Integration of Demand Side Management and Supply Side Management

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Abstract
For many years the key emphasis for meting the growing water demands in South Africa was through Supply Side Management where new and often costly water transfer schemes were developed. Over the past 10 years, however, the emphasis has shifted to one of Demand Side Management as the first priority after which Supply Side Management is considered. The key problem to this approach has been the assessment and sustainability of the Demand Side Management interventions since very few properly documented case studies are available in South Africa to support the savings that are often proposed as achievable from Water Conservation and Water Demand Management (WC/WDM) interventions. Work undertaken as part of the Vaal River System Reconciliation Study has recently produced plausible projections of the savings that can be achieved in the Vaal River System from WC/WDM interventions based on a sound methodology backed up by results from many large scale practical case studies. For the first time, it has been possible to develop an integrated approach to future water supply which can be implemented and monitored to ensure that the economic powerhouse of South Africa does not falter due to lack of water. The paper provides details of the methodology employed in the project to integrate the normal Supply-Side Management options with properly motivated WC/WDM interventions. The paper also highlights the main problem areas associated with projecting sustainable savings from WC/WDM interventions and how these problems were addressed during the DWAF study.

Keywords: *Supply Side Management and Demand Side Management.*

Introduction
The integration of Demand Side Management and Supply Side Management is a very topical and important issue internationally and particularly in arid and semi arid areas such as South Africa where water resources are extremely limited. Although it is widely recognised that Water Conservation/Water Demand Management (WC/WDM) can reduce the overall water demands and therefore help to delay costly new infrastructure developments, there is considerable resistance to the acceptance of predicted WC/WDM savings when taking the decision on when to implement a new dam, pipeline or transfer scheme.

The key problem facing the acceptance of WC/WDM is the lack of successful case studies where WC/WDM has been implemented and it can be shown that the initial savings achieved are both realistic and sustainable. There are several examples of major water resource assessment studies where the projected demand curves based on certain WC/WDM interventions have not been achieved. The actual demand curves were not in line with the projections to such an extent that the systems in question experienced severe shortfalls and the previously delayed water resource developments had to be implemented as a matter of urgency. Such cases only strengthen the resistance by the water resource planners to accept projections which are based on scenarios involving WC/WDM.

Unfortunately when it comes to WC/WDM, the failures tend to outnumber the successes and even one of the major water services providers in South Africa commented at a recent WDM forum that it had spent over R100 million on various WDM interventions 12 years previously and had nothing tangible to show for the effort or expense. Although this is a sad reflection on the implementation of the specific WC/WDM interventions, it highlights the reality of the situation in many parts of South Africa where significant funds have been spent trying to reduce wastage and at the end of the projects there is little if anything to show for the efforts. It is no surprise that the water resource planners and major bulk water service providers are often reluctant to base their new developments on projected WC/WDM savings which may or may not be achieved. They have an ultimate responsibility to provide water which is fundamental for improving living standards, providing employment and simply sustaining life. A large water resource development can take many years to implement and if the projected savings from WC/WDM are not achieved, it is often already too late to implement the next augmentation scheme and the water supply system is likely to experience shortfalls for many years until the next augmentation scheme can be implemented.

Following the numerous problems experienced in various WC/WDM interventions, DWAF decided to investigate the key issues and try to ensure that future projects would be both effective and sustainable. In this regard several key aspects were identified which influence the successful implementation of any WC/WDM intervention. The issues are addressed in more detail by **Chunda (2007)** and are basically covered under the following 4 categories:

- Technical aspects;
- Social aspects;
- Legislative aspects and
- Financial aspects.

The Department of Water Affairs and Forestry is now assisting many Municipalities and other water service providers to implement WC/WDM measures by providing targeted financial support as well as monitoring and evaluating the progress to ensure that all key issues are addressed. In this manner, it is hoped that the mistakes of the past will not be repeated and new successful case studies will be implemented that will provide assurance to even the most sceptical water resource planners that WC/WDM interventions can provide meaningful and sustainable savings.

While the authors of this paper have a wide experience in both supply side management and demand side management, they realise the importance of ensuring that water is used efficiently before implementing any new water resource development. The remainder of this paper will concentrate on the work undertaken through the Department of Water Affairs and Forestry to reconcile the future water demands with the available water resources in the Vaal River System supply area which covers the industrial heartland of South Africa including the whole of Gauteng. The work undertaken on this project represents a major shift in the methodology used to assess the potential savings that can be achieved through WC/WDM to ensure that the resulting demand projections are realistic and acceptable to both the WDM proponents as well as the water resource development proponents.

Supply Side Management

The Vaal River System is one of the most complex and integrated water resources systems in the world and it is managed by the Department of Water Affairs and Forestry through the use of various system analysis techniques based on sophisticated computer models developed over the past 20 years. Numerous studies have been undertaken and others are currently in process to ensure that the system is managed effectively and efficiently to the best interests of South Africa and its citizens. Providing an effective water supply can be achieved through the development of new water transfer schemes or by curtailing the demands through WC/WDM interventions. Unfortunately the situation in South Africa is complicated by the highly variable climate experienced throughout the country which can result in drought periods of up to 15 years being experienced in some areas. The natural variability in climate is being further exacerbated by the impacts of climate change although it appears that the impacts are not yet predictable using accepted statistical methods. The influences of a changing climate are very difficult to predict and the issue is highly controversial in South Africa as is clearly evident from the recent work undertaken by **Alexander (2007a and 2007b)** and the subsequent strong but very scientific rebuttal by **Midgley (2007)**. It is clear from these publications that Climatic Change is a serious issue but one that has yet to be clearly quantified in a manner that can be used with confidence for predictive purposes. This paper will not delve into the issue of Climatic Change although the authors do appreciate the potential significance of such change on the Vaal River System. The current system analysis techniques are based on stochastic streamflow sequences and in most cases, the variability captured by the range in stochastically generated streamflow sequences is considered sufficient to cover possible influences of Climatic Change. The issue of Climatic Change will be continually monitored to ensure that the Water Resource Planning Models provide realistic results.

The Vaal River Reconciliation Study can simplistically be split into 2 main components. The first component involves identifying the various demand centres and assessing their current and future water requirements. This component of the study must include the potential impacts of WC/WDM measures as well as various other issues which can influence the future demands. Since it is not possible to predict the future demands with certainty, it is necessary to develop several plausible demand scenarios which can be used to create a range of future demand projections. The demand projections take the form of several scenarios which will include various levels of WC/WDM as well as other key factors such as the impact of HIV/Aids etc. These demand scenarios form the basis for the 2nd component of the analysis which involves analysing the water resource capability of the system in order to plan future augmentation schemes (if required) to ensure that they are commissioned and operational when required. The resource analysis component of the study is discussed in more detail by **Coleman (2007)** and the remainder of this paper will concentrate on the 1st component with particular emphasis on the assessment of potential savings from the various WC/WDM interventions.

Potential savings through water conservation and water demand management measures

In order to estimate the future water demands in the Vaal River Supply Area, each significant demand was identified and quantified. This process was based on many previous investigations and the current demands as well as the historical demands were established with a high degree of accuracy. An indication of the split in water use in the Vaal River System Supply Area is provided in **Figure 1** from which it can be seen that most of the water is used for urban and industrial purposes with irrigation taking up the remainder (normally using lower quality water which has already been used by the urban and/or industrial sectors).

Predicting the future demands is not a simple or straightforward process and the previous approach of extrapolating the historical growth curves is not appropriate. Instead it was necessary to undertake a more detailed assessment where many factors such as demographics, impact of HIV/aids, influence of WC/WDM, influence of new sanitation policy and even the influence of a buoyant economy all have to be factored into the assessment.

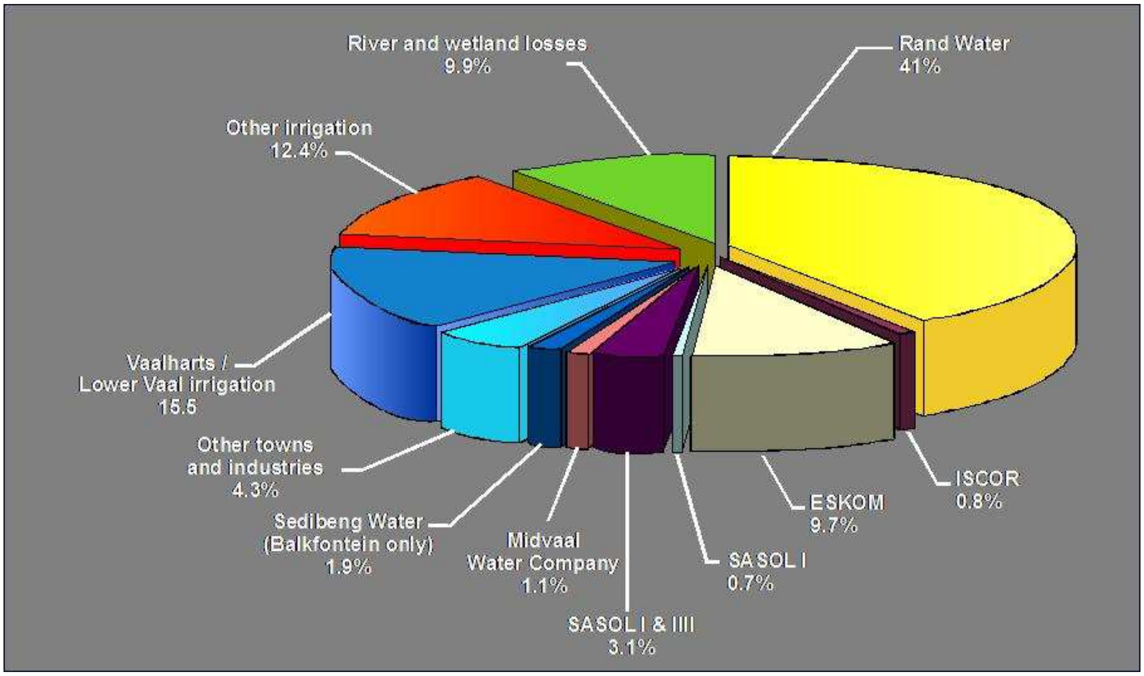

Figure 1: Breakdown of Demands in the Vaal River System

While several studies have been undertaken to assess different issues affecting the future water demands, DWAF initiated a new project to investigate and assess the potential impacts of WC/WDM in the Vaal River System Supply Area. The study was split into several components with different teams working on the irrigation, industrial and urban sectors respectively. Most of the work undertaken on the irrigation and industrial sectors was based on standard techniques as used in many previous studies and the key results are discussed to some extent in the associated paper by **Coleman. (2007).** The work undertaken on the urban sector was of particular interest and concentrated on the Rand Water component which represents over 40% of the total Vaal River System demand. The key focus of the WC/WDM assessment was therefore placed on the main urban centres within Gauteng and by analysing the nine largest urban water users it was possible to cover approximately 86% of the Rand Water demand. The total water used by the nine main urban centres was estimated to be 1 186 million m^3/annum in 2004, as listed in **Table 1**.

Table 1: Major municipal demands considered in the study

Municipality	*Water use in the year 2004 (million m^3)*
Johannesburg	**470**
Ekurhuleni	**291**
Tshwane	**255**
Emfuleni	**79**
Rustenburg	**26**
Mogale	**24**
Govan Mbeki	**18**
Matjhabeng	**16**
Randfontein	**7**
Total	**1 186**

In order to assess the potential savings that can be achieved through WC/WDM in the main urban centres listed in **Table 1**, a detailed assessment was undertaken in which each area was further sub-divided into smaller components in accordance with the information available from the specific Metro or Municipality. Details of the areas investigated are provided in **Table 2**.

Table 2: Breakdown of areas considered in the urban WC/WDM assessment

Municipality	Key demand centres	Municipality	Key demand centres
City of Johannesburg	• Midrand / Ivory Park,	**Ekurhuleni**	• Alberton
(6 areas)	• Sandton / Alexandra	**(17 areas)**	• Tokosa
	• Roodepoort/Diepsloot,		• Benoni
	• Soweto,		• Daveyton/Etwatwa
	• Johannesburg Central,		• Brakpan
	• Johannesburg South		• Tsakane
City of Tshwane	• Centurion		• Boksburg
(8 areas)	• Pretoria		• Vosloorus
	• Akasia		• Germinston
	• Soshanguve		• Katlehong
	• Mamelodi		• Springs
	• Attridgeville		• Kwa Thema
	• Odi		• Nigel
	• Temba		• Doduza
Emfuleni	• Vereenging		• Kempton Park
(4 areas)	• Vanderbijlpark		• Tembisa
	• Sebokeng		• Edenvale/Modderfontein
	• Evaton	**Mogale City**	• Krugersdorp,
Matjhabeng	• Welkom	**(2 areas)**	• Kagiso
(4 areas)	• Thabong	**Rustenburg (1 area)**	• Rustenburg
	• Riebeeckstad	**Govan Mbeki**	• Secunda,
	• Bronville	**(4 areas)**	• Bethal,
Randfontein	• Randfontein /Mohlakeng		• Leandra,
(3 areas)	• Hillside,		• Kinross,
	• Rietvallei		•

Unlike many previous assessments of potential savings that can be achieved from WC/WDM, the project team adopted a new approach based on a combination of recorded flow meter records and a sound understanding of the key problems experienced in each area. More than 400 individual flow and pressure logging results were used in the analyses, most of which were obtained from the Metros and Municipalities and a full water audit was undertaken for each of the 49 areas listed in **Table 2.** The water audits were initially based on the standard International Water Association (IWA) methodology which it is now generally accepted throughout most countries in the world. The elements of the IWA water balance are shown in **Figure 2**. and are fully explained by **Mckenzie (2001)** and **Lambert (2001)**. This water balance represents many years of discussion and debate and has been accepted by virtually all water auditing and leakage management specialists worldwide.

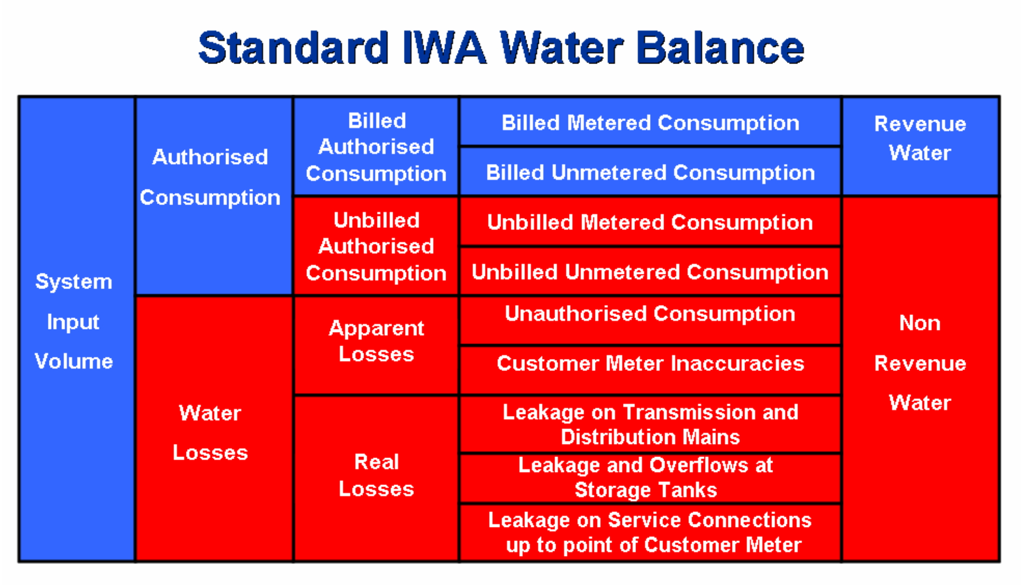

Figure 2: The Standard IWA Water Balance

Many water audits have been undertaken throughout South Africa over the past 5 years, most of which were undertaken through projects supported by the Water Research Commission which was one of the first organisations in the world to support the IWA methodology on a national basis. The most recent work on this issue, however, was carried out by members of the project team through a joint initiative supported by both DWAF and the WRC. The WC/WDM component of the Vaal River Reconciliation Study formed an integral part of the joint study and the results are provided in the report by **Seago (2007)**. During the assessment of the potential savings from WC/WDM for the Gauteng area, it was found that the standard IWA water balance lacked certain information required by the project team to estimate realistic savings. The problem is particularly significant in South Africa and is due in part to the "free basic water allowance" and in part to the high levels of non-payment for "Billed Authorised" water. In order to address this issue, the standard water balance shown in **Figure 2** was modified to that shown in **Figure 3** where it can be seen that the "Revenue Water" has been split into 3 components which have specific relevance in the South African situation.

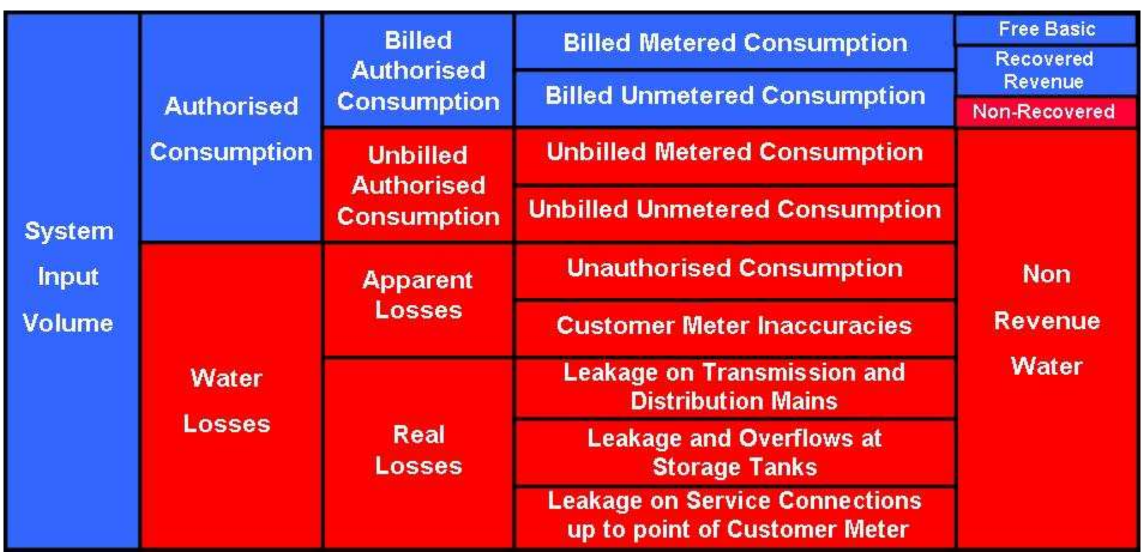

Figure 3. Modified IWA water balance for South Africa (from Seago & Mckenzie, 2007)

The modification is effectively achieved by splitting the "Revenue Water" component into three components namely:

- Free basic water – can be considered as billed and paid for at a zero tariff;
- Recovered revenue water which is billed and paid for by consumers
- Non recovered water which is reflected in the billing records as billed although there is no possibility of payment.

This last component is the key problem in many parts of South Africa and is very significant in some areas. For example, in a typical low income area with very high leakage where water is metered and bills are sent out in accordance with the metered consumption, the monthly consumption per property may be in the order of 50 kl. Of this 50kl, the consumer receives 6kl as the free basic allowance and a bill for the remaining 44 kl. Since it is a low income area, the residents are often unable to pay for the services and the accounts simply accumulate. Eventually, the water service provider decides to address the problem and installs either some form of restrictor or a pre-paid meter. If this intervention is implemented properly, the household leaks will usually be repaired as part of the process and the accumulated account will be written off as a "once-off" gesture of goodwill by the water provider on the basis that the consumer agrees to pay for all water used from that date forward.

Following the implementation of the cost recovery measures, the average consumption rarely remains at the pre-implementation levels and in most documented case studies it drops significantly to approximately 12 kl/month. In effect, the interventions will result in a real reduction of 38 kl/month per property. This component is depicted in **Figure 3** as the "non-recovered" water which was previously considered to be part of the "revenue water". This modification to the water balance has not been sanctioned by the IWA but has helped the project team to make realistic projections of savings in many of the low income areas where wastage of water is a serious problem and significant reductions can be made as shown by the various case studies.

Analysis Methodology

In view of the uncertainty concerning the savings that can be achieved through WC/WDM interventions, it was decided to develop 3 scenarios, two of which only address savings by reducing the non-revenue water while the third and most optimistic scenario also includes savings from the Revenue water through measures such as dual-flush toilets and low flow showers etc. The 3 scenarios analysed were as follows:

Scenario 1: Optimistic
water losses can be controlled within the next 5 years (2005 to 2010) and maintained afterwards. Water use efficiency measures (i.e. introduction of water efficient showers and toilets etc) are also introduced to target the billed consumption. It was assumed that a 1% per annum efficiency can be gained from 2010 to 2025. This is a very aggressive scenario based on actual achievements made in countries such as Australia. It should be considered as the upper limit of WDM achievements.

Scenario 2:
This scenario was basically the same as the first scenario but excludes any savings from the Revenue water. In effect it assumes that savings can be achieved from the non-revenue water over a period of 5 years.

Scenario 3
The third scenario is identical to the second scenario but is implemented over a 10 year period Based on previous experience, it is unlikely that the WC/WDM interventions can be implemented over the next 5 years due to financial and capacity constraints in South Africa and a 10 year implementation period may therefore be more realistic.

Results

Each of the 49 areas was analysed individually and a range of appropriate WC/WDM interventions was selected based on previous practical experience as well as a thorough knowledge of the area. Full details of the various interventions selected for each area including implementation and maintenance costs are provided in the final **DWAF (2006)** and are not repeated in this paper due to space constraints. The results from the analyses are summarised in **Tables 3, 4 and 5** and shown in **Figures 3, 4 and 5** for the three scenarios respectively.

Table 3: Summary of potential savings for Scenario 1

Year	Demand without WC/WDM (million m^3/a)	Demand without WC/WDM (million m^3/a)	Reduction in Demand (million m^3/a)	% Reduction
2004 to 2005	1 166	1 140	26	2 %
2009 to 2010	1 248	1 063	185	15 %
2014 to 2015	1 337	1 053	284	21 %
2019 to 2020	1 434	1 080	354	25%
2024 to 2025	1 540	1 109	431	30%

Table 4: Summary of potential savings for Scenario 2

Year	Demand without WC/WDM (million m^3/a)	Demand without WC/WDM (million m^3/a)	Reduction in Demand (million m^3/a)	% Reduction
2004 to 2005	1 166	1 140	26	2 %
2009 to 2010	1 248	1 063	185	15 %
2014 to 2015	1 337	1 137	200	15 %
2019 to 2020	1 434	1 224	210	15 %
2024 to 2025	1 540	1 318	222	15 %

Table 5: Summary of potential savings for Scenario 3

Year	Demand without WC/WDM (million m^3/a)	Demand without WC/WDM (million m^3/a)	Reduction in Demand (million m^3/a)	% Reduction
2004 to 2005	1 166	1 141	25	2 %
2009 to 2010	1 248	1 137	110	9 %
2014 to 2015	1 337	1 138	199	15 %
2019 to 2020	1 434	1 224	211	15 %
2024 to 2025	1 540	1 318	222	15 %

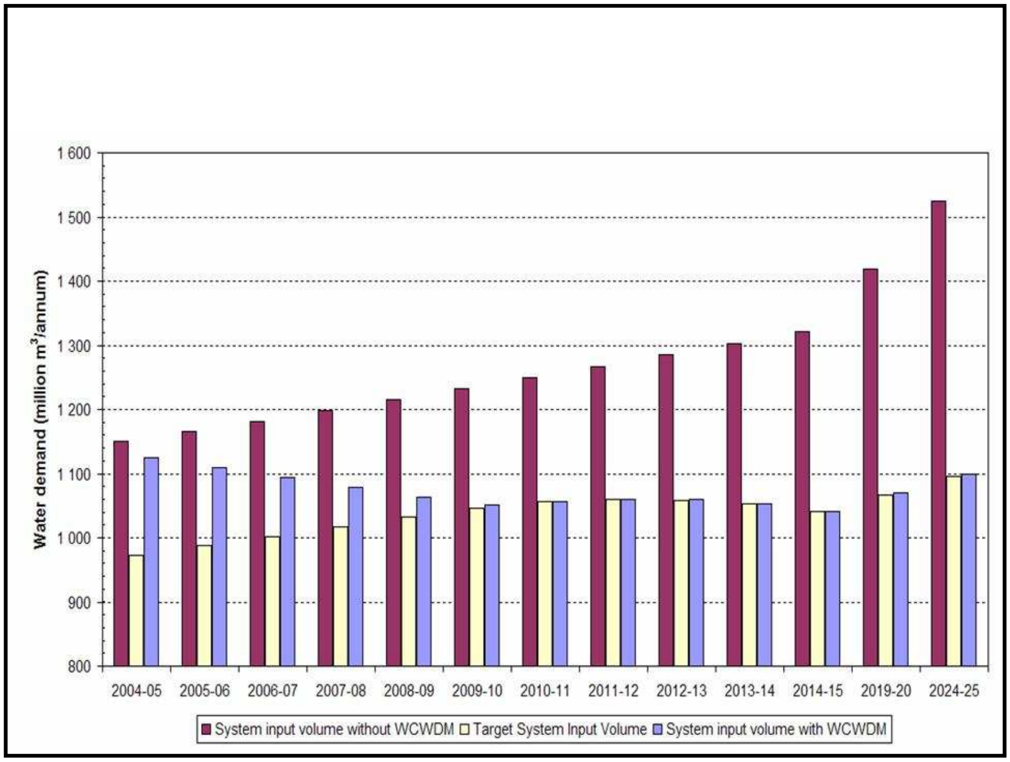

Figure 3: Possible urban demands with full implementation of WC/WDM for Scenario 1

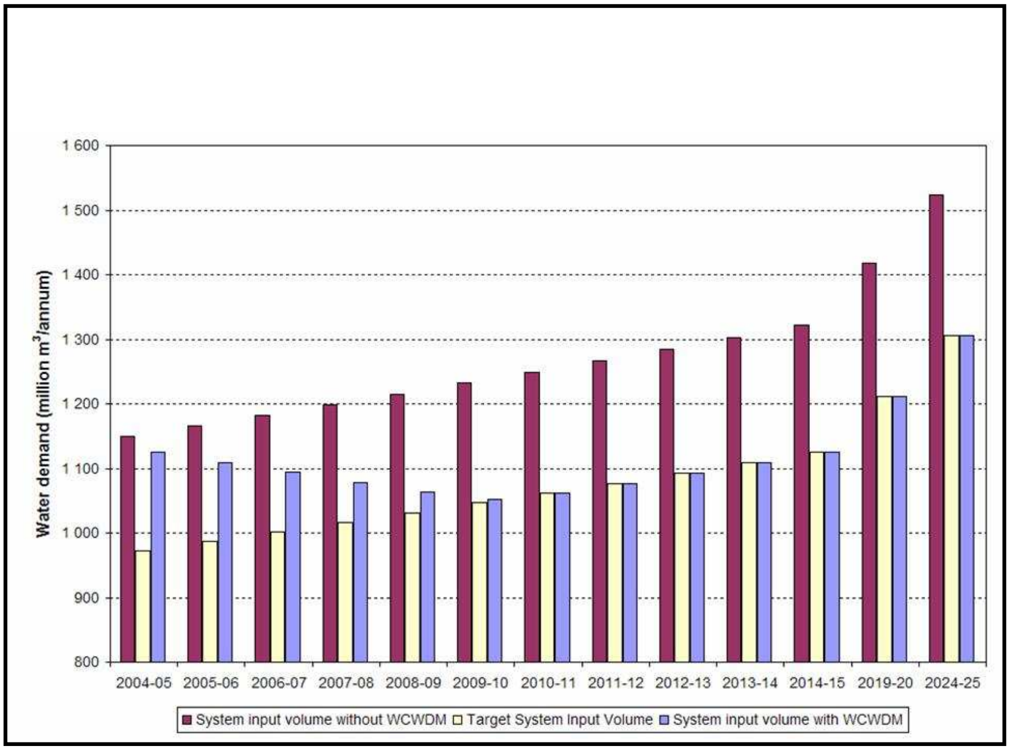

Figure 4: Possible urban demands with full implementation of WC/WDM for Scenario 2

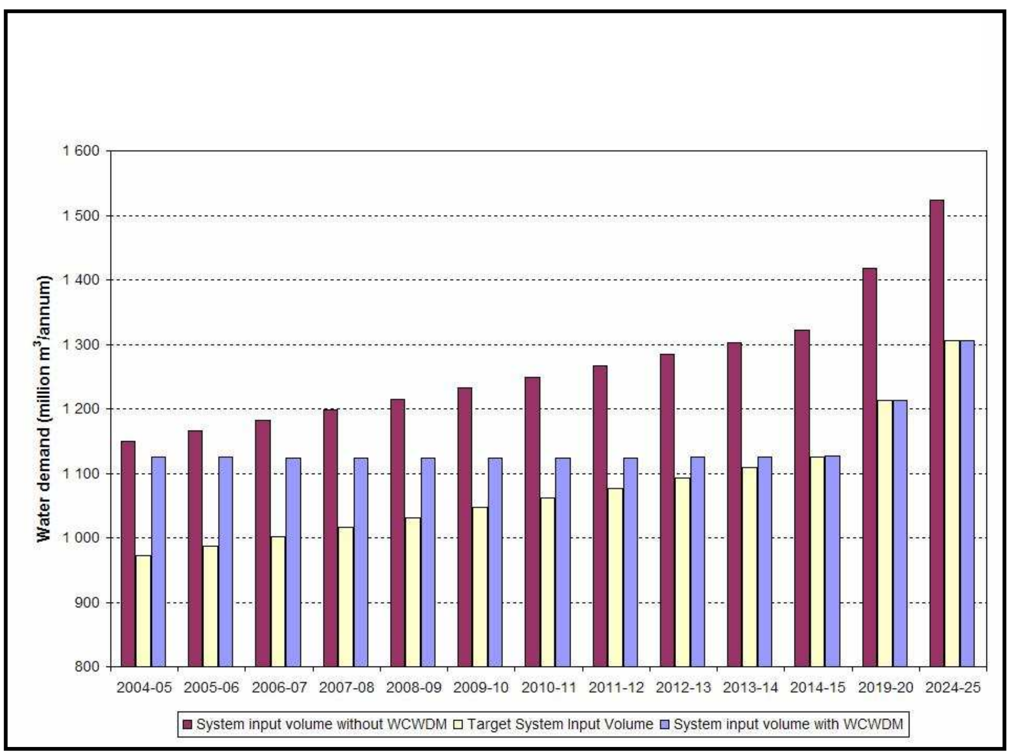

Figure 5: Possible urban demands with full implementation of WC/WDM for Scenario 3

It should be noted that the savings indicated in the various figures were assessed individually for each of the 49 areas mentioned previously. The breakdown of potential savings per Municipality are shown in **Table 6** which refers specifically to Scenario 3 although the same distribution is appropriate to scenarios 1 and 2.. From this table it can be seen that the bulk of the savings are concentrated in Johannesburg, Ekurhuleni, Tshwane and Emfuleni.

Table 6: Distribution of potential savings between the various municipalities

Area	Annual Demand (million m^3/a)	Estimated NRW (million m^3/a)	Possible Savings (Scenario 3) (million m^3/a)
Johannesburg	470	154	67
Ekurhuleni	291	91	23
Tshwane	255	66	14
Emfuleni	79	49	18
Rustenburg	26	8	3
Mogale	24	6	2
Govan Mbeki	18	5	1
Matjhabeng	16	9	2
Randfontein	7	2	<1
Total	**1 186**	**390**	**131**

Summary and Conclusions

Based on the results from the WC/WDM assessment undertaken as part of the Vaal River Reconciliation Study undertaken for the Department of Water Affairs and Forestry it is clear that WC/WDM can have a significant impact on the future water demands in the system. The financial analyses are continuing and will be finalised in due course, however, the preliminary indications clearly show that the costs associated with WC/WDM tend to be significantly lower than the corresponding resource development options. In certain instances the actual savings achieved from selected WC/WDM interventions are so high that there is simply no question regarding whether or not such interventions should be implemented.

One of the key problems facing the introduction of WC/WDM in South Africa concerns the auditing of the savings as well as the sustainability of the savings. In the course of the work discussed in this paper, it was estimated that the operation and maintenance costs are often as large if not larger than the initial implementation costs when considered over a working life of between 50 and 100 years. Many previous WC/WDM interventions have failed soon after implementation due to the fact that no operational or maintenance budget was allocated. This is an important issue and it must always be noted that WC/WDM interventions tend to require a high level of maintenance and if this is not anticipated, many potentially viable projects will fail.

Another key issue that has often been ignored concerns the softer issues associated with WC/WDM such as public awareness and education concerning the efficient use of water. Without proper public support, many WC/WDM interventions that are technically very attractive will fail. There are numerous examples throughout South Africa where well designed and well implemented technical interventions have failed miserably soon after they were implemented and the project team moved onto other work. In the few well documented case studies where public involvement was part of the project, the technical interventions continue to produce the savings, many years after implementation. It is unfortunate that providing support to the public in the form of educational materials and media coverage is often very expensive with virtually no tangible benefits that can be measured in the form of savings. Such measures must always be included as part of any technical intervention and the costs associated with the “soft” issues must therefore be added to those of the technical measures if the project is to be a success.

South Africa is a unique country with certain unique problems and it was therefore necessary to adapt the standard IWA water auditing procedures to accommodate the problems associated with high water use in low income areas where there is minimal payment for water. The approach adopted is considered realistic and the results derived from the numerous investigations were well received by both the water resource planners as well as the proponents for WC/WDM. By developing and using a systematic and pragmatic approach to WC/WDM, the different parties were able to assess the projected savings in each area as well as question the basis for the calculations.

In the case of the Vaal River System it is clear that the greatest savings from WC/WDM can be achieved in the 4 largest Metros/Municipalities. While there is scope for achieving savings in the other areas, the volumes involved are small relative to the “big four” namely Johannesburg, Ekurhuleni, Tshwane and Emfuleni.

The funding required to implement and maintain savings from WC/WDM measures is very high and will require careful consideration if the measures suggested are to become a reality. There are many problems associated with the implementation of WC/WDM measures which must be overcome if they are to succeed. DWAF has taken the first major step forward in this regard by initiating a fund to support WC/WDM measures and if successful it will be rolled out to the country as a whole.

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