intervention in most cases and it should be considered as the action of last resort after other options including pressure management and leak repair have been exhausted.

2.2.10 Cooperation between technical and financial departments in municipalities

One of the most serious problems facing many municipalities in South Africa with regard to water loss control is the divide between the technical and financial departments within the municipalities. In most cases, the technical managers who are responsible for the supply of water to all customers of the municipality have little control over the billing of the water, or the use of the funds recovered to sustain the water supply system. Too often, the sale of water is seen as a "cash cow" to the municipality, and much of the income generated from water sales is used to fund other matters. As a result, there has been a general lack of re-investment in water supply systems, which eventually results in a poor level of service to customers.

It is essential that water supply managers appreciate the need to reinvest large amounts of capital in maintaining the water supply infrastructure. A figure of 2% of the replacement cost of the water supply system annually is required to maintain a 50-year replacement cycle. Unfortunately, if the financial department is not working closely with the technical department, the 2% needed to maintain the system will rarely be allocated, and the system will gradually deteriorate. Many municipalities do not even know the replacement value of their water supply infrastructure, and have little or no idea how much they should be allocating to maintenance. In South Africa there has been a long period of under-investment in many water supply systems that even 2% of the replacement cost may not be sufficient to adequately maintain the water supply systems due to the backlog. It may therefore be necessary to provide a larger budget for several years to address the maintenance backlog after which the 2% should be sufficient.

2.2.11 Basic water balance

The South African Water Research Commission (WRC) has been providing support to municipalities to address leakage and wastage from their potable reticulation systems since the early 1990s. South Africa was one of the first countries to fully recognise the benefits of adopting the Burst and Background Estimate (BABE) methodology, which was initially developed by the UK water Industry in the early 1990s. The WRC has supported the development of various models to assist water suppliers in understanding and ultimately reducing their leakage. These include the SANFLOW night flow analysis model (1999), The PRESMAC pressure management model (2001) the ECONOLEAK active leakage control model (2002) and the AQUALITE water balance model (2009), which is used to assess the levels of NRW based on the IWA Water Balance.

Unavoidable annual real losses

An important concept recently developed[1] concerns the level of physical leakage (real losses) in a system that theoretically cannot be avoided. The concept of unavoidable annual real losses (UARL) is now one of the most useful and important concepts used in component based leakage management. 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 the lowest level of leakage that can be achieved for the given system based on the following assumptions:

- 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.

1 Lambert A., Brown T.G., Takizawa M., Weimer D, 1999. A Review of Performance Indicators for Real Losses from Water Supply Systems. AQUA, December 1999.

Considerable work was undertaken to assess the minimum level of leakage for water distribution systems and a relatively simple and straightforward equation has been developed:follows:

UARL = (18 * Lm + 0.80 * Nc + 25 Lp) * P

Where
UARL = Unavoidable annual real losses (per day)
Lm = Length of mains (km)
Nc = Number of service connections (main to meter)
Lp = Length of underground pipe from street edge to customer meter (km)
P = Average operating pressure at average zone point (m)

The basic equation is based on an average length of pipe from the water main to the customer meter of 10m. The third term (the Lp term) is only used in cases where the customer meter is located in excess of 10m from the water main. In countries such as South Africa where the customer meter is located at the street edge, the equation can therefore be simplified to the following:

UARL = (18 * Lm + 0.80 * Nc) * P

To show how easily the UARL can be calculated for a system a simple example can be used. If a system has 114km of mains, 3 920 service connections all located at the street property boundary edge, and an average operating pressure of 50m, the UARL can be calculated in the following manner:

UARL	=	(18 * 114 + 0.80 * 3920 + 25 * 0) * 50 litres/day
	=	102 600 + 156 800 litres/day
	=	259 400 litres/day
	=	259.4 m^3/day
	=	94 681 m^3/year
	=	66 litres/connection/day

Performance Indicators (PIs) including the Infrastructure Leakage Index (ILI)

Selecting an appropriate Performance Indicator (PI) to quantify and monitor leakage from a water network is often a contentious issue as there are several schools of thought in this regard. What is generally accepted by everyone around the world is that percentages should not be used as they can be extremely unreliable and will often give the wrong picture. This statement can be explained using a very simple example. In a water supply system which is supplied with 150 million m^3/annum, the leakage is known to be 50 million m^3/annum and the water use is 100 million m^3/annum. The leakage in this case is ± 33.3%. A drought occurs and the municipal manager is tasked with reducing the water use in the area and s/he implements water restrictions resulting in the water use dropping from 100 million m^3/annum to 50 million m^3/annum. The total water entering the system is now 50 million m^3/annum consumption and 50 million m^3/annum leakage. The percentage leakage has now increased to 50% despite the fact that in reality the leakage has remained the same. Despite general agreement on why percentages must not be used; they remain the indicator of choice in most parts of the world. If it is accepted that percentages will always be used, they should always be accompanied by some form of warning and, if possible, one of the other more reliable PIs should be included.

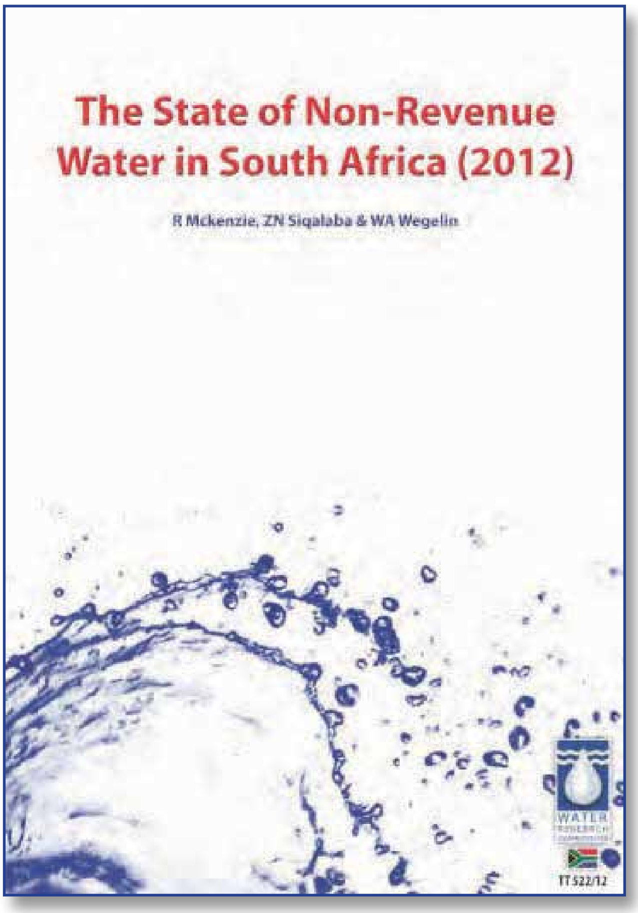
The three recommended PIs are discussed below:

1. The most basic PI is expressing the losses in litres/ service connection/day OR m^3/km mains/day. If a system has more than 20 service connections per kilometre, it is recommended that litres/service connection/day be used. In more rural systems with less than 20 connections per kilometre, it is recommended that m^3/km mains /day be used.

2. A more sophisticated PI can be used in cases where the average system pressure is taken into account. This PI is similar to the basic version discussed above for systems with more than 20 connections per kilometre of mains. The losses are expressed in terms of litres/service connection/ day/metre of pressure. This PI takes the average system pressure into consideration, but does not allow for the actual density of connections and average length of private un-metered supply pipe.

3. If there is information on the length of mains, the number of service connections and the system pressure then a more sophisticated PI called the Infrastructure Leakage Index (ILI) can be used. It is a single number that is dimensionless and is the ratio of the current annual real losses to the unavoidable annual real losses. It is a very useful PI and should be used whenever possible. A value of 1.0 suggests that the actual leakage is equal to the minimum level of leakage that can be achieved in the specific zone. If the ILI is 10.0 then it suggests that the actual leakage is 10 times higher than it could be. Any value of 10 or above suggests there is a very serious leakage problem.

<u>The 2012 NRW assessment in South Africa</u>



Four NWR assessments have been published by the WRC in the last 20 years: in 1999, 2005, 2007 and 2012. The 2012 assessment is the most comprehensive, and involved water balance information from 132 (of a possible 237) municipalities. The project was supported by both the WRC and the Department of Water and Sanitation (DWS).

The data gathered covered municipal water supply to more than 40 million residents. This represents over 75% of the total volume of municipal water supply in South Africa. The results indicate that the current level of NRW estimated for the country as a whole is 36.8%, with an average ILI (indicating physical leakage) of 6.8. The NRW figure for South Africa is similar to the estimated world average of 36.6%. It is considered high in comparison to developed countries but low in comparison to developing countries. Once again, it must be stressed that percentages can be misleading and the values provided in Figure 13 should therefore be used with caution.

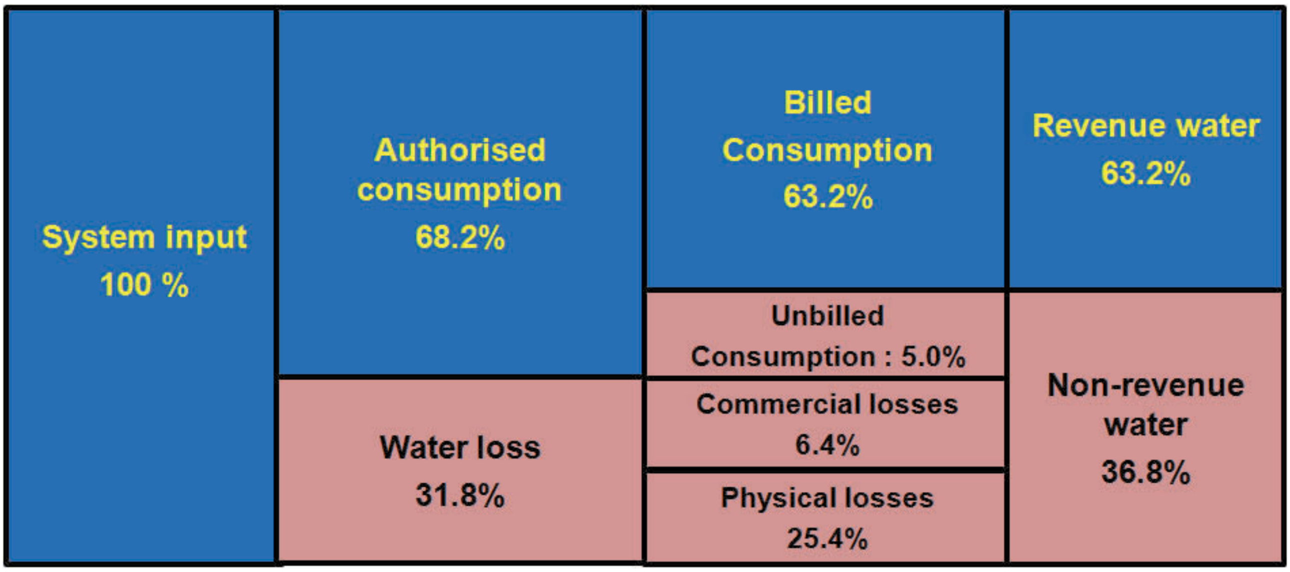


Figure 13: National water balance for SA from WRC Report (WRC, 2012)

It is noted that in South Africa every water supplier is categorised according to the size of the population supplied and whether the area is urban or rural. The results from the breakdown into the different categories are provided in Table 1.

Table 1: NRW figures for South African municipalities (2012)

Category	Population	Input (m^3/a)	NRW (m^3/a)	Revenue Water (m^3/a)	l/c/d
A	17 420 512	1 849 091 117	634 192 022	1 214 899 095	291
B1	7 756 187	683 667 320	282 585 164	401 082 156	241
B2	3 882 070	325 623 095	99 407 207	226 215 889	230
Urban Total	**29 058 769**	**2 858 381 532**	**1 016 184 393**	**1 842 197 140**	**269**
B3	3 845 279	230 642 568	85 229 869	145 412 699	164
B4	4 245 736	101 138 956	73 334 514	27 804 442	65
Rural Total	**8 091 015**	**331 781 524**	**158 564 383**	**173 217 141**	**112**
National Total	**37 149 784**	**3 190 163 056**	**1 174 784 776**	**2 015 414 281**	**235**
Extrapolated	**49 988 373**	**4 292 650 981**	**1 580 730 012**	**2 711 920 969**	**235**

The figures provided in Table 1 are based on an estimated total urban and rural consumption of approximately 4 292 million m^3/annum, and this figure was used in the calculations to generate the extrapolated values provided in the last row of the table.

The 2012 NRW study represents a major advance in the understanding and assessment of water losses from municipal water supply systems in South Africa. The overall NRW for South Africa is estimated at 1 580 million m^3/annum, which is approximately one third of the total water supplied. Conservatively, this represents an annual loss of over R7 billion based on an average bulk water tariff of approximately R5/m^3.

Effectively, the ILI value of 6.8 supports the perception created from the percentage NRW figures for South Africa (36.8%) where there is a high level of wastage or water losses in the country and considerable scope for improvement.

It is noted that the figures are based on the Standard IWA Water Balance in which the "Revenue Water" figures provided by financial departments are assumed to be correct. In South Africa, however, there can be a significant component of revenue water that is not paid for by consumers. Preliminary estimates suggest that if this is taken into account the level of NRW may increase by up to 10%. Investigations are continuing to try and quantify this element with greater certainty so that future assessments can provide a more accurate water balance.

2.2.12 Community awareness and education

This is perhaps the most important aspect of ensuring successful water loss programmes. Too often, well-designed and implemented technical interventions fail because the community they serve are not included in the planning and implementation process, and they do not "buy into" the project. In extreme cases community representatives may go out of their way to ensure that some technically sound project fails. Proper consultation with the community is therefore an essential element of any technical WDM intervention (see Figure 14).

Figure 14: Discussing WDM intervention with local residents

It is unfortunate that community awareness and education activities are difficult to monitor and quantify with regard to the cost of the activities, and the expected savings. As it is difficult to develop a cost-benefit analysis for the proposed activities, they are often not supported at the political level where funds are allocated. It is therefore necessary to incorporate the costs associated with the community awareness and education activities as part of every technical intervention when undertaking the cost-benefit calculation for the technical intervention.

3 TWO CASE STUDIES: EKURHULENI AND DRAKENSTEIN

The findings of two water demand management interventions – one in a Metro and one in a Local Municipality – to give municipal water managers a vision for undertaking such work in their municipalities.

3.1 Ekurhuleni Bulk Meter Management Project

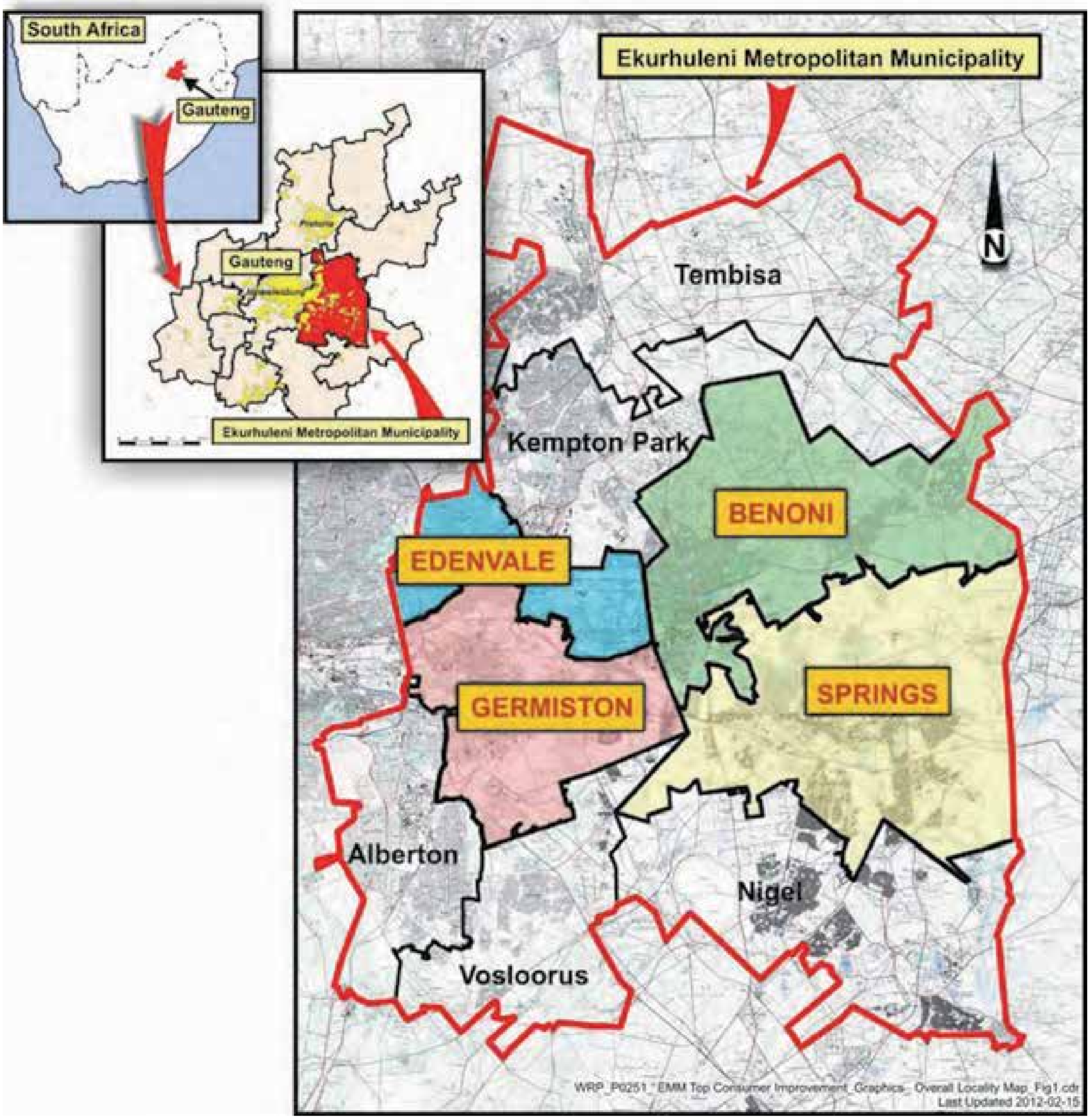


Figure 15: Ekurhuleni Metropolitan Municipality locality map

The project was funded entirely by the Ekurhuleni Metropolitan Municipality at a cost of around R20 million. The municipality benefited from the reduction of "commercial losses" which appeared as additional water sales to most of the consumers. In some instances, the increases in billed consumption were more than expected due to the location of buried meters that were brought into the consolidated supplies. Based on the metered and billed consumption during the first year after completion of the project it was estimated that the increase in billed consumption was in the order of R43 million/year. This represents a pay back on the investment of approximately six months.

This project led directly to the creation of approximately 20 full-time jobs for a period of two years, creating more than 4 500 person-days of employment.

In addition to the decrease in NRW water and job creation, a number of additional benefits were achieved:

- The number of consumer meters requiring reading and maintenance was greatly reduced.
- The relationship between Council and their bulk consumers was greatly improved.
- Council has a full report for each large consumer indicating their water demand, all supply points, "as-built" drawings, and detailed photographs of all key customer water connections.
- The hydraulic condition of the network was assessed and council now has information on where improvements/enhancements are required.
- A better understanding of the location and condition of network isolating valves was established. All buried network valves were located and housed in proper valve boxes.
- Consumers can now isolate their water supply in case of an emergency, which was not previously possible in the majority of cases.
- Consumers were encouraged to repair leakage on their properties and operate more efficiently since they now know how much water they consume.
- Consumers are now able to accurately budget for their water use expenses.

3.2 Drakenstein Water Demand Management Programme

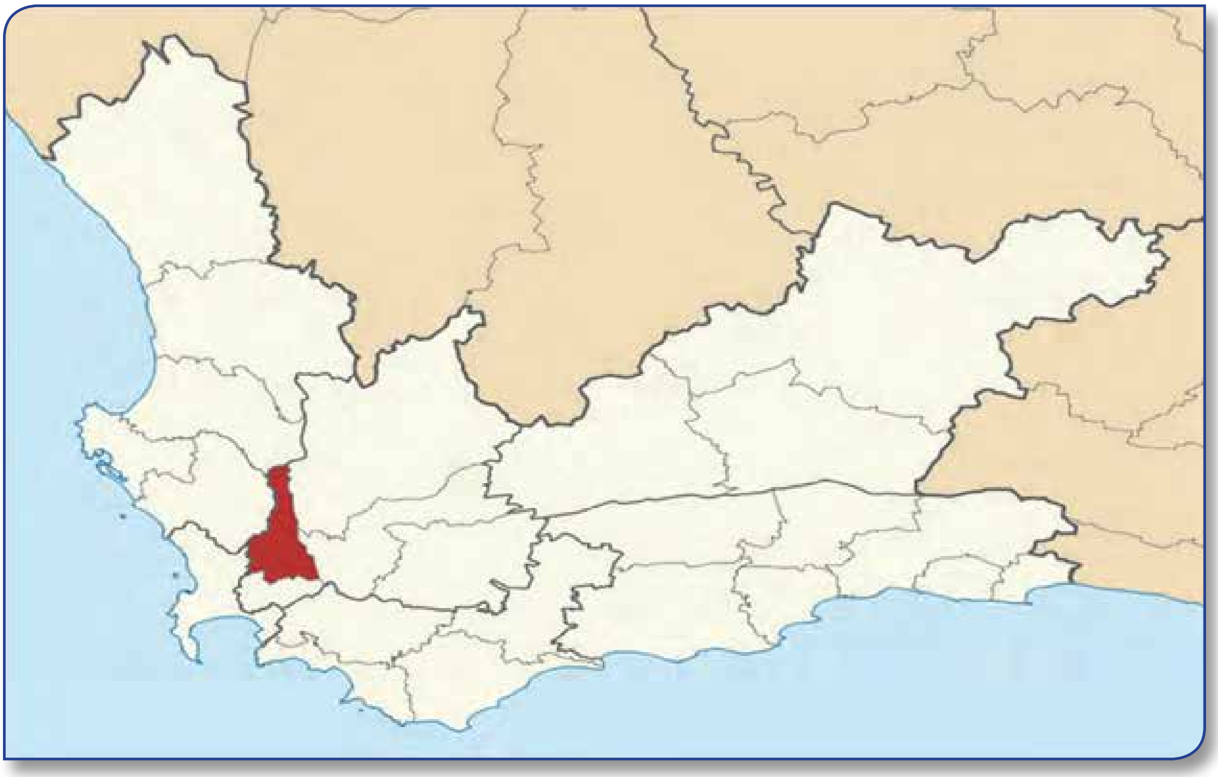


Figure 16: Drakenstein Local Municipality locality map

The key goals of the WDM strategy were met in full and the results achieved by this project have earned Drakenstein Municipality numerous national and international awards for water use efficiency. The unacceptably high level of NRW was reduced from over 33% in 1999 to 12% over a period of 14 years.

Despite selling less water to its consumers, a combination of the new block tariff structure and the purchase of significantly less water from the City of Cape Town, has resulted in a significant gain in net revenue. Water savings over the 14 year period have amounted to more than R700 million.

The most impressive and significant statistic is the reduction in annual water use from 17.8 Mm^3/a in 1999 to 11.3 Mm^3/a in 2012. The true impact of the WDM interventions is well shown in comparing expected water demand with actual water usage in the main town of Paarl, as shown in Figure 17.

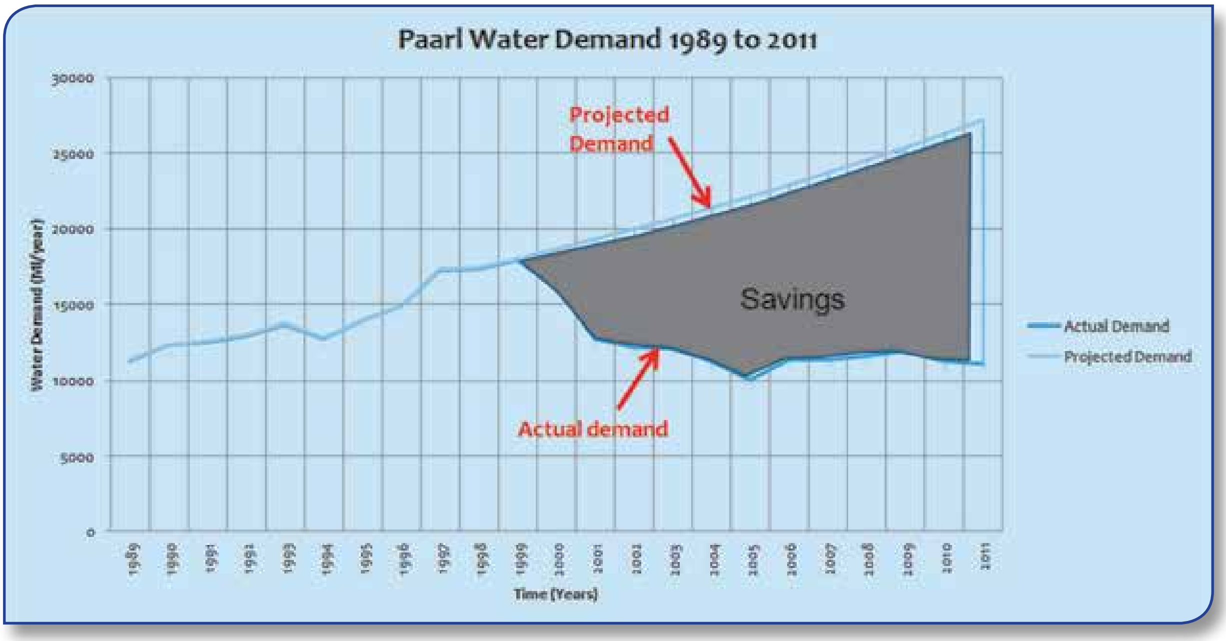


Figure 17: Reduction in water demand in Paarl due to WDM activities (Courtesy A Kowalewski)

The success of the project is to a very large extent due to the enthusiasm and professionalism of several key individuals within the Drakenstein municipal water department, together with the full support from the municipal managers and the relevant political decision makers.

The key challenges faced by the technical personnel tasked with implementing the various interventions included obtaining funding, vandalism of infrastructure, as well as sustaining buy-in from Council and municipal management. Another critical challenge related to the scarcity of competent technical staff and retaining them in a very competitive market. With respect to the pressure management interventions, the main challenges included the selection of the different pressure management zones and maintaining their integrity. The issue of maintaining zone integrity was achieved to a large extent by the use of continuous GSM or GPRS based pressure and flow logging at various strategic points throughout the reticulation.

4 CONCLUSION

The Guidelines for Reducing Water Losses in South African Municipalities (WRC TT 595/14) contain a very useful list of **references** (pages 35-40) and **websites** (pages 40-42).

Further, they contain the two sets of **Appendices:**

1. Appendices for implementation of water loss reduction

1.1 Appendix A: Burst and background leakage
1.2 Appendix B: Logging and minimum night flow analysis
1.3 Appendix C: Live logging of bulk meters
1.4 Appendix D: Design of PRV and meter installations
1.5 Appendix E: Cost of leakage
1.6 Appendix F: Various forms of active leakage control
1.7 Appendix G: Understanding logging results
1.8 Appendix H: Software available from WRC
1.9 Appendix I: Principles of pressure management
1.10 Appendix L: Community awareness and education
1.11 Appendix M: Household water use (apparent losses)
1.12 Appendix N: Sectorising

2. Appendices with details on the two case studies

2.1 Appendix J: Ekurhuleni Bulk Meter Management Project
2.2 Appendix K: Drakenstein Municipality WDM Programme

The value of these Guidelines cannot be over-stressed as they are practical and easy to use.

Repurposed for a wider audience by

Kerry Barton-Hobbs (Harris):
project integrator | development practitioner | writer | editor

The WIN-SA lesson series aims to capture the innovative work of people tackling real service delivery challenges. It also aims to stimulate learning and sharing around these challenges to support creative solutions. To achieve this, the lessons series is supported by ancillary learning opportunities facilitated by WIN-SA to strengthen people-to-people learning.

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Our mission is to ensure the body of knowledge in the sector is well managed, readily accessible and applied, leading to improved decision-making and performance, especially of local government.

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