

14. Benchmarking and tracking of water losses in all municipalities of South Africa

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ABSTRACT

South Africa is a water scarce country with an annual runoff, which is less than 13% of the world average. In addition, the country has a very uneven rainfall distribution varying from 10mm/annum in the west to over 2000mm/annum in the Drakensberg mountains in the east. Despite limited water resources and continually increasing demands, very few municipalities can provide accurate water balance data and most have no accurate record keeping of their input volume or billed consumption. An assessment of non revenue water in South Africa, a study completed in 2007 for the SA Water Research Commission (Seago and McKenzie) estimated the total water losses (real and apparent) for 62 systems analysed to be in the order of 670 million m³/annum or 31% of the total urban water supplied.

The non-revenue water is effectively the sum of the total water losses and the estimated un-billed consumption. The un-billed consumption was conservatively estimated to be approximately 104 million m³/annum which in turn provides an estimate of 774 million m³/annum for the non-revenue water - approximately 36% of the water supplied. Estimating the un-billed consumption was difficult in many areas due to a lack of reliable information, however, it was estimated in the cases where proper data was available and subsequently extrapolated to cover the whole country. The results from this study have been quoted extensively and are considered one of the most reliable sources of quantifying water losses in South Africa. Water losses in South Africa are generally considered very high, but the exact extent of the problem has not been properly defined. Subsequently, various Directorates in the Department of Water Affairs and the South African Water Research Commission (WRC) have joined forces to establish a better understanding of water losses in South Africa. This paper will describe the various sources of information, procedures and processes that have been put in place to derive the latest estimate of Water Losses (often referred to as Un-accounted for Water) and Non-Revenue Water (the current preferred term) from Municipal water supply systems in South Africa.

INTRODUCTION

The water losses from municipal water supply systems countrywide have been under investigation for many years. Various projects in the past, locally and abroad, have been conducted to develop a standard methodology and appropriate key performance indicators (KPIs) to establish and quantify the magnitude of losses. One key indicator that is most commonly used to define the levels of wastage is the percentage of Non-Revenue Water (NRW).

To ensure that all water supply institutions across the world define their water losses in a similar way, the International Water Association (IWA) has developed a standard water balance. The components of the standard IWA water balance are shown in Figure 1 and discussed in detail in Section 2 of this paper.

It should be noted that the “Revenue Water” component of the standard IWA water balance has been modified slightly (WRC Report No TT300/07, 2007) for use in South Africa. This change was considered necessary to deal with the free-basic-water allowance which is a key issue in South Africa.

System Input Volume	Authorised Consumption	Billed Authorised Consumption	Billed Metered Consumption	Potential Revenue Water	Free basic
		Unbilled Authorised Consumption	Billed Unmetered Consumption		Recovered revenue
		Apparent Losses	Unauthorised Consumption	Non Revenue Water	
Water Losses	Real Losses	Real Losses	Unbilled Metered Consumption	Non Revenue Water	Non Recovered revenue
			Unbilled Unmetered Consumption		
			Customer Meter Inaccuracies		
			Leakage on Transmission and Distribution Mains		
			Leakage on Overflows at Storage Tanks		
			Leakage on Service Connections up to point of Customer Meter		

Figure 1: Standard IWA water balance

NRW is defined as the volume of water used by the municipality for which no income is received. It should be noted that the Standard International Water Association (IWA) water balance is a volumetric water balance and not a financial balance. For purposes of calculating the NRW in this report it is assumed that all billed water is paid for. Expressing the NRW as a percentage of the system input volume is not encouraged as it can be misleading as percentage figures are strongly influenced by the consumption.

Percentage NRW is, however still used extensively in the industry and while it can be misleading, it is acknowledged that it will continue to be used as the indicator of choice by most officials. Previous studies undertaken by the WRC and DWA have provided significant detail on the methodology and terminology which is not repeated in this review. The previous work was also based on a smaller sample of Municipalities due to the budget limitations and lack of reliable data. The review discussed in this paper includes information from all Municipalities and the assessment therefore provides a more reliable estimate of the Non-Revenue Water for the country as a whole. It should be noted that the work undertaken in this assessment is based on previous studies undertaken by the WRC and DWA.

WATER BALANCE TERMINOLOGY

In many water balance assessments, the term Unaccounted for Water (UAW or UFW) is used to indicate the level of leakage in a water distribution system and has become the standard term adopted by most utilities around the world.

This term, however, is open to some level of subjective judgement with the result that it can be manipulated based on the various assumptions used in its calculation. 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. As mentioned previously, the objective of the study was to perform a high level non-revenue water assessment of



all municipalities in the country based on the IWA's standard water balance. The standard water balance proposed by the International Water Association (IWA) was modified slightly to accommodate the "free basic water" allowance, which is an important component of all water balances in South Africa. The water balance used in the assessments is shown in, Figure 1 and described in the following paragraphs.

APPARENT LOSSES

Apparent losses are made up from the unauthorised consumption (theft or illegal use) plus all technical and administrative inaccuracies associated with customer metering.

While it should be noted that the apparent losses should not be a major component of the water balance in most developed countries, it can represent the major element of the total losses in many developing countries. A systematic estimate should be made from local knowledge of the system and an analysis of technical and administrative aspects of the customer metering system.

AUTHORISED CONSUMPTION

Authorised consumption is the volume of metered (authorised metered) and/or unmetered (authorised unmetered) water taken by registered customers, the water supplier and others who are implicitly or explicitly authorised to do so by the water supplier, for residential, commercial and industrial purposes.

It should be noted that the authorised consumption also includes 'water exported' to neighbouring water authorities and, in some cases may include items such as fire-fighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, building water, etc. These may be billed or unbilled, metered or unmetered, according to local practice.

BILLED AUTHORISED CONSUMPTION

Billed authorised consumption is the volume of authorised consumption, which is billed by the WSA and paid for by the customer. It is effectively the revenue water, which, in turn, comprises:

- Billed metered consumption;
- Billed unmetered consumption.

NON-REVENUE WATER

Non-revenue water is becoming the standard term replacing unaccounted-for water (UFW) in many water balance calculations and is the term recommended by the International Water Association in preference to UFW. It is a term that can be clearly defined, unlike the unaccounted-for water term, which often represents different components to the various water suppliers. Non-revenue water incorporates the following items:

- Unbilled authorised consumption;
- Apparent losses; and
- Real losses.

REAL LOSSES

Real losses are the physical water losses from the pressurised system, up to the point of measurement of customer use. In most cases, the real losses represent the unknown component in the overall water balance and the purpose of most water balance models is therefore to estimate the magnitude of the real losses so that the WSA can gauge whether or not it has a serious leakage problem.

The real losses are generally calculated as the difference between the total

losses and the estimated apparent losses.

SYSTEM INPUT

The system input represents the volume input to the water supply system from the WSAs own sources allowing for all known errors (i.e. errors on bulk water meters) as well as any water imported from other sources - also corrected for known bulk metering errors.

UNBILLED AUTHORISED CONSUMPTION

The unbilled authorised consumption is the volume of authorised consumption that is not billed or paid for. The level of unbilled authorised consumption will vary from WSA to WSA and in some areas virtually all water is metered and billed in some manner with the result that the unbilled authorised consumption is zero.

WATER LOSSES

Water losses are the sum of the real and apparent losses and are calculated from the difference between the total system input and the authorised consumption. In most countries the water losses were also considered to be the unaccounted-for water (UFW) although, the exact definition of the UFW can vary from country to country.

Key Performance Indicators

The IWA has developed various water loss key performance indicators to evaluate and compare different distribution systems. Calculating KPIs depends on the availability of information, which is not always obtainable. Based on the availability of information, the following KPIs have been used in the study:

- % Non-revenue water : Although the use of percentages to define water losses is not recommended by the IWA, the term is widely accepted and used in the South African water industry. For this reason it has been retained although it should be used with caution in the knowledge that it can sometimes be misleading. The % NRW is calculated as follows :

$$\% \text{ NRW} = \frac{\text{System Input volume} - (\text{Billed consumption} + \text{free basic water})}{\text{System Input volume}} \times 100$$

- Litres / capita / day : provides an indication of the gross volume of water used per capita (person) per day. Although the calculation is based on the total system input volume (m³/annum) and not just the domestic component, it does provide a useful indicator. Care should be taken in areas where there is a large non-domestic component of water use and if necessary it should be excluded from the calculation in order to derive a more realistic per capita consumption.

$$\ell/c/d = \frac{\text{System Input volume} \times 1000 \div 365}{\text{Population}}$$

METHODOLOGY

Data sources

The data sources used in the study are summarised as follows:

- 2005 StatsSA Non-Financial Census of Municipalities
- 2006 StatsSA Non-Financial Census of Municipalities
- 2007 StatsSA Non-Financial Census of Municipalities
- 2009 Regulatory Performance Measurement System
- Data provided by Municipalities
- DWA NIS demographic data
- Water Services Development Plans

Unfortunately the non-revenue water assessment was not included in the 2008 StatsSA Non-Financial Census of Municipalities and the 2010 data set is not yet available.

These data sets were supported by the following :

- Strategic Gap Analysis reports (2007, 2008, 2009)
- All Town Reconciliation Strategy Study
- 2005 StatsSA Financial Census of Municipalities
- 2006 StatsSA Financial Census of Municipalities
- 2007 StatsSA Financial Census of Municipalities

Data representation

Table 1 shows the number of usable records per municipal category. In the years 2005 to 2007 almost 50% of the municipalities submitted usable records whereas the number of usable records for 2008 and 2009 is very limited and almost restricted to municipalities in the A, B1 and B2 categories.

A very limited number of records have been submitted by municipalities in Category B3 and B4.

Table 1: Summary of data records

Category	Total municipalities	Number of useable records				
		2005	2006	2007	2008	2009
A - Metro	6	6	6	6	6	6
B1 - Major Cities	21	15	15	16	2	8
B2 - Minor Cities	29	17	21	16	5	12
B3 - Rural Dense	110	50	58	60	1	9
B4 - Rural Scattered	70	11	8	9	0	2
Total records	236	99	108	107	14	37
% of total municipalities		42%	46%	45%	6%	16%

Grouping

The data were categorised according to the Municipal Infrastructure Investment Framework (MIIF) as summarised in Table 2.

Table 2: Municipal categories

Category	Number	Short description	Long Description
A	6	Metros	Metropolitan municipalities
B1	21	Major cities	Secondary cities, local municipalities with the largest budgets
B2	29	Minor cities	Municipalities with a large town as core
B3	111	Rural dense	Municipalities with relatively small population and significant proportion of urban population but with no large town as core
B4	70	Rural scattered	Municipalities which are mainly rural with, at most, one or two small towns in their area
C1			District municipalities which are not water services providers
C2			District municipalities which are water services providers

Results for district municipalities in categories C1 and C2 were broken down into category B municipalities.

RESULTS

National water balance

Details of the national water balance are shown in Figure 2.

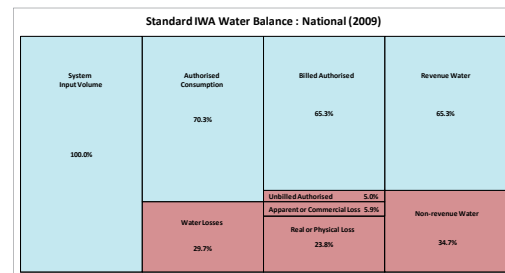


Figure 2: National Water Balance

It should be noted that the national water balance is highly influenced by data from the metros and municipalities with large cities. The water balance shown also represents only 45% of municipalities with very limited information regarding the remaining 55%, although it does cover over 56% of the total water demand by volume. In the water balance calculation, once an account has been generated, the water being billed is considered to be part of the “Authorised Billed“ consumption. The calculation does not look beyond the billing stage into the payment process, which is considered to be a completely separate, albeit important issue. Levels of payment are very low in some parts of the country and this inadvertently has a major influence on the NRW since there is little incentive to save water when the user has no intention of paying for it. The cost recovery aspect is not part of the NRW calculation either in South Africa or elsewhere in the world, and must be addressed through a social and community education programme. Very limited information exists on the unbilled authorised consumption, which was estimated at 5% of the input volume. The apparent or commercial losses were also estimated at 20% of the total water loss but vary considerably between municipalities due to the different ages of the infrastructure and the various meter replacement policies adopted by each Municipality. It is estimated that apparent losses could be as high as 50% of the water loss in some municipalities and as low as 5% in others. The water balance per municipal category is shown in Figure 3. The NRW varies considerably for the municipal categories with the NRW in the metropolitan areas estimated to be the highest. The NRW for rural municipalities is very questionable as it is based on a very limited data.



Figure 3: Water balance per municipal category



Key Performance Indicators

The % non-revenue water per municipal category, based on usable data sets, is shown in Figure 4.

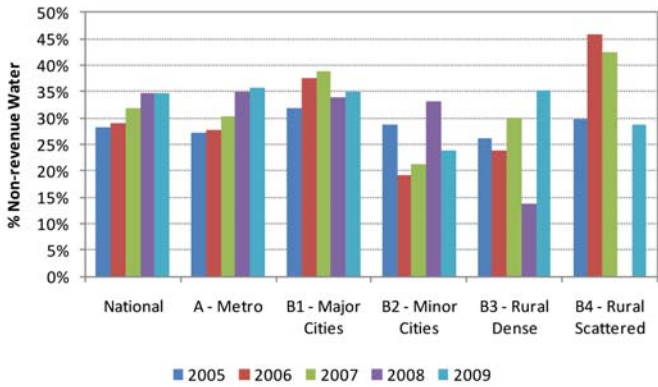


Figure 4: % Non-revenue Water (2005 to 2009)

The NRW varies between 20% and 40% with most of the categories indicating an upward trend over the past 5 years. The NRW for municipalities in categories A and B1 are all near 35% with municipalities in category B3 at around 25%.

The lower NRW in category B3 is thought to be due to the fact that these towns are easier to manage with the result that the NRW is under control. The data for municipalities in categories B3 and B4 are very limited and erratic and it is therefore difficult to make a realistic estimate of the NRW. Fortunately the volumes of water used in these areas are relatively small with the result that the errors do not have a significant influence on the overall NRW estimate.

The 2008 results are rather erratic and inconclusive since it is based on a very small sample size.

The national NRW figures compare well with international trends as shown in Figure 5. The average NRW over the past 5 years for various countries across the world is 36.6%, ranging from over 70% in developing countries such as Albania and Armenia to below 10% in highly developed countries such as Australia and New Zealand.

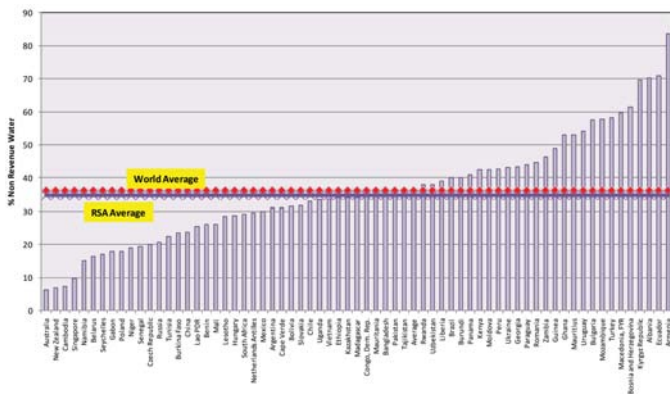


Figure 5: International % Non revenue water data set

The litres / capita / day per category, based on usable data sets, is shown in Figure 6.

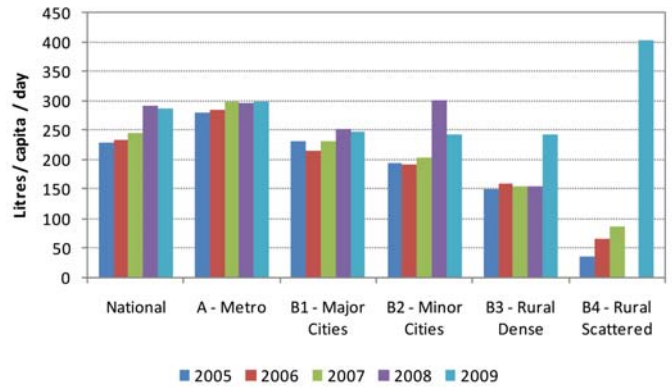


Figure 6: Average litres/capita/day (2005 to 2009)

The average l/c/d for the Metros are the highest, but this is to be expected since the total water demand includes the industrial water use and this tends to be relatively high in most Metros which support the highest number of wet industries in the country.

Although the datasets for categories B3 and B4 are much smaller, the average per capita consumption seems significantly lower than for the bigger municipalities. The national average water consumption varies between less than 226 l/c/d in 2005 to 286 l/c/d in 2009.

The average per capita consumption for South Africa is high compared to most other countries as shown in Figure 6. The international gross average consumption is 173 l/c/d.

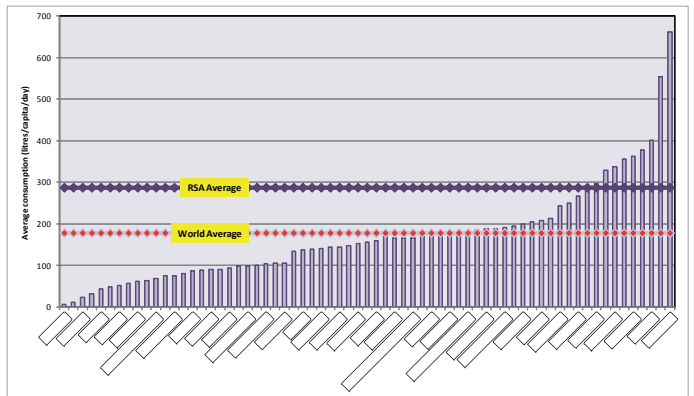


Figure 7: International litres / capita / day

STRATEGIC OVERVIEW

Data Quality

It was found that the quality of the data presented by municipalities is very poor, especially on the smaller and rural municipalities. In some cases, municipalities have provided the same information for two or three consecutive years indicating that this information is not updated on an annual basis. A further concern is that a significant number of the municipalities could not even provide a system input volume indicating that measurement processes are neither adequate nor effective. It is clear from the observations noted above that Water Demand Management is not taking place, even at a rudimentary level in many areas. In the absence of proper metering and monitoring, appropriate reliable planning cannot be undertaken.

Extrapolated NRW



Extrapolating the water balance for the whole country, the results are as shown in Table 3.

Table 3: National extrapolated water balance

Year	2005	2006	2007	2008	2009
Est System input volume	4 062.0	4 147.0	4 213.3	4 302.8	4 371.6
Revenue water	2 882.2	2 963.8	2 881.1	2 798.7	2 855.2
Non-revenue water	1 179.8	1 183.2	1 332.2	1 504.1	1 516.4
% NRW	29.0%	28.5%	31.6%	35.0%	34.7%

The estimated national non-revenue water is estimated to be in the order of 1 500 million m³/annum, which is approximately one third of the water supplied and almost equal to the total Rand Water supply per annum. At the estimated average bulk supply tariff of R 3.50, the value of this Non-revenue water amounts to more than R 5 billion / annum.

It is very difficult to assess how much water could be saved since it is never possible to eliminate all of the non-revenue water.

One of the most significant issues influencing the Non-revenue Water in South Africa is the high levels of non-payment for services in some parts of the country. It is estimated that this can be as high as 20% in some areas based on a document titled Local Government Budgets 2009/10 Financial Year Third Quarter Local Government Section 71 Report (May 2010), which shows debtors of R44.8 billion over 90 days of which ±30% or R13 billion is from water. If this component of water loss is included in the calculation of Non-revenue water, the overall estimate would increase to 47.7%. It should be noted that the international approach to the calculation of Non-revenue Water excludes the payment issue from the calculation and the whole issue of non-payment for services is considered to be a completely separate issue.

Using the results from previous studies, it is estimated that approximately 40% to 50% or about 600 to 750 million m³ of the NRW could be saved, representing almost 13 to 17% of the system input volume. The results from this study compare reasonably well with the previous WRC study completed in 2007, which indicated as follows:

- The total non-revenue water for the 62 systems analysed was estimated to be approximately 774 million m³/annum or approximately 36% of the water supplied.
- The total non-revenue water for the whole country is estimated to be 1 430 million m³/annum (extrapolated from the 54% sample size).
- The potential savings that can be achieved from the 62 water reticulation systems analysed are estimated to be 263 million m³/annum.
- If the above figure is extrapolated to the whole country (based once again on the 54% sample size), the potential savings are estimated to be almost 500 million m³/annum, representing approximately 12.5% of the total system input.

Key Interventions required

Water losses in a distribution network are often an indication of the “health” of the water distribution network as most WC/WDM activities are related to the operation and maintenance of the system. In a well managed system the input volume will be known, leaks will be fixed, consumers will be metered and billed, there will be limited disruption in the supply and pressures will be within the acceptable range.

The Water Services Act (Act 108 of 1997) and the Regulations Relating to Compulsory National Standards and Measures to Conserve Water (R509 of 2001) under the Water Services Act of 1997 require Water Services Institutions to perform certain functions to report on and control their water losses.

Although the Act and regulations are very clear on what is required from Water Services Institutions, these functions are often not performed and is the very core of water losses in most water distribution networks. Enforcing the requirements of the Water Services Regulations, would make a tremendous difference in the reduction of water losses in the country and should focus on :

- Resolving intermittent supply and focusing on providing a proper service;
- Fixing of internal plumbing leakage by municipalities regardless of whether services are paid for or not
- Fixing of visible leaks on the distribution network
- Bulk metering and calculations of non-revenue water
- Accurate metering, reading and billing
- Consumer awareness and elimination of inefficient use.

CONCLUSIONS AND RECOMMENDATIONS

- With each new assessment, more information becomes available and the extent of extrapolation therefore decreases and the reliability of the overall assessment improves. The results discussed in this paper are therefore the most comprehensive national non-revenue water database compiled to date;
- NRW appears to have increased over the past 5 years from approximately 30% to approximately 35% although this conclusion should be treated with caution since the earlier data sets involved a greater level of extrapolation than the more recent data sets.
- Only continuous monitoring, analysis and feed back will improve results. Data must be scrutinised for errors and analysed based on KPIs. It is expected that participation will improve once municipalities gain confidence and receive feedback from DWA on their results. . Municipalities will wish to compare themselves with other municipalities and this should be promoted as a key motivation for municipalities to participate and support the annual water balance assessments.
- A web-based application should be considered to enable municipalities to enter their data online. Once the data has been submitted, it should be scrutinised by the database manager and checked for errors. Feedback should be provided to the municipality on acceptance or rejection of data sets. Once the data sets have been accepted, the municipality will gain access to national and provincial reports for comparative purposes.
- Based on the state and quality of the data obtained from the municipalities, it is evident that a nationwide training programme is required on the basic principles Water Demand Management with specific reference to the development of a meaningful and realistic water balance. The data obtained to date from many municipalities highlights many serious inaccuracies or errors, which may be due to a general lack of understanding of the water balance. With improved knowledge and understanding of the water balance and basic WDM principles, it is anticipated that the quality and usefulness of the data will improve.
- Additional data will be required to calculate other key performance indicators. This data should include the length of mains,



average system pressure, number of connections (meter and unmetered) and domestic and non-domestic water use etc.

- A major concern is the lack of information for 55% of the municipalities. Lack of resources and metering, ignorance, continuous crisis management and apathy are some of the reasons given for this lack of information. These problems must be addressed as a matter of urgency.
- The Blue and Green drop assessment has been very useful in assessing the condition of water and waste water treatment works in South Africa. Indications are that participation by municipalities and data quality have improved significantly over the past few years. It is proposed that a NRW assessment is performed for each municipality. This will provide an opportunity to gain insight into problem areas and how they can be resolved.
- Very few municipalities can provide a comprehensive Water Conservation and Water Demand Management (WC/WDM) strategy that sets targets, intervention programmes and budget requirements. If the lack of information for 55% of the municipalities, suggest that almost half of the country's municipalities are not even aware they have a problem. As part of the National Water Audit, support should be given to municipalities on the development of WC/WDM strategies, which can then be roll-up to provincial and national strategies. In this regard, the WRC has just released its WDM Strategy Scorecard Model, which is an ideal tool for assisting water suppliers in developing a simple and pragmatic WDM strategy.
- Various government departments have spent considerable time and money collecting and collating NRW data. This data is of little value unless it is verified, validated and converted into reliable information which can be used for planning purposes.

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