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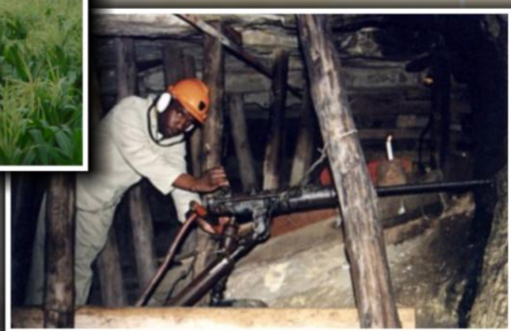
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA
Directorate: National Water Resource Planning

Vaal River System: Large Bulk Water Supply Reconciliation Strategy

SECOND STAGE RECONCILIATION STRATEGY



MARCH 2009

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VAAL RIVER SYSTEM: LARGE BULK WATER SUPPLY RECONCILIATION STRATEGY

LIST OF REPORTS

Report No:	Title
P RSA C000/00/4406/01	Urban Water Requirements and Return Flows
P RSA C000/00/4406/02	Potential Savings through WC/WDM in the Upper and Middle Vaal Water Management Areas
P RSA C000/00/4406/03	Re-use Options
P RSA C000/00/4406/04	Irrigation Water Use and Return Flows
P RSA C000/00/4406/05	Water Resource Analysis
P RSA C000/00/4406/06	Groundwater Assessment
P RSA C000/00/4406/07	First Stage Reconciliation Strategy
P RSA C000/00/4406/08	Second Stage Reconciliation Strategy
P RSA C000/00/4406/09	Executive Summary

Above list of reports effective as at March 2009

VAAL RIVER SYSTEM: LARGE BULK WATER SUPPLY RECONCILIATION STRATEGY

SECOND STAGE RECONCILIATION STRATEGY

(March 2009)

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Prepared by:

DMM Development Consultants, Golder Associates Africa, SRK, WRP Consulting Engineers and Zitholele Consulting.

DWAF Report Number: **P RSA C000/00/4406/08**

Title:	***Second Stage Reconciliation Strategy (March 2009)***
Authors:	*Study Team*
Project Name:	***Vaal River System: Large Bulk Water Supply Reconciliation Strategy***
DWAF No:	***P RSA* C000/00/4406/08**
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Consultants: DMM / Golder Associates Africa / SRK / WRP and Zitholele

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Vaal River System: Large Bulk Water Supply Reconciliation Strategy

Second Stage Reconciliation Strategy (March 2009)

Executive Summary

Introduction

*The Large Bulk Water Supply Reconciliation Strategy Study for the Vaal River System Study has the purpose to develop a strategy for meeting the growing water requirements of the industrial and urban sectors that are served by the Integrated Vaal River System (IVRS). The need for the study was identified in the Internal Strategic Perspective (ISP) for the Vaal River System Overarching (**DWAF, 2004d**) and the key objectives were, as follows:*

- *Update the current and future urban and agricultural water requirements.*
- *Assess the water resources and existing infrastructure.*
- *Take into account the Reserve requirements for alternative classifications.*
- *Formulate reconciliation interventions, both structural and administrative/regulatory.*
- *Conduct stakeholder consultation in the development of the strategies.*

*The core of the study area consists of the Upper, Middle and Lower Vaal River Water Management areas (WMAs), however, due to the numerous inter-basin transfers that link this core area with other WMAs, reconciliation planning has to be undertaken in the context of the Integrated Vaal River System which also includes portions of the Komati, Usutu, Thukela and Senqu River (Located in Lesotho) catchments. **Figure A-1** in **Appendix A** provide and map of the extended study area showing the Vaal River and linked systems. **Figure A-1** also highlights the proposed future transfer scheme to the Crocodile (West) River system, which is discussed in more detail in **Chapter 10** of the report.*

Study procedure and methodology

The overarching study approach was to develop reconciliation strategies in two stages. The first stage involved developing and assessing scenarios of possible future reconciliation options. The First Stage Reconciliation Strategy was presented to the Department of Water Affairs and Forestry (DWAF) Management and Stakeholders for comments. Further investigations were identified for *assessment during the development of the Second Stage Reconciliation Strategy of which the results were incorporated in this document.*

An essential part of the strategy development process was the integration of information from various processes and studies in order to arrive at a strategy that account for all major aspects that influence the bulk water supply situation in the Vaal River System. This was achieved by co-ordinating activities among the following three studies:

- *Integrated Water Quality Management Plan Study (**DWAF, 2008c**).*
- *Potential Savings through Water Conservation / Water Demand Management (WC/WDM) in the Upper and Middle Vaal Water Management Areas (**DWAF, 2006b**).*
- *Vaal River System: Large Bulk Water Supply Reconciliation Strategy (this study).*

*In addition to the above three studies, integration with the Crocodile (West) River Reconciliation Strategy Study (**DWAF, 2008a**) was essential to formulate strategic recommendations that are coherent for the Vaal and Crocodile (West) river systems.*

An integrated stakeholder engagement process was followed for the first three studies listed above, which involved combined Project Management and Steering Committee meetings for the Reconciliation and WC/WDM studies. Furthermore, shared representation of DWAF management and study team members on the Reconciliation and Water Quality Management studies ensured the co-ordination of interdependent activities and integration with the proposed water quality management measures was achieved.

The focus of the assessments for the Reconciliation Strategy included the following:

- *Develop water requirement and return flow scenarios.*
- *Determine the potential for Water Conservation and Demand Management by concentrating on the main urban areas.*
- *Estimate the irrigation water requirements and compile possible future scenarios.*
- *Identify and assess potential large scale water re-use options.*
- *Provide an initial indication of how the implementation of the Ecological Water Requirements could influence the projected water balance situation.*

- *Analysis of water quality management options relating to blending, dilution and water re-use.*

Water requirement scenarios

The assessment of the irrigation water requirements showed that the estimated water use in the year 2005 for this sector is 970 million m^3/annum, which is 204 million m^3/annum higher than what was applied in previous investigations (see **Table 4.3***). Results from the Upper Vaal Water Management Area Validation Study indicated that as much as 174 million m^3/annum of the year 2005 irrigation water use could be unlawful (presented in* **Table 4.1***). The total registered water use for irrigation in the Vaal River System is estimated to be 1 375 million m^3/annum and is an indication that the increasing trend that was experienced since 1998 could continue further if interventions to curb unlawful water use are not successful.*

Water requirement scenarios for the three large industries ***Eskom, Sasol*** *and* ***Mittal Steel*** *were provided by the respective organisation for the development of the strategy and are described in* ***Section 4.3.***

Urban water requirement scenarios were developed for the ***Rand Water supply area*** *by applying the Water Requirement and Return Flow Model (****DWAF, 2004e****) for the planning period up to 2030. One of the driver variables in the model is population scenarios, which were reassessed during the Second Stage Strategy using the same methodology applied in the Crocodile (West) River Reconciliation Strategy Study (****DWAF, 2008a****). The Stats SA 2007 projection developed for DWAF (****Stats SA, 2007****) was used as the Base Scenario and remained unchanged from the First Stage Strategy. Alternative High and Low scenarios were developed with information from the Crocodile (West) River Reconciliation Strategy Study, as described in* ***Section 4.4****.*

The Water Requirement and Return Flow Model was configured for 47 Sewage Drainage Areas (SDAs) and calibrated for the year 2001 (year for which census data was available). The calibration involved changing model parameters to match both the water use and return flows observed for each SDA for the year 2001. The 47 SDAs were divided into those draining into the Crocodile River System (Northern SDAs) and those discharging into the Vaal River System - Southern SDAs, see ***Figure 4-3*** *for a map showing the location of the SDAs.*

Water requirement and return flow scenarios were compiled based on the High, Base and Low Population scenarios for the Rand Water supply area, as summarised in ***Table I****.*

*Water requirement scenarios for **Sedibeng Water** and **MidVaal Water Company** were obtained from the respective organisations and for all the **other urban areas** the water requirement projections were determined using the growth rates from the National Water Resource Strategy (NWRS). Where actual water use data were available, the starting point (volume for the first year in the projection) was adjusted to match the actual value on which the future growths were applied.*

*Water requirement scenarios for the **raw water transfer to the Crocodile (West) System and the Lephalale Area** were obtained from the Crocodile (West) River Reconciliation Strategy Study (**DWAF, 2008a**) and are explained in detail in **Chapter 6**. This transfer will be necessary to augment the water supply of the proposed developments on the Lephalale coal fields including new power stations planned by Eskom and a possible Coal to Liquid plant by Sasol.*

***Table 4.12, Table 4.13** and **Table 4.14** in the document summarise the water requirements* for the High, Base and Low Population scenarios*, presenting the overall system gross and net water requirements for the planning years 2007 to 2030.*

Table I: Water Requirements and return flow scenarios for the Rand Water supply area

Scenario	***Component***	***Planning Year***					
		2007	**2010**	**2015**	**2020**	**2025**	**2030**
High	*Water Requirements*	*3,634*	*3,671*	*3,775*	*3,938*	*4,046*	*4,168*
	Return Flows	*705*	*711*	*767*	*815*	*850*	*891*
Base	*Water Requirements*	*3,557*	*3,624*	*3,704*	*3,827*	*3,914*	*4,016*
	Return Flows	*698*	*699*	*746*	*786*	*815*	*850*
Low	*Water Requirements*	*3,535*	*3,577*	*3,603*	*3,657*	*3,668*	*3,688*
	Return Flows	*692*	*686*	*719*	*740*	*750*	*764*

Notes: (1) .All volumetric values are given in million m^3/annum.

Potential savings through water conservation and water demand management measures

A parallel study to determine the potential savings that can be achieved through water conservation and water demand management (WC/WDM) in the Vaal River System was commissioned by the Directorate: Water Use Efficiency and a high level of integration with the Reconciliation Study assured that the products of the two studies were aligned.

The focus of the WC/WDM assessment was on the nine largest urban water users, which in total used 1 186 million m^3/annum of water in the year 2004. A standard water balance was compiled for each municipality, which was built up from assessments of water supply zones in their respective supply areas to represent the actual conditions in each zone. From this water balance the potential savings were determined with the focus on the "Billed but not paid for consumption" as well as the "Potential savings on physical leakage" components.

Based on detailed assessments made on numerous supply zones in each municipal area, the potential savings coupled with a range of WC/WDM measures were determined. With the knowledge that these measures will require substantial financial and human resources to implement, a schedule (projection) of future savings was made, resulting in the development of three scenarios.

Three saving scenarios were compiled from the assessment of the potential for water conservation and water demand managements (WC/WDM) in the urban sector. The savings were applied to come of the water requirement scenarios (see ***Chapter 5****) and were labelled* ***Scenarios C****,* ***D*** *and* ***E*** *respectively. The description and saving results from the scenarios are as following:*

- **Scenario C**: 5 Year water loss programme where water wastages are reduced through measures such as leak detection and repair. The loss management measures are maintained after the five year period. This scenario also include measures to improve the efficiency of water use and the assumption was made that a 1% saving can be gained per annum from the year 2015 onwards for the entire planning period (1% of selected large urban users that were assessed in detail).

- **Scenario D**: Reduction in wastage over 5 years. No efficiency improvement measures were included in this scenario.

- **Scenario E**: Reduction in wastage over 10 years, allowing for a slower implementation period of the proposed measures.

*A summary of the estimated savings in the water requirements for the pertinent scenarios are presented in **Table II.***

Table II*: Savings for the indicated scenarios and planning years*

Scenarios	*Planning Years*				
	2010	*2015*	*2020*	*2025*	*2030*
C3,L8,High	*185 (11%)*	*282 (15%)*	*351 (17%)*	*402 (19%)*	*402 (18%)*
D3,L8,High	*180 (11%)*	*191 (10%)*	*204 (10%)*	*217 (10%)*	*217 (10%)*
D3,L8,Base	*180 (11%)*	*191 (11%)*	*204 (11%)*	*217 (11%)*	*217 (10%)*
D3,L8,Low	*180 (11%)*	*191 (11%)*	*204 (12%)*	*217 (13%)*	*217 (12%)*

Notes: *(1)* *All volumetric values are given in million m^3/annum.*

(2) *Values in brackets give the percentage reduction in the total system urban demand for the different scenarios. The urban demand include the following components; Rand Water, Midvaal Water Company, Sedibeng Water and "Other towns and industries" as listed in **Tables 4.12** to **4.14**.*

Future intervention requirements and augmentation schemes

Given the water requirement and return flow scenarios and the potential saving scenarios through WC/WDM measures presented in the previous sections, the need for intervention (when further WC/WDM measures and/or the development of an augmentation scheme are required) was determined by assessing the water reconciliation (water balance) situation over the planning period. This was undertaken by firstly defining the planning scenarios and, secondly, carrying out scheduling analysis to determine the date when further intervention should be required (see description of planning scenarios in a subsequent section).

The Vaal Augmentation Planning Study (VAPS), completed in 1996, concluded that either a further phase of the Lesotho Highlands Water Project (LHWP) or further water resource developments in the Thukela River System could be considered as alternatives for augmenting the water resources of the Vaal River System.

Further feasibility and comparison studies were carried out for these two options and in December 2008 the Minister of the DWAF and the Cabinet announced that planning and negotiations should proceed to implementation Phase II of the Lesotho Highlands Water Project. This consists of the construction of Polihali Dam and conveyance tunnel to transfer water in Katse Dam from where it is delivered to South Africa via the existing delivery tunnel.

Planning scenarios and reconciliation options

Given the water requirement and return flow scenarios as well as the WC/WDM saving options, the following planning scenarios were compiled for analysis of the water balance:

- ***Scenario I**: High population scenario for the urban water requirements including the eradication of unlawful irrigation and the implementation of loss reduction measures over the next 5 years i.e. 15% WC/WDM.*

- ***Scenario II**: High population scenario for the urban water requirements including the eradication of unlawful irrigation.*

- ***Scenario III**: High population scenario for the urban water requirements and unlawful irrigation not removed.*

- ***Scenario IV**: Low population scenario for the urban water requirements including the eradication of unlawful irrigation and the implementation of loss management measures over the next 5 years i.e. 15% WC/WDM Scenario.*

- ***Scenario V**: Rand Water high water requirement projection including the eradication of unlawful irrigation and the implementation of loss management measures and water use efficiency over the next 5 years i.e. 30% WC/WDM Scenario.*

Figure 7-2 *presents the net system demand compared to the supply capability of the system and shows:*

- *The unlawful water use in the irrigation sector results in the system being in a deficit situation from 2007 to 2009.*

- *Based on the projected balance situation for* ***Scenario I****, it is shown that the system will require intervention by the year 2014.*

- *If the potential savings through WC/WDM are not achieved as in* ***Scenario II****, and the unlawful irrigation is also not reduced (****Scenario III****) the system is in deficit throughout the projection period and a severe risk of water shortages exists. This is a extreme scenario and was only configured to motivate why the eradication of the unlawful water use and loss management measures are essential to ensure a sustainable water supply is available for the users receiving water from the Vaal River System.*

- *The balance situation for* ***Scenarios IV*** *shows that if the low population projection realises and the unlawful irrigation is reduced and waste management initiatives are implemented, the system surplus water is available throughout the projection period.*

- *The balance situation for* ***Scenario V*** *shows that if Rand Water's High water requirement projection realises and both the unlawful irrigation is reduced and both waste management and water use efficiency initiatives are implemented the system will require an intervention by 2018.*

Section 7.6 *in the report presents the possible reconciliation option to supply the water requirements of the five planning scenarios presented above and from the results the following perspective on the augmentation requirements for the Vaal River System can be formulated:*

- *Eradication of the unlawful water use in the irrigation sector is essential to obtain a positive water balance in Vaal River System.*

- *Water Conservation and Water Demand Management initiatives to reduce the losses in the system are necessary to reduce the risk of drought curtailments until the next large augmentation scheme can be implemented by the year 2019.*

- *Planning activities required to implement the next bulk augmentation scheme should continue to ensure delivery is possible by 2019.*

The results of the simulation analysis showed that excess water that is effectively a loss to the Vaal River System water users will occur in Bloemhof Dam should the 600ml/g water quality management blending rule in the Vaal Barrage be implemented without considering re-use.

It was found that the combined effect of implementing Phase II of the LHWP and re-using mine water effluent (desalinate to potable quality) has the benefit that the subsequent (follow-on) augmentation scheme is postponed until 2038. This is a significant benefit in that the capital expenditure of the subsequent follow-on scheme can be postponed for many years and that the quality of the water in the Middle and Lower Vaal Water Management Areas will be improved due to the removal of salts from the mine water effluent.

It can therefore be concluded that re-use of effluent improves the water balance and contributes to reduce the risk of drought curtailments until the next bulk augmentation scheme can deliver water. (The simulation analysis of re-use scenarios are described in ***Chapter 9****).*

Perspective on water quality management

A water quality situation assessment of the Vaal River System was carried out as part of the Integrated Water Quality Management Plan (IWQMP). This process identified that salinity (as represented by Total Dissolved Solids), eutrophication and microbiological water quality as the major water quality issues that need to be addressed by the strategy.

The salinity in the Grootdraai Dam and Vaal Dam catchments is currently adequate and meets the water user requirements. However the water quality in both these dams is influenced by the water quality of the transfers from Lesotho, Thukela, Zaaihoek and the Usutu transfer schemes. Currently this transfer water is of a good quality and assists in maintaining the current water quality in these dams. However the water quality in Grootdraai Dam is under threat from mining in particular decants from closed mines in the catchment. The salinity deteriorates significantly from the Vaal Barrage to Bloemhof Dam due to the urbanisation of the catchment, return flows from wastewater treatment works, industrial discharges and mine dewatering discharges. The current status does not meet the Resource Water Quality Objectives (RWQOs) set for this reach of river.

The water quality assessment showed that Vaal Dam, Vaal Barrage and Bloemhof Dam are eutrophic to hypertrophic. The average phosphorus concentrations exceed the proposed RWQO significantly. The eutrophic conditions in the middle reaches of the Vaal River have impacted on the performance of the water treatment plants of Midvaal and Sedibeng Water. Additional treatment processes to deal with the colour and odour associated with the eutrophic waters has *had to be installed. The major source of the nutrients is the wastewater treatment works (WWTWs) effluent discharges and the management and maintenance of the sewerage systems. A number of WWTWs are not performing according to specifications.*

The available microbiological database does not support an extensive assessment of the entire Vaal River System. The database does however identify "hot spots" located in the tributaries close to WWTWs discharges. The microbiological water quality in the main stem of the Vaal River however in general meets the full contact recreation water quality requirement for E-Coli.

The findings from the Integrated Water Quality Management Plan were used to formulate the following management measures to improve the water quality in the system.

The proposed immediate to short term management strategy is as follows:

- *Continue with dilution of the Vaal Barrage water with releases from Vaal Dam. This approach does not result in the RWQOs set for the Vaal main stem being met. A waste discharge charge will be levied on discharges to offset the economic dis-benefit of the downstream users.*
- *Implement an upgraded monitoring programme.*
- *Selection of target saline effluent treatment schemes.*
- *Incorporated into the dilution releases will be the flow manipulation required to manage the algal blooms in the middle reaches of the Vaal River.*
- *Audit WWTWs and develop perspectives on hotspots requiring urgent action.*
- *Document and pilot protocols for flow manipulation releases as a strategy in Middle Vaal from Vaal Barrage to Bloemhof Dam.*
- *Source control, through Water Use Licence Application and Integrated Water and Waste Management Plans.*
- *Implement monitoring plan of nutrient sources.*
- *Implement upgraded monitoring and reporting plan.*

The medium to long term management strategy is:-

- *Implement target saline effluent treatment schemes.*
- *Implement waste discharge charges.*
- *Continue monitoring/assessment.*
- *Implement WWTW retrofit and upgrading projects in the hot spot areas.*
- *Nutrient Balance Study.*

- *Set up nutrient balance model – Vaal Barrage to Bloemhof Dam.*
- *Apply model to investigate alternative management strategies such as:*
    - *Stricter discharge standards.*
    - *Modified hydrodynamics.*
    - *Phosphorus free soaps and detergents.*
    - *Economic impacts of eutrophication on water users to be quantified.*

Strategic perspective on water resource management

The size of the Vaal River System, the various inter-basin transfers coupled with the extensive bulk water distribution infrastructure and the geographical location of the water users in relation to the position of the water resource components provides for a complex mix of variables that influences both the demand and availability.

Ensuring that sufficient water is available to supply the future water requirements in the supply area of the Vaal River System requires a five pillar strategy consisting of the following main components:

- *Water use compliance enforcement to eradicate unlawful water use.*
- *Water Conservation and Water Demand Management measures to reduce losses and improve efficiency.*
- *Utilisation of treated effluent and other discharges, especially those from the mines.*
- *Implementation of infrastructure augmentation option.*
- *Management of the water quality in the system.*

The above measures originate from the understanding of the supply situation in the Vaal River System as discussed in detail in the report and are expanded on below:

- *The eradication of the unlawful water use is an essential strategy that has to be implemented in order to rectify the current deficit (negative water balance) in the Vaal River System. The legal actions and procedures that will be implemented should be designed to achieve legal precedence to protect the entitlements of lawful water users and assist in compliance monitoring and water use regulation in future.*

- *The continuation of current and the initiation of further Water Conservation and Water Demand Management measures are essential to maintain a positive water balance in the Vaal River System over the next ten years. The potential savings that can be achieved through the* *reduction of water wastage will ensure the risk of drought curtailments are reduced until such time as Phase II of the LHWP can deliver water.*

- *The results from the simulation analysis presented in* ***Chapter 9*** *show that the re-use of mine water effluent in combination with other interventions could have a significant benefit by postponing the need for further augmentation after the implementation of Phase II of the Lesotho Highlands Water Project. Given the various options and associated implication (costs of treatment as well as environmental considerations) of implementing options of reusing effluent, it is recommended that a feasibility study be commissioned to evaluate all alternative options to compare the advantages and disadvantages with the aim of finding an optimum solution.*

- *The Minister of the Department of Water Affairs and Forestry and Cabinet made the decision in December 2008 that the Department should proceed to negotiations with the Government of Lesotho for the implementation of the Phase 2 of the Lesotho Highlands Water Project. These negotiations should take into consideration the findings from the Reconciliation Strategy.*

- *It is proposed that a Strategy Steering Committee (SSC) be established to oversee the implementation of the Reconciliation Strategy. Broadly, the function of the committee will be to continuously monitor the water balance situation of the Vaal River System and advise the responsible institutions on whether or not the objectives of the strategies are being achieved.*

Strategy maintenance recommendations

From the start of the study it was envisaged that the Reconciliation Strategy should not be stagnant and regular revisions would be required in future to ensure the strategy remain relevant. Several aspects have been identified that should be considered in the future maintenance of the strategy and are listed below:

- Monitor net system water demand

  In the past, annual monitoring was carried out only for the main water user's receiving water from the Vaal River System. Due to the importance of urban return flows, and the impact WC/WDM could have on the return flows, it is required to also implement continuously monitoring of the return flows and to use the information to update the net water requirements of the system. This will enable regular updates of the water balance and monitoring of the situation against the scenarios presented in this document.

- *Review reconciliation options based on results from reserve study*

  The Comprehensive Reserve Determination Study (commissioned by the DWAF Directorate: RDM in August 2006) will produce Ecological Water Requirement Scenario results towards the end of 2010, and the implication thereof on the reconciliation options will have to be determined and evaluated.

- *Integration of the Vaal and Crocodile (West) River System strategies*

  The interdependency of the Vaal River and Crocodile (West) River systems and their respective Reconciliation Strategies was clearly demonstrated in the report. Future revisions of the strategies for these systems have to be coordinated and activities need to be synchronized to ensure coherent scenarios are formulated and the strategy revisions reflect the prevailing situations of both systems.

  Consideration should be given to have shared representation on the respective Strategy Steering Committees of the two systems.

- *Complete the validation studies for the Middle and Lower Vaal WMAs*

  The completion of the validation studies in the Middle and Lower Vaal Water Management Areas is required to obtain a reliable estimate of the situation regarding the irrigation water use in those areas. A product of the validation studies should be an assessment of the lawful water use. The results from the validation studies should be used to revise the projected water balance of the system.

- *Monitoring of population information*

  In addition to the monitoring of the water requirements it is proposed that the population statistics from Stats SA be monitored to detect deviations from the figures that were assumed in the scenarios applied for the development of the Reconciliation Strategy. Particular focus should be given to the population changes in the Gauteng Province. The frequency of the comparisons will depend on the update cycle of Stats SA.

Stakeholder Participation

During the course of the study several Stakeholder Participation meetings were held for different purposes as presented in ***Table III****. A Study Steering Committee was established to guide the* *development of the Reconciliation Strategy, representing the following sectors, industrial, agricultural, environmental, water service providers and local government. The list in* ***Table IV*** *indicates the names and affiliations of the Steering Committee Members.*

Table III. Stakeholder Participation meeting details

MEETING DESCRIPTION	DATE	VENUE	COMMENTS	TOTAL NUMBER OF STAKEHOLDERS ATTENDED EACH MEETING
Vaal River Studies: Pre-consultation with key stakeholder	29 July 2005	Emerald Casino and Conference Centre, Vanderbijlpark	Stakeholders sanctioned study processes	**47** stakeholders attended the workshop
Stakeholder/Public Meeting	11 November 2005	Moqhaka Local Municipality (reception hall) Kroonstad	Nomination of PSC members	**41** stakeholders attended the workshop for the nominations of PSC members
IWQMP for the Vaal River System: 1st Project Steering Committee	28 March 2006	Golder Associates offices, Midrand	PSC	**22** members of the Steering committee attended the meeting
Large Bulk Water Supply Reconciliation Strategy Study: 1st Project Steering Committee	29 March 2006	Gauteng Regional Office, Pretoria	PSC	**42** members of the Steering committee attended the meeting
IWQMP for the Vaal River System: 2nd Project Steering Committee	10 November 2006	Gauteng Regional Office, Pretoria	PSC	**23** members of the Steering committee attended the meeting
Large Bulk Water Supply Reconciliation Strategy Study: 2nd Project Steering Committee	17 November 2006	Gauteng Regional Office, Pretoria	PSC	**26** members of the Steering committee attended the meeting
IWQMP for the Vaal River System: 3rd Project Steering Committee	12 November 2007	Gauteng Regional Office, Pretoria	PSC	**30** members of the Steering committee attended the meeting
Large Bulk Water Supply Reconciliation Strategy Study: 3rd Project Steering Committee	19 November 2007	Gauteng Regional Office, Pretoria	PSC	**30** members of the Steering committee attended the meeting
Large Bulk Water Supply Reconciliation Strategy Study: 4th	3 September 2008	Gauteng Regional Office, Pretoria	PSC	**42** members of the Steering committee

MEETING DESCRIPTION	DATE	VENUE	COMMENTS	TOTAL NUMBER OF STAKEHOLDERS ATTENDED EACH MEETING
(final) Project Steering Committee				attended the meeting
IWQMP for the Vaal River System: 4th (final) Project Steering Committee	4 September 2008	Gauteng Regional Office, Pretoria	PSC	**28** members of the Steering committee attended the meeting
Stakeholder Information Meeting	9 September 2008	Stone Haven-on-Vaal, Vanderbijlpark	To present to stakeholders the proposed integrated water management strategy for the Vaal River System	**47** stakeholders attended the workshop
Stakeholder Information Meeting	18 September 2008	Flamingo Casino and Conference Centre, Kimberley	To present to stakeholders the proposed integrated water management strategy for the Vaal River System	**25** stakeholders attended the workshop

Table IV: Steering Committee members

COMMITTEE MEMBER	ORGANISATION	COMMITTEE MEMBER	ORGANISATION
Peter van Niekerk	DWAF - CD: IWRP	Rafat Khan	Midvaal Water
Johan van Rooyen	DWAF – D:NWRP	Alwyn van der Merwe	Eskom
Hayley Rodkin	DWAF – D:WUE	Dr Nikki Wagner/Martin Ginster	Sasol
Seef Rademeyer	DWAF – D:NWRP	Jon Machanik	Chamber of Business
Dragana Ristic	DWAF – D:NWRP	Nikisi Lesufi	Chamber of Mines
Cain Chunda	DWAF – D:WUE	Nic Opperman	AgriSA
Chabedi Tsatsi	DWAF – D:WUE	Ms Hameeda Deedat	South African Water Caucus (NGOs/Civil Society)
Peter Pyke	DWAF – D:OA	Valita Roos	Johannesburg Water
Muruvan Sugandree	DWAF – D:WS (Regulation)	Jean-Pierre Mas	Johannesburg Water
Ashwin Seetal	DWAF – D:WA	Tina Korfias	Ekurhuleni Metropolitan Municipality
Kalinga Pelpola	DWAF – D:WS (Support Services)	Frans Mouton	Tshwane Metropolitan Municipality
Carin Bosman	DWAF – D:RP&W	Sam Shabalala	Metsi-a-Lokoa Local Municipality
Piet Pretorius	DWAF – D:WA & U	Rodney Spies	Matjhabeng Municipality
Beason Mwaka	DWAF – D:WRPS (SO)	Mrs van der Merwe	Mogale City
Jurgo van Wyk	DWAF – D:WRPS (WQP)	Thandiwe Mhlongo	Rustenburg Municipality
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Walther van der Westhuizen	DWAF – Gauteng Region	Kathy Eales	City of Johannesburg
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Pricilla Mohapi	DWAF – Free State Region	Hennie Smit	DWAF: Gauteng Regional Office
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Elsabe Powell	Provincial DEAT - Northern Cape		

Vaal River System: Large Bulk Water Supply Reconciliation Strategy

Second Stage Reconciliation Strategy (March 2009)

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ABBREVIATIONS

ACRONYM	MEANING
AASA	Actuarial Association of South Africa
CTL	Coal to Liquid
CWRS	Crocodile (West) River Reconciliation Strategy
Dir: HI	Directorate: Hydrological Information
Dir: NWRP	Directorate: National Water Resource Planning
CMS	Catchment Management Strategy
Dir: OA	Directorate: Option Analysis
Dir: PSC	Directorate: Policy and Strategic Co-ordination
Dir: WRPS	Directorate: Water Resource Planning Systems
Dir: RDM	Directorate: Resource Directed Measures
Dir: WCDM	Directorate: Water Conservation and Demand Management
Dir: WDD	Directorate: Water Discharge and Disposal
Dir: WUE	Directorate: Water Use Efficiency
DWAF	Department of Water Affairs and Forestry
EWR	Ecological Water Requirements
IVRS	Integrated Vaal River System
IWQMPS	Integrated Water Quality Management Plan Study
ISP	Internal Strategic Perspective
KOSH	Klerksdorp, Orkney, Stilfontein and Hartbeesfontein
LHWP	Lesotho Highlands Water Project
MCWAP	Mokolo Crocodile (West) Water Augmentation Project
NWA	National Water Act
NWRS	National Water Resource Strategy
RWQO	Resource Water Quality Objective
SDA	Sewage Drainage Area
SSC	Strategy Steering Committee
TDS	Total Dissolved Solids
TWPDSP	Thukela Water Project Decision Support Phase
TWP	Thukela Water Project
TWPFS	Thukela Water Project Feasibility Study
UARL	Unavoidable Real Losses
VAPS	Vaal Augmentation Planning Study
VRESAP	Vaal River Eastern Sub-system Augmentation Project
VRSAU	Vaal River System Analysis Update
WARMS	Water Allocation Registration Management System
WDM	Water Demand Management
WC	Water Conservation
WMA	Water Management Area
WRPM	Water Resource Planning Model
WRDP	Water Resource Development Project
WUA	Water User Association
WWTW	Waste Water Treatment Work

FORMER AND NEW MUNICIPAL NAMES

Former Name	New Municipal Name	Province
Johannesburg	City of Johannesburg	Gauteng
Pretoria	City of Tshwane	Gauteng
Khayalami	Ekurhuleni Metropolitan	Gauteng
Vereeniging	Emfuleni Local Municipality	Gauteng
Bronkhorstspruit	Kungwini Local Municipality	Gauteng
Heidelberg	Lesedi Local Municipality	Gauteng
Carletonville	Merafong City Local Municipality	Gauteng
Bronkhorstspruit; Highveld DC	Metsweding District Municipality	Gauteng
Meyerton	Midvaal Local Municipality	Gauteng
Krugersdorp	Mogale City Local Municipality	Gauteng
Cullinan	Nokeng tsa Taemane Local Municipality	Gauteng
Randfontein	Randfontein Local Municipality	Gauteng
Lekoa/Vaal, Vereeniging/Kopanong,	Sedibeng District Municipality	Gauteng
Southern DC	West Rand District Municipality	Gauteng
Westonaria	Westonaria Local Municipality	Gauteng
Bethlehem	Dihlabeng Local Municipality	Free State
Trompsburg	Kopanong Local Municipality	Free State
Allanridge, Boshof, Bothaville, Bultfontein, Dealesville, Goldfields, Hertzogville, Greater Brandfort, Hennenman, Hoopstad, Moddervaal, Odendaalsrus, Sandrivier, Soutpan, Theunissen, Verkeerdevlei, Virginia, Vetvaal, Ventersburg, Welkom, Wesselbron, Winburg	Lejweleputswa District Municipality	Free State
Frankfort	Mafube Local Municipality	Free State
Qwa-Qwa	Maluti a Phofung Local Municipality	Free State
Theunissen	Masilonyana Local Municipality	Free State
Welkom	Matjhabeng Local Municipality	Free State
Sasolburg	Metsimaholo Local Municipality	Free State
Kroonstad	Moqhaka Local Municipality	Free State
Bothaville	Nala Local Municipality	Free State
Parys	Ngwathe Local Municipality	Free State
Reitz	Nketoana Local Municipality	Free State
Vrede	Phumelela Local Municipality	Free State
Senekal	Setsoto Local Municipality	Free State
Eastern Free State DC	Thabo Mofutsanyane District Municipality	Free State
Hoopstad	Tswelopele Local Municipality	Free State
Balfour	Dipaleseng	Mpumalanga
Highveld Ridge	Govan Mbeki Municipality	Mpumalanga
Standerton	Lekwa	Mpumalanga
Ermelo	Msukaligwa	Mpumalanga
Volksrust	Pixley Ka Seme	Mpumalanga
Reivilo	Greater Taung Local Municipality	North West
Ganyesa	Kagisano Local Municipality	North West
Koster	Kgetlengrivier Local Municipality	North West
Christiana	Lekwa-Teemane Local Municipality	North West
Schweizer-Reneke	Mamusa Local Municipality	North West

Former Name	New Municipal Name	Province
Wolmaransstad	Maquassi Hills Local Municipality	North West
Pomfret	Molopo Local Municipality	North West
Vryburg	Naledi Local Municipality	North West
Potchefstroom	Potchefstroom Municipality	North West
Ventersdorp, Klerksdorp, Potchefstroom, Wolmaransstad	Southern District Municipality	North West
Delareyville	Tswaing Local Municipality	North West
Ventersdorp	Ventersdorp Local Municipality	North West
Barkley West	Dikgatlong Municipality	Northern Cape
Warrenton	Magareng Municipality	Northern Cape
Hartswater	Phokwane Municipality	Northern Cape
Kimberley	Sol Plaatjie Municipality	Northern Cape
Kathu	Gamagara Municipality	Northern Cape
Kuruman	Ga-Segonyana Municipality	Northern Cape
Griekwastad	Siyancuma Municipality	Northern Cape
Danielskuil	Kgatelopele Municipality	Northern Cape
Postmasburg	Tsantsabane Municipality	Northern Cape

Vaal River System: Large Bulk Water Supply Reconciliation Strategy

Second Stage Reconciliation Strategy (March 2009)

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs and Forestry (DWAF) has, as part of the development of the Internal Strategic Perspectives (ISPs)[1] for the three Vaal River Water Management areas (WMAs) identified and prioritised several studies that are necessary to further support Integrated Water Resource Management in the Vaal River System. Although previous water balance assessments indicated that augmentation of the Vaal River System is only required by the year 2025 (**DWAF, 2004a to d**), several factors were identified that could influence this date and require further investigations.

Firstly, it was acknowledged that the water requirement projection scenarios used in the ISP study did not explicitly include the effect of water conservation and water demand management initiatives (**DWAF, 2004d**) and as a result the Directorate Water Use Efficiency commissioned a Water Conservation and Water Demand Management study with particular focus on the Upper and Middle Vaal WMAs.

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

Thirdly, a comprehensive Reserve Determination has not been undertaken for the Vaal River System and will have to be incorporated into the development of reconciliation strategies.

[1] The Internal Strategic Perspectives (ISPs), the first version was compiled in 2004.

In view of the above considerations as well as other uncertainties identified in the assumptions used in the ISP study (see **DWAF, 2004d** for details), the Directorate: National Water Resource Planning (D:NWRP) has commissioned this reconciliation study of the large bulk water supply system of the Vaal River.

The ISPs for the Vaal River WMAs further identified the need for integrated water quality management of the Vaal River and its major tributaries. Although there are several individual Catchment Management Strategies already completed, these strategies and their objectives need to be integrated and co-ordinated in a system context. To this end, the D:NWRP has commissioned a study to develop an **Integrated Water Quality Management Plan** (**DWAF, 2008c**) for the Vaal River System which was running concurrently with the **Reconciliation and Water Conservation and Water Demand Management** (**DWAF, 2006b**) studies.

During the inception phases of these studies it was identified by the respective management teams that the integration of strategies and co-ordination of study activities would be essential to development coherent water resource management measures for the Vaal River System. The management of the studies was therefore coordinated by combining the project management of the Water Conservation and Reconciliation studies and have cross representation of study managers on the Water Quality Study.

In each of the three abovementioned studies the importance of stakeholder involvement in the development of the strategies was emphasised and an integrated stakeholder engagement process was designed. This resulted in combining the stakeholder meetings for all three the studies, combining the Steering Committee Meetings of the Water Conservation and Reconciliation studies and having shared representation on the Water Quality Study.

The reconciliation strategies for the Vaal River System: Large Bulk Water Supply Reconciliation Strategy Study were developed in two stages. The first stage involved developing and assessing scenarios of possible future reconciliation options which were then presented to the DWAF and the stakeholders for comments. Further investigations were identified for assessment during the development of the Second Stage Reconciliation Strategy and the results have been incorporated in this report.

1.2 PURPOSE OF THE STUDY

The Large Bulk Water Supply Reconciliation Strategy for the Vaal River System Study had the objective to develop strategies for meeting the growing water requirements of the industrial and urban sectors that are served by the Integrated Vaal River System. The development of these strategies requires reliable information of the water requirements and the water resources for the current situation as well as likely future scenarios for a planning horizon of twenty to thirty years.

The key objectives of the study were to:

- Update the current and future urban and agricultural water requirements.
- Assess the water resources and existing infrastructure.
- Take into account the Reserve requirements for alternative classifications.
- Formulate reconciliation interventions, both structural and administrative/regulatory.
- Conduct stakeholder consultation in the development of the strategies.

In order to achieve these objectives the study was undertaken through a series of tasks which culminated into a set of study reports that are listed on the back of the cover page of the report. The information from the task reports was combined to formulate the reconciliation strategy, the main deliverable from the study, which is presented in this report.

1.3 STUDY AREA

The core of the study area consists of the Upper, Middle and Lower Vaal River Water Management areas, however, due to the numerous inter-basin transfers that link this core area with other WMAs, reconciliation planning has to be undertaken in the context of the Integrated Vaal River System which also includes portions of the Komati, Usutu, Thukela and Senqu River (Located in Lesotho) catchments. Significant water transfers also occur to water users in the Olifants and Crocodile (West) River catchments of which most are totally dependant on the water resources of the Integrated Vaal River System. In addition, a scheme has been proposed to transfer water from the Crocodile (West) River to the Lephalale Area (Mokolo River System), in order to address the increasing water needs resulting from significant future developments planned in the area. DWAF has thus commissioned the Mokolo Crocodile (West) Water Augmentation Project (MCWAP) Feasibility Study, which is currently in the process of being conducted. **Figure A-1** in **Appendix A** shows a geographical map of the Integrated Vaal River System which is the area of concern for the study.

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

It should be noted that the study area of the Integrated Water Quality Management Plan Study (IWQMPS) covers a slightly larger area than the three Vaal River WMAs and also include the Riet and Modder River Catchments, which is part of the Upper Orange WMA. The inclusion of these catchments was necessary to cover all water quality aspects of the entire Vaal River's catchment down to it's confluence with the Orange River.

1.4 PURPOSE AND LAYOUT OF THIS REPORT

This report describes the Second Stage Reconciliation Strategy for the Vaal River System, which is a refinement of the First Stage Reconciliation Strategy, where the results of identified items that required further investigations were incorporated. The document serves as a summary that collates the information of other technical reports that were compiled in the study.

The introduction, given in **Chapter 1**, is followed by descriptions of the study procedure and the reconciliation strategy development methodology in **Chapter 2** and **Chapter 3** respectively. **Chapter 4** describes the water requirement and return flow scenarios on which the water conservation and water demand management scenarios, presented in **Chapter 5**, were based. Transfer requirements to the Crocodile (West) River System are presented in **Chapter 6**. The results from the first six chapters are used to determine future interventions that are needed to reconcile the demand with the available supply, as presented in **Chapter 7**. A perspective on water quality management aspects are provided in **Chapter 8** followed by a description of simulation analysis of re-use options in **Chapter 9**. **Chapter 10** presents and assessment of a a scheme to transfer waste water treatment works (WWTW) effluent from the Vaal to the Crocodile (West) Catchment. The report concludes with three chapters covering recommendations, strategic perspective regarding water management and finally, the references used in the report are presented in **Chapter 13**.

CHAPTER 2. STUDY PROCEDURE

The overarching study approach was to develop the reconciliation strategy in two stages. The first stage involved developing scenarios of possible future reconciliation options which included various assessments to firm up on certain uncertainties that were identified when the study was commissioned. The First Stage Reconciliation Strategy results were presented to DWAF Management and Stakeholders and items requiring further investigations were identified and incorporated into the Second Stage Reconciliation Strategy described in this report.

An essential part of the strategy development process was the integration of information from various processes and studies in order to arrive at a strategy that account for all major aspects that influence the bulk water supply situation in the Vaal River System. This was achieved by co-ordinating activities among the three studies (see **Section 1.1**) as well as incorporating information from other DWAF and stakeholder investigations that were carried out in parallel assignments.

The focus of the assessments for the First Stage Strategy was on the following aspects:

- Develop water requirement and return flow scenarios by focussing the assessments on the urban water use sector of the Gauteng Province.

- Determine the potential for Water Conservation and Water Demand Management by concentrating on the main urban areas. This involved developing scenarios of potential savings in water use for the planning period leading up to the year 2030.

- Estimate the irrigation water requirements by evaluating preliminary information that was obtained from the water use validation process, which is undertaken by DWAF. (The final results from the validation studies were not available at the time of writing this report.)

- Identify and assess potential large scale water re-use options that could have water quality and water supply benefits.

- Provide an initial indication of how the implementation of the Ecological Water Requirements (a component of the Reserve) could influence the projected water balance situation. (In August 2006, DWAF has initiated studies to undertake Comprehensive Reserve determinations for the Integrated Vaal River System, however, results from these assessments will only become available in the year 2010. Recommendations are made in **Chapter 12** on how the results from the reserve determination study should be used in future to revise the Reconciliation Strategy.

- Preliminary analysis of existing water quality management options relating to blending, dilution and water re-use.

Additional information and the integration with other planning processes were considered in the development of the Second Stage Reconciliation Strategy and the following elements were incorporated into the strategy:

- Synchronisation of the scenarios with those of the *Crocodile (West) River Reconciliation Strategy Version 1* (**DWAF, 2008a**). This included the following aspects:
  - o Updated population and related water requirement scenarios based on alternative population scenarios developed as part of the Crocodile (West) River Reconciliation Strategy Study. (See **Section 4.4.2** for details)
  - o Assess the implications of transferring additional raw water to the Crocodile River System. The need for this transfer was identified as a requirement in the *Crocodile (West) River Reconciliation Strategy Study* and originates from the planned developments in the Lephalale Coal Fields for energy provision industries, described in **Chapter 6**.
- Updated information on Stage 2 of Lesotho Highlands Water Project (LHWP) Feasibility Study (**DWAF, 2008b**).
- Revised water use information obtained from Sasol and Eskom.
- Revised information from the Water Use Validation Study regarding irrigation water requirements in the Upper Vaal and the estimated portion that is deemed to be unlawful.
- Carried out detailed water resource simulation analysis to assess the implications water re-use options, coupled with the alternative water requirement scenarios, has on the long term reliability of supply. This involved analysing various scenario combinations of re-use and infrastructure augmentation options to determine the date when the system needs further augmentation - after the next large bulk supply scheme is implemented. These analyses are described in **Chapter 9**.

In support of the above described technical work, an integrated stakeholder engagement process, which consolidated the communication needs of the three studies (referred to in **Section 1.1**), were followed as depicted graphically in **Figure 2-1**.

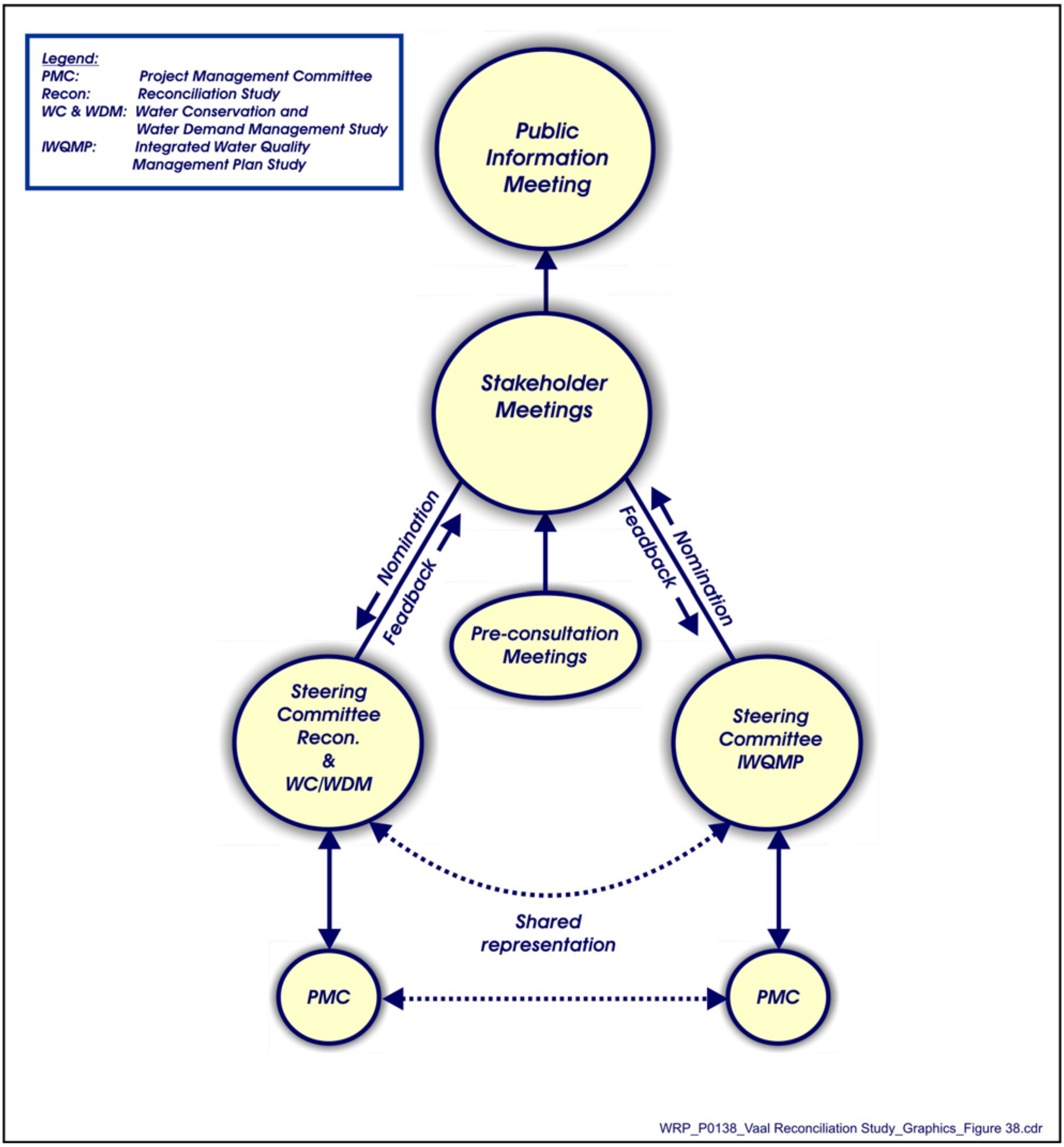


Figure 2-1: Schematic representation of the Stakeholder Engagement Process

The stakeholder engagement events are listed in **Table iii** of the **Executive Summary**.

CHAPTER 3. RECONCILIATION STRATEGY DEVELOPMENT METHODOLOGY

3.1 OVERVIEW

The development of strategies to reconcile the water requirements with the available water in the Vaal River System has to be founded on a sound understanding of the projected water balance for at least a fifteen year planning period into the future. This long term view is necessary due to the long lead time required to implement a large bulk water augmentation scheme and that the decision to proceed with such schemes has to be taken ten to fifteen years before the first water is delivered.

Understanding the water balance of the system, requires information on the water that is available from the water resource systems on the one hand, and what the water requirements are, on the other. DWAF has over the years developed sophisticated analysis techniques and decision support systems to determine the water availability and, as stated in the *Vaal River System Overarching Internal Strategic Perspective* report (**DWAF, 2004d**), the current knowledge on the water availability estimates are at a sufficient level of confidence. The approach taken in this study is to use the existing available hydrological databases and simulation models and only make changes to the configurations in accordance with the requirements of each scenario that was analysed. Therefore, neither the hydrology database nor the calibration of the salinity modules were updated in the study.

Several uncertainties were however identified concerning the current and future water requirements, with the result that the focus of the technical work revolved around determining quantitative scenarios of future water use for all sectors, quantifying the potential for water conservation and water demand management in the urban sector, estimate the irrigation water requirements, identify potential large bulk water re-use opportunities and obtain preliminary indications of the reconciliation situation in meeting the Ecological Water Requirements.

Once the quantification of the above-mentioned “demand side” components had been completed, scenarios were defined to represent possible future conditions. These scenarios were then analysed in the simulation models (Water Resource Planning Model - WRPM) to determine the date when intervention is required. The WRPM produces, among other things, a projection of the risk of curtailments for each year of the planning period, and the date when the user reliability criteria is violated (risk of curtailment are more than the criteria) defines the year in which an intervention measure should be commissioned. These interventions could be measured on either side of the water balance, such as more intensive water conservation measures or the development of an infrastructural solution in the form of new water resource augmentation schemes.

In addition to the water quantity balance the incorporation of water quality management scenarios as part of the reconciliation strategy is essential. This was achieved by integrating the options identified from the *Integrated Water Quality Management Plan Study* (IWQMPS) with the scenarios of the Reconciliation Study, to account for interdependencies to be able to develop coherent strategies. Although the detail water quality assessments and results are provided in the study reports of the IWQMPS, the key outcomes of the study are briefly described in **Chapter 8**.

The sections below give brief descriptions of the methodology that was followed in the study, grouped according tot the main study tasks.

3.2 URBAN WATER REQUIREMENT AND RETURN FLOW SCENARIO DEVELOPMENT

Substantial increases in the water use occurred in the urban and industrial sectors in the past years, which can be contributed to the favourable socio-economic conditions that existed in the country. The economic expansion is however unevenly distributed among the provinces, with the growth rate of the economy in the Gauteng Province being substantially higher than the country average. The opportunities created by the expanding economy in Gauteng, resulted in a trend of in-ward migration of people to the province as reflected in the "*2006 Mid-Year Population Estimates" (**SSA, 2006**),* published in August 2006 by Stats SA. The economic prospects, coupled with rising living standards of the population, as well as other factors such as HIV AIDS are, and will continue having significant influences on the future water requirements to be supplied from the Vaal River System.

The methodology for determining the urban water requirement scenarios were based on the procedures that were developed as part of the *Crocodile River (West) Return Flow Analysis Study* (**DWAF, 2004e**). This method involves defining algorithmic models of each Sewer Drainage Area (SDA), where a SDA encompasses urban areas that are serviced by a sewer collection system that discharges to a particular Waste Water Treatment Works (WWTW). The algorithm uses population as the main driver (independent variable) and through a process of calibration of model parameters define the relationship between population and water requirements as well as return flows.

Treated wastewater forms a substantial portion of the available water resources in both the Vaal and Crocodile River systems and has historically increased due to the urban developments in the Gauteng Province. It is expected that this resource will further increase in future as a result of increasing population and associated provision of water services. Scenarios of return flows were therefore developed that correlates with the water requirement projections and take into consideration the influence of WC/WDM measures.

Given the inherent uncertainties that exist in long-term water requirement estimates, a process of scenario development has been followed to derive likely alternative future water requirement projections. The development of the urban water requirement scenarios is discussed in **Section 4.4** and the scenarios are summarised in **Scenario 4.5**.

3.3 UPDATING OF THE IRRIGATION WATER REQUIREMENTS AND RETURN FLOWS

Water requirements of the Irrigation Sector have been the subject of various studies in the past, of which the information from the *"Loxton Venn"* Study (**DWAF,1999**) was used in previous water resource planning investigations. The subsequent water use registration, validation and verification processes commissioned by DWAF have generated further sources of information in the form of the Water Allocation Registration Management System (WARMS) and the database generated from the validation studies. At the time the irrigation water requirement task was carried out in the First Stage Strategy, the validation study of the *Upper Vaal Water Management Area* was partly completed and it was possible to extract partial validated information (about 70% of the properties were validated) for analysis in this study. The validation study was completed in the interim and the final results have been incorporated in the Second Stage Reconciliation Strategy. This has resulted in a 23 million m^3/annum reduction in lawful irrigation and 67 million m^3/annum reduction in the unlawful irrigation as discussed in **Section 4.2**.

The validation studies of the *other two Vaal WMAs* were only commissioned and again no validated information was available at the time of the First Stage Strategy. The approach followed to estimate the irrigation water use in the Middle and Lower Vaal WMAs, was to prepare comparison reports of the data sources from previous studies and the WARMS database. These comparisons were then discussed with the water resource managers of the respective regional offices to make a decision on the most appropriate data to use for the study. The validated information was also not yet available at the time of finalising the Second Stage Reconciliation Strategy and the irrigation water use volumes from the First Stage Strategy were adopted in the Middle and Lower Vaal WMA's and thus remained unchanged.

3.4 POTENTIAL SAVINGS FROM WATER CONSERVATION AND WATER DEMAND MANAGEMENT

A parallel study (**DWAF, 2006b**) to determine the potential savings that can be achieved through water conservation and water demand management (WC/WDM) in the Vaal River System was commissioned by the Directorate: Water Use Efficiency and a high level of integration with the Reconciliation Study assured that the products of the two studies were aligned.

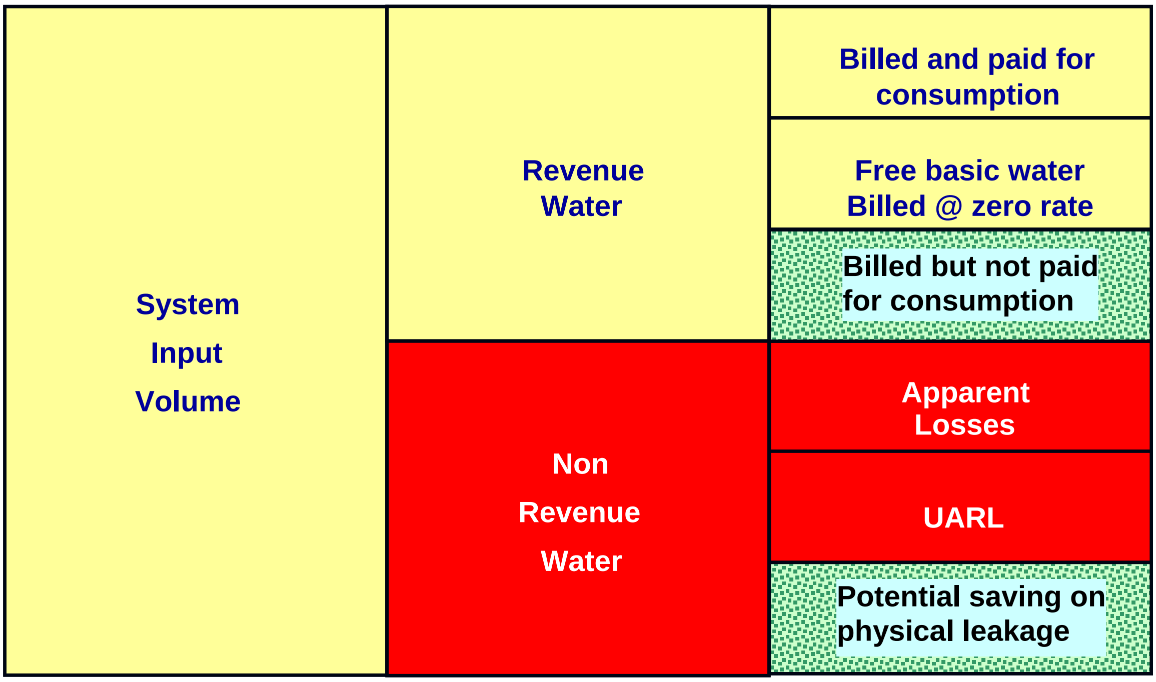
The focus of the WC/WDM assessment was on the nine largest urban water users, which in total used 1 186 million m^3/annum of water in the year 2004, as listed in **Table 3.1** below.

Table 3.1: Major municipal demands considered in the study listed in descending order

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**

A standard water balance was undertaken for each municipality, which was built up from assessments of water supply zones in their respective supply areas to represent the actual conditions in each zone.

An illustration of the components that make up the water balance is provided in **Figure 3-1**, indicating the losses and non-revenue water. From this water balance the potential savings were determined with the focus on the “Billed but not paid for consumption” as well as the “Potential savings on physical leakage” (green hashed blocks) components.



Notes: UARL – Unavoidable Real Losses

Figure 3-1: Illustration of a standard water balance

Based on detailed assessments made on numerous supply zones in each municipal area, the potential savings coupled with a range of WC/WDM measures were determined. With the knowledge that these measures will require substantial financial and human resources to implement, a schedule (projection) of future savings were made, resulting in the development of three scenarios (see **Section 5.2.1** for a description of these scenarios).

3.5 RECONCILIATION FOR A PRELIMINARY RESERVE SCENARIO

In the **Vaal River System Overarching ISP** (**DWAF, 2004d**) it was recommended that a comprehensive reserve determination of the Vaal River System and the supporting source catchments has to be undertaken. Although high confidence reserve determinations have been carried out in a few catchments, the need for a Comprehensive Reserve Determination Study that covers the entire integrated system has been identified by DWAF. The Directorate: Resource Directed Measures (Dir: RDM) has, therefore, commissioned studies during the end of 2006 for undertaking Comprehensive Reserve Determination Studies.

In order to provide an interim perspective on the water balance concerning the Reserve as part of this study, an analysis was carried out where all available Ecological Water Requirement (EWR) information was sourced from Dir: RDM and incorporated into the WRPM. Two scenarios were simulated, one with, and the other without the EWRs, and in each case the date when system failure occurred were determined for a selected water requirement projection scenario that covers the planning period up to the year 2030. The results showed that the available water (available system yield) reduced by about 140 million m^3/annum or 5% of the total system yield, which supports the need that the Reconciliation Strategy has to be revised once the Reserve Determination Study had been completed – this recommendation is discussed further in **Chapter 12.**

3.6 DETERMINATION OF THE REQUIRED INTERVENTION DATES

Operational and planning decisions concerning the Integrated Vaal River System are informed by risk analysis techniques involving simulation of the water resource system using computer models. The analysis is undertaken by means of a suit of water resource simulation models, which contains an extensive hydrological database that covers all the catchments and river systems comprising the Integrated Vaal River System. The suit of models consists of various supporting utilities, all having the function of generating data and information required by the WRPM.

The WRPM is the main decision support system, which through scenario analysis determines, among other things, the future date when intervention is required based on the probability (risk) of curtailments for a given set of variables and assumptions. The model contains an allocation procedure (algorithm) to simulate curtailment rules, which reduce (curtail) the water requirements when the storage state of the system is depleted to such levels, that the short-term yield (supply capability) is less than the water requirements.

The date when intervention is required is determined by undertaking a system analysis using a large number of possible hydrological inflows (runoff). In the analysis curtailments are implemented for each of the inflow sequences when droughts occur, and an estimate of the probability of curtailments is then obtained. These simulations are carried out for a planning period of about twenty years, during which the water requirements increase over time, resulting in more frequent curtailments being required from year to year. The most important result from the simulations is the annual projected risk of curtailments, and the year in which the reliability criteria are violated, defines the date when intervention is necessary.

Due to the extent of the analysis presented above, it was not practical to undertake simulation analysis with the WRPM for all the scenarios identified in the study. Alternative complimentary annual water balance assessments were developed to determine the future intervention dated and provide estimates of the magnitude of augmentation requirements. These balances were carried out by using results from simulation analysis of selected scenarios and performing difference analysis to derive the required perspectives for each scenario.

In this study the above described methodology were applied to the scenarios presented in **Section 7.3** and the scheduling results are presented in **Section 7.5**.

CHAPTER 4. WATER REQUIREMENT AND RETURN FLOW SCENARIOS

4.1 INTRODUCTION

This chapter describes the water requirements and return flow scenarios that were developed in the study and presented according to the following headings:

- Irrigation water requirements **(Section 4.2).**
- Bulk industrial water requirements **(Section 4.3).**
- Urban water requirements and return flows **(Section 4.4).**
- Summary of the water requirement and return flow scenarios **(Section 4.5).**

4.2 IRRIGATION WATER REQUIREMENTS AND RETURN FLOWS

4.2.1 Overview

Irrigation water requirements comprise about thirty five percent of the total system water use, of which the Vaalharts Irrigation Scheme, the largest in the country, uses 31% of this sector's water. The *Internal Strategic Perspective: Vaal River System: Overarching* **(DWAF,2004d)** indicated that, due to the strategic decision that any new water use will have to pay the full cost of water, irrigation water use is likely to remain constant. The Water Resource Managers in the regions, however, expressed their concern, due to the substantial irrigation developments that have taken place since 1998, and of which most is perceived to be unlawful. This lead to the commissioning of a water use validation study in the Upper Vaal WMA, from which the final information was received and incorporated in the Second Stage Reconciliation Strategy.

An element of the water balance that required further analysis was to improve the confidence in the estimates of the return flows from irrigation areas in the Vaal River System. Assessments of the main irrigation schemes were therefore carried out in the study based on the method developed in the *Crocodile River (West) Return Flow Analysis Study* (**DWAF, 2004e**). The assessment of the irrigation return flow and the results is described in the *Irrigation Water Use and Return Flows* report compiled as part of this study.

The following sections summarise the irrigation water use information for the three Vaal WMAs and present a description of the scenarios that were compiled for analyses.

4.2.2 Upper Vaal Water Management Area

The revised irrigation water requirement results for the total Upper Vaal WMA are shown in **Table** 4.1. The results illustrate a reduction in the total irrigation water use (90 million m^3/annum) estimates compared to the results presented in the First Stage Strategy. A 23 million m^3/annum reduction occurs in the lawful irrigation and a 67 million m^3/annum reduction in the unlawful category.

Table 4.1: Irrigation water requirements in the Upper Vaal WMA

Description	Irrigation Water Use (million m^3/annum)		
	Existing Lawful	Total Water Use (2005)	Possible Unlawful
First Stage Strategy (November 2007)	153	394	241
Second Stage Strategy (August 2008)	130	304	174
Difference	**23**	**90**	**67**

4.2.3 Middle and Lower Vaal Water Management Areas

Due to the absence of Validation Study information for the Middle and Lower Vaal WMA, the suggested irrigation water requirements derived in the First Stage Strategy were accepted. The approach followed to derive the irrigation water requirements involved preparing water use comparisons from the Vaal River System Analysis Update (VRSAU), Loxton Venn studies and the WARMS database, which were presented to the DWAF Regional Office Water Resource Managers to obtain their consent at deriving the “suggested” water use figures. The water use in the Lower Vaal WMA is predominantly for the irrigation requirements supplied to the Vaalharts Irrigation Scheme. The irrigation water use for the Middle and Lower Vaal WMA are shown in **Table 4.2** .

Table 4.2 : Irrigation water requirements in the Middle and Lower Vaal WMA

Water Management Area	Irrigation Water Use (million m^3/annum)			
	Accepted for this study	VRSAU[(1)]	Loxton Venn[(2)]	WARMS
Middel Vaal	228	210	161	369
Higher than Loxton Venn	67	49	0	208
Lower Vaal	438	462	460	412
Higher than VRSAU	-24	0	-2	+50

Notes: (1) Vaal River System Analysis Update Study.

(2) The water use from Loxton Venn study was used in previous planning studies.

Further details of the irrigation water use analysis can be obtained in the *Irrigation Water Use and Return Flows* report of the study.

4.2.4 Vaal River System summary of irrigation water use

Table 4.3 provides a summary of the data comparison of the irrigation water use applied for the Second Stage Reconciliation Strategy and shows the total water use is 204 million m^3/annum higher than what was applied for planning studies prior to the Reconciliation Study. The previous water requirements data were determined in a study undertaken by Loxton Venn for the DWAF, dated 1999, and interpreted for analysis with the Water Resources Planning Model.

Evaluation of the irrigation water requirements data from the Validation Study (information received in 2008) shows that between the years 1998 and 2005 the irrigation water requirements substantially increased. It was further established (through preliminary investigations) that this increase is predominantly unlawful and poses a significant challenge to DWAF as the regulating authority. (It should be noted that the verification of the lawful status of the water use has not been undertaken at the time the data was evaluated.)

Table 4.3: Summary of irrigation water use comparisons for the three Vaal WMAs

Description	Water use applied in previous investigation (2) Column A	WARMS	Accepted for this study (2005 development)
Total Vaal	766	1 375	970
Higher than Column A	-	609	204
% Higher	0%	80%	27%

Notes: (1) All values are given in million m^3/annum.

(2) Data from a study carried out by Loxton Venn for the DWAF, dated 1999, and interpreted for analysis with the Water Resources Planning Model

4.2.5 Scenarios of future irrigation water use

The information presented in the previous sections focused on the historical and current irrigation water use. For planning purposes it is required to compile scenarios of future water use for the period up to 2030, which is presented in this section. Given that the year 2005 water use estimates are significantly higher than the preliminary estimates of what is considered lawful, a scenario was compiled where it was assumed that the current water use will be reduced over the medium term through legal interventions and water use compliance monitoring. The assumptions used in the scenario are listed below:

Irrigation Scenario 1: Curtailment of unlawful irrigation water use

- **Upper Vaal WMA**
  - Assume the growing trend, which was observed over the period 1998 to 2005, continuous for two years until 2008. This implies the interventions will take two years to become effective.
  - Eradication of unlawful irrigation water use from 2008 onwards and assumes the water use will decrease over a period of 3 years.
  - The assumption is made that the interventions will reduce the irrigation to the lawful volume plus 15% and that this will be achieved in the year 2011. The additional 15%

above the estimates of the lawful water use is a conservative assumption providing for possible under estimations from the current data.

- **Middle and Lower Vaal WMAs**
  - o Due to the absence of information from validation studies in these areas, it is assumed that the current suggested irrigation water use will remain constant over the planning period.

Irrigation Scenario 2: Recent trend continues unattended

- **Upper Vaal WMA**
  - o The assumption was made that the irrigation water use will continue to increase at the trend observed between 1998 and 2005 until the registered volume from the WARMS database is reached.
- **Middle and Lower Vaal WMA**
  - o Assume the future water use remains constant at the suggested water use levels.

The **Irrigation Scenario 2** will create an unsustainable situation in the Vaal River System and is not considered to be viable. However, this scenario was derived to illustrate the potential impact should the situation arise where the interventions are not successful to cut back the unlawful water use.

4.2.6 Future irrigation water use scenario results

Figure 4-1 presents the future irrigation water requirements for the two scenarios described in the previous section and shows that the **Irrigation Scenario 2** is about 560 million m^3/annum higher than the **Irrigation Scenario 1** over the long term. These two irrigation water requirement scenarios were used in the system planning scenarios which are described in **Section 7.3**.

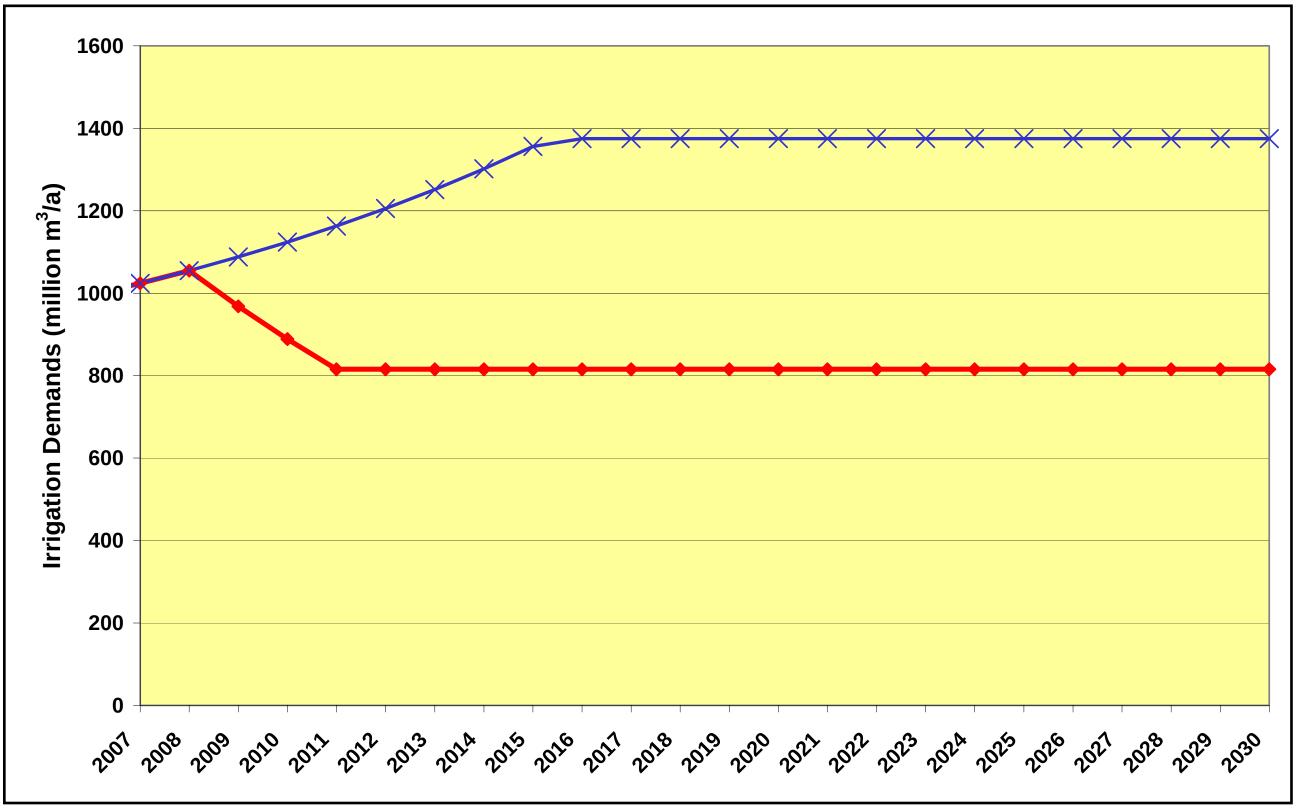


Figure 4-1: Irrigation water requirement scenarios for the Vaal River System (Blue top line for Irrigation Scenario 2, bottom read line for Irrigation Scenario 1)

4.3 BULK INDUSTRIAL WATER REQUIREMENTS

4.3.1 Overview

There are three main industries receiving water in bulk from the Vaal River System, the electrical power utility Eskom, petrochemical (coal to liquid fuel) industry Sasol, and Mittal Steel. These industries were requested to provide water requirements scenarios based on their future outlook of their respective operations and water management programs. These water requirement scenarios are presented in the subsequent sections.

4.3.2 Eskom

Eskom currently operates 12 coal fired electrical power stations, which receive water from the Integrated Vaal River System. Some of these stations were decommissioned and are now reinstated to increase supply in response to the growing demand for electrical power to fuel the South African economy. There are also plans to develop three new power stations, envisaged to receive water from the Vaal River System. Two are scheduled to receive water from the Zaaihoek Subsystem, and current planning is that the third will be located close to the existing Kendal Power

Station and receive water from the Eastern Vaal River Sub-system (a component of the Integrated Vaal River System).

Table 4.4 provides a summary of the water requirements and lists all the power stations, their primary water source, as well as the projection of water requirements for the indicated years of the planning period. This information was received from Eskom after the First Stage Strategy had been completed (received in April 2008). These updated requirements were used in all the planning scenarios, see **Section 7.3** for details.

Table 4.4: Eskom power stations' water requirements (reference of projection April 2008)

Power Station	Primary Water Source	Water Requirements (million m^3/annum)					
		2007	2010	2015	2020	2025	2030
Hendrina	Komati Sub-system	31.0	31.7	31.2	31.2	31.2	31.2
Arnot		28.5	34.2	35.0	35.0	35.0	35.0
Duvha		49.6	49.3	49.5	49.5	49.5	49.5
Komati		5.3	16.4	15.6	12.4	9.1	3.3
Kriel	Usutu Sub-system	37.9	40.6	42.4	42.4	42.4	42.4
Matla		49.6	50.2	51.8	51.8	51.8	51.8
Kendal		3.2	3.3	3.3	3.3	3.3	3.3
Camden		13.4	19.6	17.9	14.4	7.2	1.6
New coal-fired 1		0.0	0.8	9.7	15.2	14.6	14.1
Majuba	Zaaihoek Sub-system	24.3	29.5	27.7	24.1	24.1	24.1
Majuba CCGT		0.0	0.0	1.0	1.0	1.0	1.0
Majuba UCGP		0.0	3.9	7.8	7.8	7.8	7.8
Tutuka	Grootdraai Sub-system	38.39	42.8	43.9	45.4	45.4	45.4
Grootvlei	Vaal Dam	7.0	14.1	14.7	13.7	8.9	3.9
Lethabo		46.8	46.4	46.7	46.7	46.7	46.7
Total		**331.1**	**382.8**	**398.2**	**394.1**	**378.2**	**361.3**

4.3.3 Sasol

Sasol has two plants receiving water from the Integrated Vaal River System. The Sasol Secunda Complex's primary source of water is Grootdraai Dam, which will be supported through the Vaal River Eastern Sub-system Augmentation Project (VRESAP) once it is operational in 2008. The Sasol Sasolburg Complex is supplied from Vaal Dam, which is supported from the Thukela-Vaal Transfer Scheme, as well as the Lesotho Highlands Water Project. The water requirements for the two complexes are presented in **Table 4.5** for the indicated years of the planning period. Revised information was received from Sasol after the First Stage Strategy had been completed (received in October 2007). These updated requirements were used in all the planning scenarios, see **Section 7.3** for details.

Table 4.5: Sasol's water requirements for the indicated complexes

Description	Water Requirements (million m^3/annum)					
	2007	**2010**	**2015**	**2020**	**2025**	**2030**
Sasol Secunda Complex(1)	91.0	94.74	107.3	114.8	122.6	130.4
Sasol Sasolburg Complex(2)	27.0	28.9	32.3	35.5	38.9	42.7
Total	**118.0**	**123.7**	**139.7**	**150.2**	**161.5**	**173.2**

Notes: (1) Reference of projection October 2007.

(2) Reference of projection June 2007.

4.3.4 Mittal Steel

Mittal Steel receives its water from Vaal Dam, and in their projections (reference July 2006) they are planning to decrease their current water use from 17.4 million m^3/annum to 16.6 million m^3/annum in 2010, from where onwards it remains constant for the subsequent years of the planning period.

4.4 URBAN WATER REQUIREMENTS AND RETURN FLOWS

4.4.1 Overview

The urban sector represents the largest portion of the systems water use, and in the Gauteng Province substantial increases in the water use occurred historically as a result of the increasing urban population and expanding economic activities. In the Gauteng Growth and Development Strategy, developed by the Gauteng Provincial Government (**Gauteng Province, 2005**), it was shown that the Tertiary Sector constitutes more than 70% of the Gross Geographic Product of the province in 2001, and has continuously increased to this level since 1996. This growth in the Tertiary Sector was at the expense of Secondary and Primary Sectors, indicating that the economy of the Gauteng Province continues to expand into the service sectors where the future water requirements are predominantly driven by the population dynamics in the province.

In the First Stage Strategy the results of the parallel demographic study commissioned by DWAF (by the Directorate: Water Resource Planning) to update the country wide population scenarios were used as indicated in the Terms of Reference of the Reconciliation Study (**DWAF, 2003**).

The parallel study developing the reconciliation strategy for the Crocodile (West) Water Supply System (**DWAF, 2008a**), referred to as the CWRS hereafter, presented two alternative population projections as a basis for estimating the domestic water requirements and return flows for a range of possible future scenarios. These population projections were alternative scenarios and introduced two projections that were respectively higher and lower compared to the scenario applied in the First Stage Reconciliation Strategy.

The revised population scenarios are discussed in the section below with the main focus on the population in the Gauteng Province.

4.4.2 Population projections

The main characteristics and dominant drivers of the three population scenarios are summarised in **Table 4.6**. The Stats SA 2007 projection developed for DWAF (**Stats SA, 2007**) was used as the Base Scenario, which are similar to the scenario applied in First Stage Strategy. Alternative High and Low Scenarios were developed using the Actuarial Association of South Africa (ASSA) Model (**Care, 2006a**).

Table 4.6: Main Characteristics/Drivers associated with Different Future Population Variants

Future Population Variant	Main Characteristics	Dominant Drivers
High	Strong economic growth in Gauteng Effective service delivery Effective HIV/AIDS interventions	Migration increases steadily due to improved employent opportunities and service delivery Increased natural growth due to HIV/AIDS interventions and the cumulative effects of migration
Base (Statistics SA Projection)	“Most likely” conditions based	Extension of current trends
Low	Sluggish economic growth Constrained service delivery HIV/AIDS lowers internal growth rate	Depressed internal growth due to the effects of HIV/AIDS

The Base, Low and High population projections are illustrated graphically in **Figure 4-2**. The population projections are for the Gauteng Province areas predominantly supplied by Rand Water from the Vaal River System. The population projections for the different scenarios are presented in

Table 4.7 showing the projected population as well as the annual compound growth for the indicated planning years.

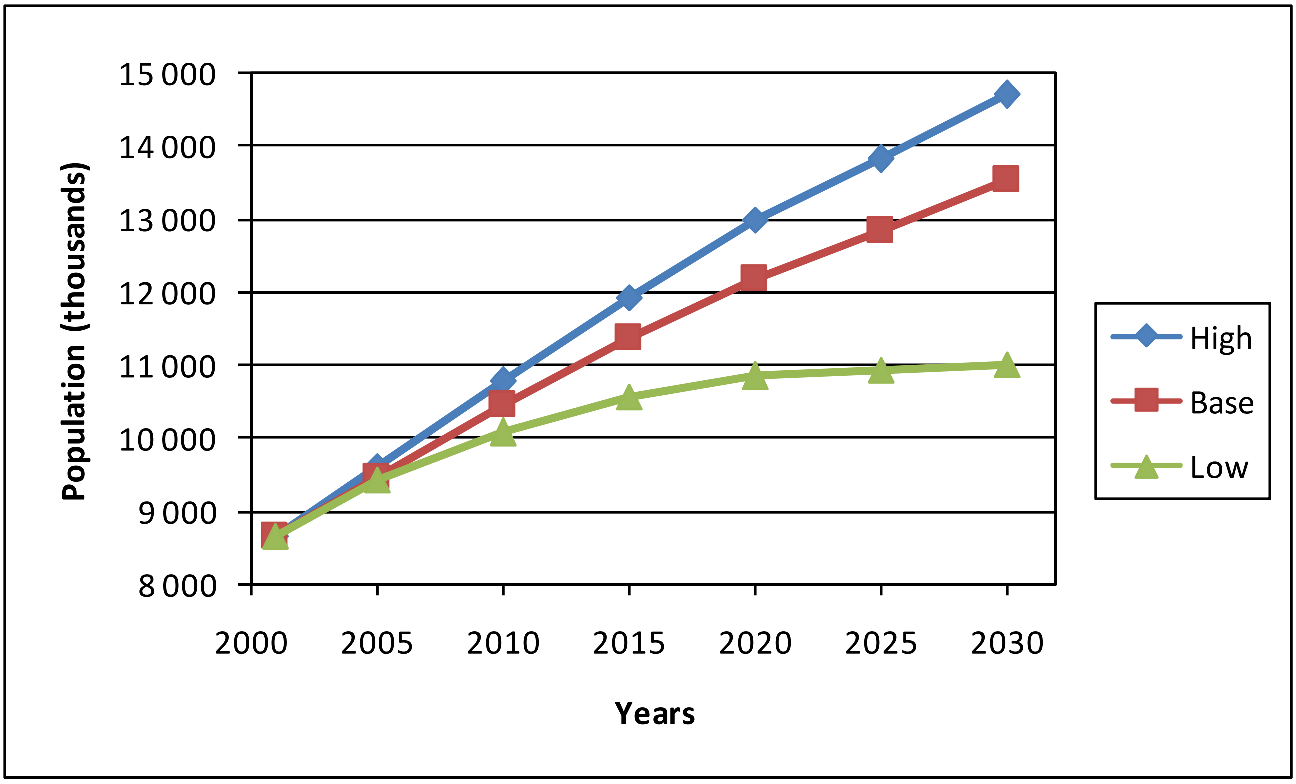


Figure 4-2: Population projections (Gauteng Province)

Table 4.7: Population projections (Gauteng Province)

Description	Planning Years						
	2001	2005	2010	2015	2020	2025	2030
Total Population (in thousands)							
High	8 674	9 614	10 769	11 931	12 988	13 811	14 688
Base	8 674	9 470	10 460	11 364	12 177	12 843	13 548
Low	8 674	9 442	10 074	10 572	10 843	10 927	11 013
Annual Compounded Growth (%)							
High	-	-	2.30	2.07	1.71	1.24	1.24
Base	-	-	2.01	1.67	1.39	1.07	1.07

Low	-	-	1.31	0.97	0.51	0.15	0.15

4.4.3 Water Requirement and Return Flow Scenarios for Rand Water's Supply Area

4.4.3.1 Methodology

The water requirements and return flows for the Rand Water supply area were determined with the Water Requirement and Return Flow Database Model, which was developed for DWAF as part of the Crocodile (West) River Return Flow Assessment Study (**DWAF, 2004e**). The model uses Sewage Drainage Areas as modelling component where a sewer pipe network system collects the wastewater for treatment at waste water treatment works before it is discharged into a river system. There were forty seven Sewage Drainage Areas (SDAs) identified in the Rand Water (Gauteng) supply area, as illustrated graphically in **Figure 4-3,** where the thick black line shows the catchment divide between the northern and southern areas. The wastewater returned in the northern SDAs, contributes to the water resources of the Crocodile (West) River, and those SDAs draining to the south, contributes the Vaal River System. **Table 4.8** lists all the Sewage Drainage Areas in each of the indicated municipal areas.

Table 4.8: List of Sewage Drainage Areas according to municipal areas

Municipality	**Sewage Drainage Areas**	**Number of SDAs**
Ekurhuleni	Waterval, Ancor, Benoni, Carl Grungling, Daveyton, Dekema, Herbert Bickley, Jan Smuts Dam, JP Marais, McComb, Rhynfield, Rondebult, Tsakane, Vlakplaats, Heidelberg, Ratanda, Hartebeestfontein, Olifantsfontein	18
Emfuleni	Sebokeng South, Vanderbijlpark, Sharpville, Vereeniging	4
Johannesburg	Bushkoppies, Olifantsvlei, Goudkoppies, JHB Northern, Driefontein, Ennerdale, Eldorado Park, Sebokeng North	8
Mogale	Percy Stewart, Flip Human	2
Randfontein	Randfontein	1
Tshwane	Baviaanspoort, Zeekoegat, Daspoort, Rooiwal,Rietgat, Temba, Babalegi, Sandspruit, Sunderlandridge, Klipgat, Tolwane, Kutswane, Apies, Remainder – North	14
TOTAL NUMBER OF SEWAGE DRAINAGE AREAS		**47**

The methodology that was followed to compile the water requirements and return flow projection, involved the following steps:

- Populate the data for each SDA in the database model with the revised population scenario data for the years 2001, 2005 and five yearly intervals up to 2030.
- Incorporate land use data, other than housing land use into the database for the SDAs, where it was available.
- Assign water supply meter data of the year 2001 to the SDAs, using GIS area intersection analysis.
- Collate the discharge volume data of the year 2001 from the Waste Water Treatment Works and assign the appropriate data to each SDA.
- Establish the relationships with population and land use by calibrating the model parameters to match the recorded water requirements and return flows for the year 2001.
- A simulation was carried out with the model to generate water requirements for the year 2005 using the parameters as calibrated for the year 2001. The model results were compared against actual water use data for the year 2005 and further adjustments were made to match the 2005 water use.
- Generate the projected water requirements at five year intervals for the planning period up to 2030.
- The above steps were carried out for all 47 sewage drainage areas and the results were incorporated into a spreadsheet database to generate the data required by the Water Resource Planning Model (WRPM).

The Crocodile (West) River Reconciliation Strategy Study (**DWAF, 2008a**) applied the same Water Requirements and Return Flow Database Model (see **Section 3.2** for a description) for the development of the urban water requirement scenarios. Water balances were then compiled for the planning period up to the year 2030 to calculate the required transfer from the Vaal River System through the Rand Water supply system (These transfers are for the Northern Gauteng areas as indicated in **Figure 4-3**). These balance results took into consideration the availability of local resources in the Crocodile (West) River System as well as scenarios with Water Conservation and Water Demand Management measures.

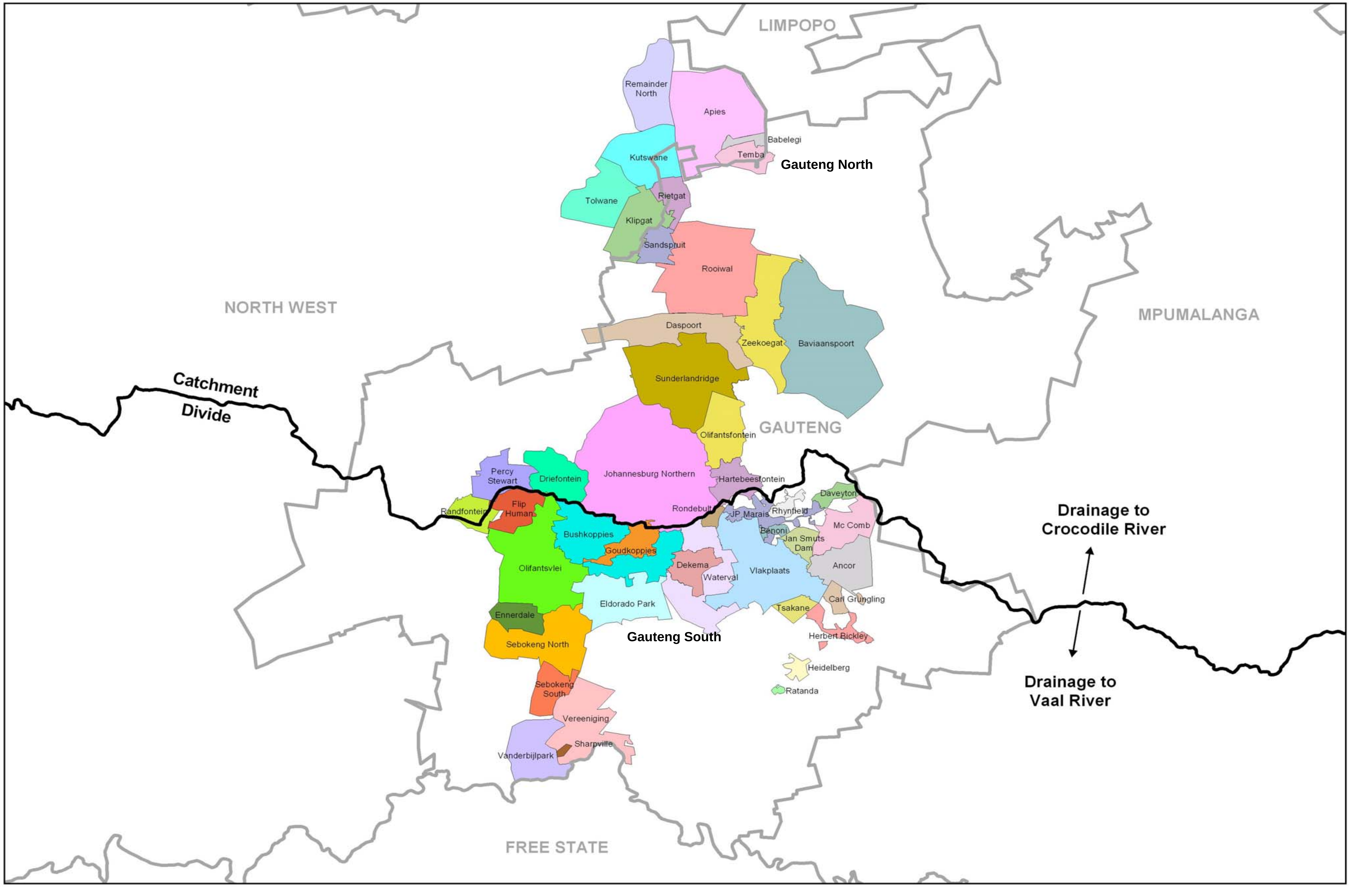


Figure 4-3: Location of the forty seven Sewage Drainage Areas

4.4.3.2 Water requirement and return flow scenarios

The revised population projection scenarios (described in **Section 4.4.2**) were imported into the Water Requirements and Return Flow Database Model, and water requirement and return flow scenarios were generated for the planning period up to the year 2030, according to the steps listed in the previous section. The water requirement projections for the Gauteng North Rand Water supply area were adopted from the CWRS study (see **Section 4.4.3.1**)

A summary of the water requirement projections for the High Population Scenario are presented in **Figure 4-4**, showing the water requirements for each municipality and a remainder component called “Other”. The “Other” component includes water requirements of individual users, including mines, industries and other small municipalities supplied directly by Rand Water. The assumptions for the other users were that they would increase by the same ratio as the water requirements of the municipalities.

It should be noted that for both Rustenburg and Tshwane the water requirements presented in **Figure 4-4** represent the supply from Rand Water and exclude water received from other sources.

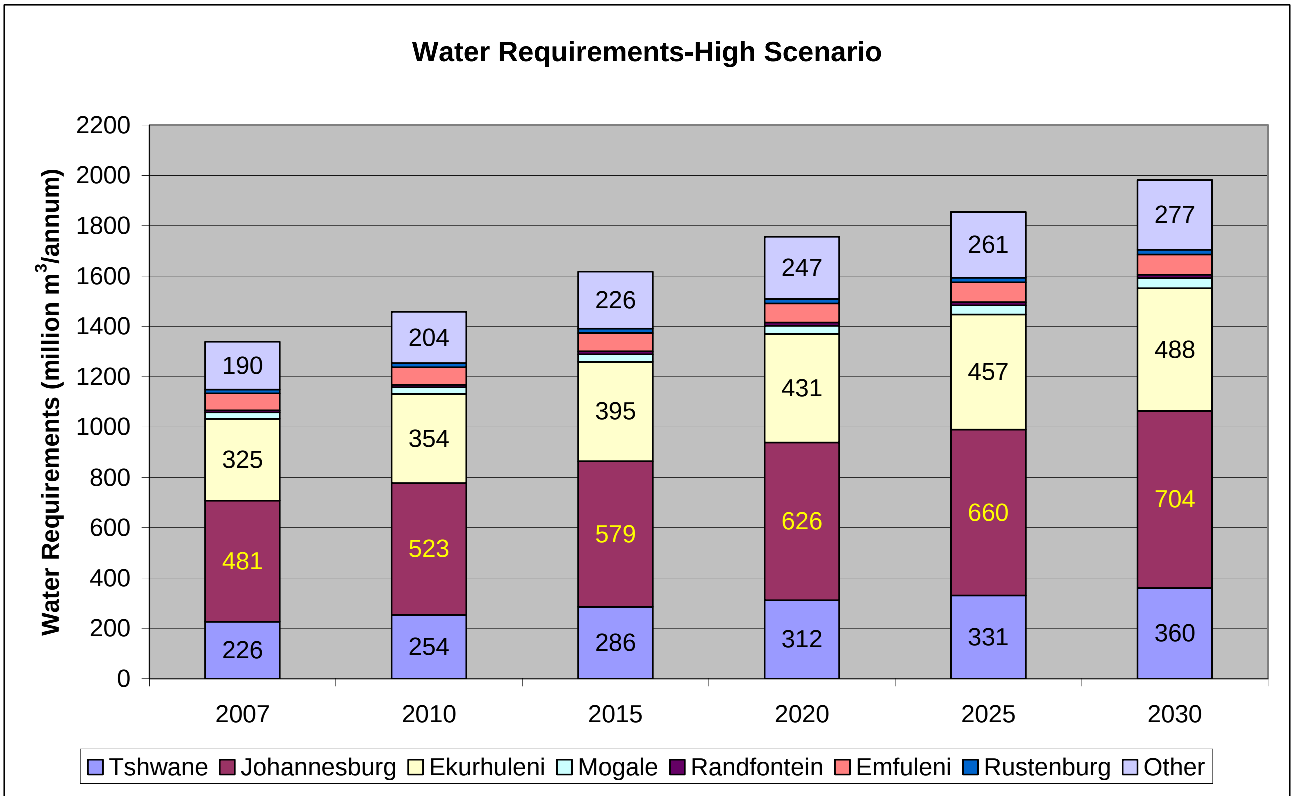


Figure 4-4: Water requirements for the Rand Water supply area (High Population Scenario)

The average annual growth rate of the water requirements between 2007 and 2030 is 1.60% compounded, with a slightly higher growth rate of 1.82% over the first nine years.

The total return flow projections for the High Scenario (southern and northern SDAs) are presented in **Figure 4-5**, indicating an increase from 703 million m^3/annum in 2007 to 1 046 million m^3/annum in the year 2030.

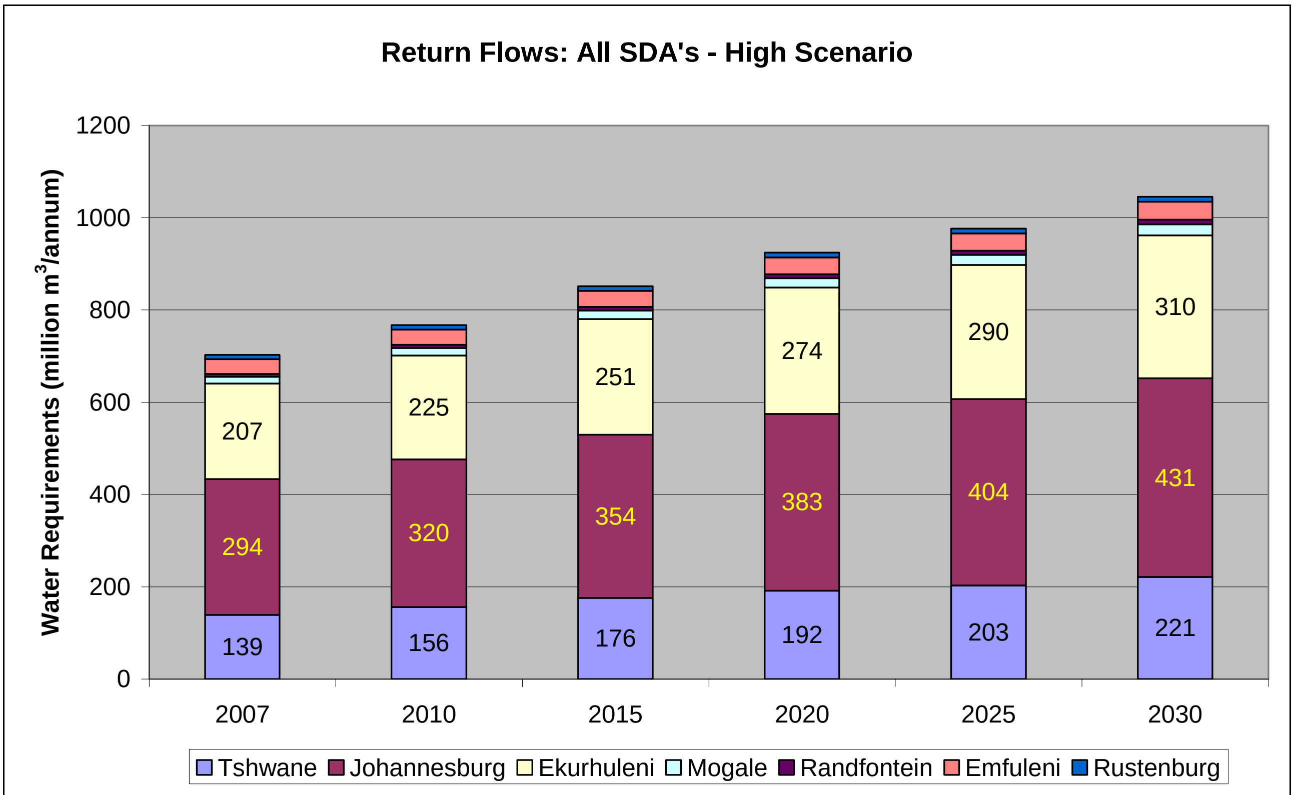


Figure 4-5: Return Flows for the Rand Water supply area (High Population Scenario)

The projection for the return flows contributing to the water resources of the Vaal River System (southern SDAs) is shown in **Figure 4-6** which is expected to increase from 354 million m^3/annum in the year 2007 to about 509 million m^3/annum in the year 2030.

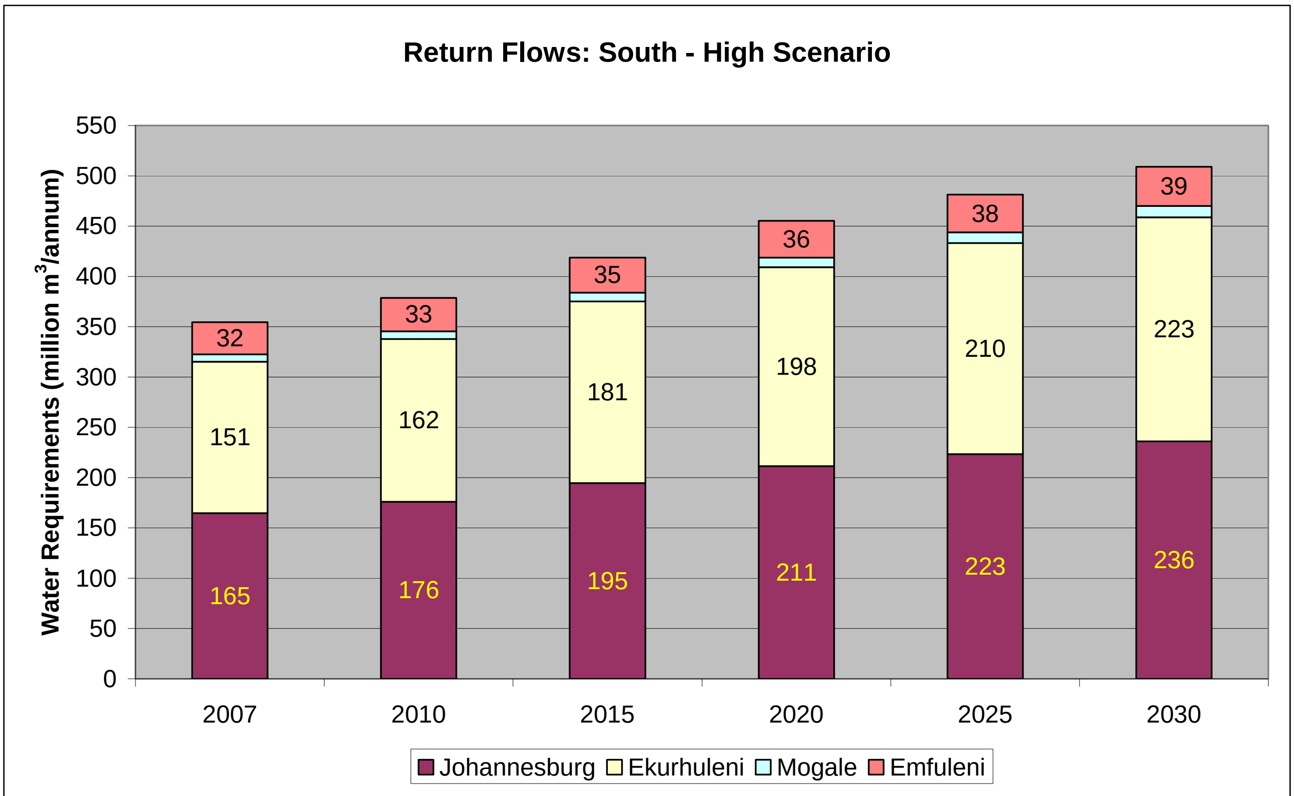


Figure 4-6: Return Flows for the Southern SDAs of the Rand Water supply area (High Scenario)

Following the same methodology as explained for the High Scenario, alternative water requirement and return flow scenarios was developed for the Base Population and Low Population Scenarios. The results of the High, Base and Low Scenarios are illustrated in **Table 4.9**, **Table 4.10** and **Table** 4.11 respectively.

Table 4.9: Water requirement and return flow scenario (High Population Scenario)

Component Descriptions		Planning Years					
		2007	2010	2015	2020	2025	2030
Water Requirements (Supplied by Rand Water)	Northern Municipalities	566	632	704	763	805	872
	Southern Municipalities	583	622	687	746	788	833
	Other users	204	192	201	237	262	274
	Total	**1353**	**1446**	**1592**	**1746**	**1855**	**1979**
	Portion North	49.3%	50.4%	50.6%	50.6%	50.5%	51.2%
	Portion South	50.7%	49.6%	49.4%	49.4%	49.5%	48.8%
Return Flows (From all municipalities)	Northern Municipalities	348	389	433	469	495	537
	Southern Municipalities	354	379	419	455	481	509
	Total	**703**	**767**	**852**	**925**	**977**	**1046**
	Portion North	49.5%	50.7%	50.8%	50.8%	50.7%	51.3%
	Portion South	50.5%	49.3%	49.2%	49.2%	49.3%	48.7%

Notes: (1) All volumetric values are given in million m^3/annum.

Table 4.10: Water requirement and return flow scenario (Base Population Scenario)

Component Descriptions		Planning Years					
		2007	2010	2015	2020	2025	2030
Water Requirements (Supplied by Rand Water)	Northern Municipalities	537	600	664	718	761	821
	Southern Municipalities	556	602	644	688	722	755
	Other users	182	197	212	228	239	251
	Total	**1275**	**1399**	**1521**	**1634**	**1723**	**1827**
	Portion North	49.2%	49.9%	50.8%	51.1%	51.3%	52.1%
	Portion South	50.8%	50.1%	49.2%	48.9%	48.7%	47.9%
Return Flows (From all municipalities)	Northern Municipalities	339	370	414	448	474	512
	Southern Municipalities	347	367	398	426	446	468
	Total	**686**	**737**	**812**	**874**	**921**	**980**
	Portion North	49.4%	50.2%	51.0%	51.3%	51.5%	52.2%
	Portion South	50.6%	49.8%	49.0%	48.7%	48.5%	47.8%

Notes: (2) All volumetric values are given in million m^3/annum.

Table 4.11: Water requirement and return flow scenario (Low Population Scenario)

Component Descriptions		Planning Years					
		2007	2010	2015	2020	2025	2030
Water Requirements (Supplied by Rand Water)	Northern Municipalities	529	584	614	639	650	672
	Southern Municipalities	546	578	606	620	621	621
	Other users	179	189	200	205	206	207
	Total	**1 254**	**1 352**	**1 420**	**1 464**	**1 477**	**1 500**
	Portion North	49.2%	50.3%	50.3%	50.8%	51.1%	51.9%
	Portion South	50.8%	49.7%	49.7%	49.2%	48.9%	48.1%
Return Flows (From all municipalities)	Northern Municipalities	334	362	380	395	401	415
	Southern Municipalities	341	354	371	380	381	382
	Total	**675**	**716**	**751**	**775**	**782**	**797**
	Portion North	49.5%	50.5%	50.6%	51.0%	51.3%	52.1%
	Portion South	50.5%	49.5%	49.4%	49.0%	48.7%	47.9%

Notes: (3) All volumetric values are given in million m^3/annum.

4.4.4 Sedibeng Water

Sedibeng Water is the bulk service provider and receives water from the Vaal River System from two abstraction locations. The first is Balkfontein on the Vaal River and, the second, from Allemanskraal Dam at their Virginia Works. The water use in their supply area has decreased historically, mainly due to the declining mining activity in the region. Sedibeng Water provided projections in April 2007, which indicated that their water requirement will increase from 56 million m^3/annum in the year 2006 to 64 million m^3/annum in the year 2030. The portion of their total water use to be supplied from their Virginia Works (Allemanskraal Dam) is constant over the planning period at 15.2 million m^3/annum and is equal to their allocation from the resource.

4.4.5 MidVaal Water Company

Midvaal Water Co treats and supplies water to users in the Klerksdorp, Orkney, Stilfontein and Hartbeesfontein (KOSH) areas and has experienced a decline in water use, mainly due to the closing of several mining operations. Projections for Midvaal Water Co were received from them in May 2007, indicating that their water use will remain constant at 37 million m^3/annum over the planning period.

4.4.6 Other urban areas

The projections for all the other urban areas receiving water from the Vaal River System were determined, using the growth rates from the National Water Resource Strategy (NWRS). Where actual water use data was available, the starting point (volume for the first year in the projection) was adjusted to match the actual value on which the future growths were applied. In total, the water requirement in the year 2006 is projected to be 161 million m^3/annum for this group, and increases to 190 million m^3/annum in the year 2030.

4.5 SUMMARY OF WATER REQUIREMENT AND RETURN FLOW SCENARIOS

Combining all the water requirements and return flows of all the sectors from the information of the previous sections, and including other components such as losses and mine dewatering, provides the summary of gross and net system demands for each of the scenarios. The water requirements for the Northern Gauteng area included in the subsequent tables were obtained from the water balances of the Crocodile (West) River System Reconciliation Strategy Study and represent the potable water transfers from the Vaal to Crocodile systems through the Rand Water supply system.

In addition to the potable water transfer it was established that additional raw water is required to reconcile the future water requirements in the Crocodile (West) River System, see **Chapter 6** for a description of the raw water transfer requirements.

Table 4.12, Table 4.13 and **Table 4.14** present the summarised information for the **High, Base** and **Low Population Scenarios** respectively. Due to the excess water in the system downstream of Vaal Barrage (see **Section 7.6.1** for details) it was required to exclude a portion of the return flows above a certain threshold from the calculation of the system's net water requirements. Furthermore, the tables exclude the volume required for raw water transfer to the Crocodile (West) River System. This transfer will be supplied from the excess water and therefore represents a reduction in the excess and does not influence the net water demand of the system.

Therefore only a portion of the total southern return flows shown in **Table 4.9**, **Table 4.10** and **Table 4.11** contribute to the net water requirements and the remainder forms part of the excess in the lower part of the system. The return flows volumes excluded from the net demand calculation are shown in the last row of each table in **Table 4.12**, **Table 4.13** and **Table 4.14** respectively. Graphs of the net system water requirements are presented in **Figure 7-1** and discussed in **Section 7.3.6.**

Table 4.12: Summary of water requirements and return flows (High Population Scenario)

Water users	Planning years					
	2007	**2010**	**2015**	**2020**	**2025**	**2030**
Water Requirements						
Rand Water (South)	787	814	888	983	1 050	1 107
Rand Water (North)	566	632	704	763	805	872
Mittal Steel	17	17	17	17	17	17
ESKOM (2)	349	402	418	413	398	381
SASOL (Sasolburg)	25	27	30	33	37	41
SASOL (Secunda)	91	95	107	115	123	130
Midvaal Water Company	37	37	37	37	37	37
Sedibeng Water (Balkfontein only)	59	45	46	47	48	49
Other towns and industries	168	185	188	189	189	190
Vaalharts/Lower Vaal irrigation	542	542	542	542	542	542
Other irrigation (adjusted for updated lawful irr.)	668	550	471	471	471	471
Wetland / River Losses	325	326	327	329	330	331
Return Flows						
Southern Gauteng (Rand Water)	331	315	317	337	351	366
Midvaal Water Company	1	1	1	1	1	1
Sedibeng Water	2	2	2	2	2	2
Other towns and industries	63	65	69	73	76	81
Irrigation	68	52	43	43	43	43
Mine dewatering	116	109	126	128	126	126
Increased urban runoff	101	103	107	113	121	129
OVERALL GROSS SYSTEM DEMAND:	**3 634**	**3 671**	**3 775**	**3 938**	**4 046**	**4 168**
OVERALL NET SYSTEM DEMAND:	**2 952**	**3 024**	**3 111**	**3 241**	**3 326**	**3 420**
Portion of Southern Gauteng Return Flow excluded from net demand calculation. (Contribution to lower Vaal excess)	23	63	102	118	130	143

Notes: (1) *All volumetric values are given in million m^3/annum.*

(2) *Includes 3rd party users.*

Table 4.13: Summary of water requirements and return flows (Base Population Scenario)

Water users	Planning years					
	2007	2010	2015	2020	2025	2030
Water Requirements						
Rand Water (South)	738	799	857	916	961	1 007
Rand Water (North)	537	600	664	718	761	821
Mittal Steel	17	17	17	17	17	17
ESKOM (2)	349	402	418	413	398	381
SASOL (Sasolburg)	25	27	30	33	37	41
SASOL (Secunda)	91	95	107	115	123	130
Midvaal Water Company	37	37	37	37	37	37
Sedibeng Water (Balkfontein only)	59	45	46	47	48	49
Other towns and industries	168	185	188	189	189	190
Vaalharts/Lower Vaal irrigation	542	542	542	542	542	542
Other irrigation (adjusted for updated lawful irr.)	668	550	471	471	471	471
Wetland / River Losses	325	326	327	329	330	331
Return Flows						
Southern Gauteng (Rand Water)	331	315	317	337	351	366
Midvaal Water Company	1	1	1	1	1	1
Sedibeng Water	2	2	2	2	2	2
Other towns and industries	63	65	69	73	76	81
Irrigation	68	52	43	43	43	43
Mine dewatering	116	109	126	128	126	126
Increased urban runoff	101	103	107	113	121	129
OVERALL GROSS SYSTEM DEMAND:	**3 557**	**3 624**	**3 704**	**3 827**	**3 914**	**4 016**
OVERALL NET SYSTEM DEMAND:	**2 874**	**2 977**	**3 040**	**3 129**	**3 194**	**3 268**
Portion of Southern Gauteng Return Flow excluded from net demand calculation. (Contribution to lower Vaal excess)	16	52	82	89	95	102

Notes: (1) *All volumetric values are given in million m^3/annum*

(2) *Includes 3rd party users.*

Table 4.14: Summary of water requirements and return flows (Low Population Scenario)

Water users	Planning years					
	2007	2010	2015	2020	2025	2030
Water Requirements						
Rand Water (South)	725	767	806	825	828	828
Rand Water (North)	529	584	614	639	650	672
Mittal Steel	17	17	17	17	17	17
ESKOM (2)	349	402	418	413	398	381
SASOL (Sasolburg)	25	27	30	33	37	41
SASOL (Secunda)	91	95	107	115	123	130
Midvaal Water Company	37	37	37	37	37	37
Sedibeng Water (Balkfontein only)	59	45	46	47	48	49
Other towns and industries	168	185	188	189	189	190
Vaalharts/Lower Vaal irrigation	542	542	542	542	542	542
Other irrigation (adjusted for updated lawful irr.)	668	550	471	471	471	471
Wetland / River Losses	325	326	327	329	330	331
Return Flows						
Southern Gauteng (Rand Water)	331	315	317	337	351	366
Midvaal Water Company	1	1	1	1	1	1
Sedibeng Water	2	2	2	2	2	2
Other towns and industries	63	65	69	73	76	81
Irrigation	68	52	43	43	43	43
Mine dewatering	116	109	126	128	126	126
Increased urban runoff	101	103	107	113	121	129
OVERALL GROSS SYSTEM DEMAND:	**3 535**	**3 577**	**3 603**	**3 657**	**3 668**	**3 688**
OVERALL NET SYSTEM DEMAND:	**2 853**	**2 930**	**2 939**	**2 960**	**2 948**	**2 941**
Portion of Southern Gauteng Return Flow excluded from net demand calculation. (Contribution to lower Vaal excess)	10	39	54	43	30	16

Notes: *(1) All volumetric values are given in million m^3/annum*

(2) Includes 3rd party users.

CHAPTER 5. WATER CONSERVATION AND WATER DEMAND MANAGEMENT SCENARIOS

5.1 OVERVIEW

Three saving scenarios were compiled from the assessment of the potential for water conservation and water demand management (WC/WDM) in the urban sector and were labelled **Scenarios C**, **D** and **E** respectively as documented in the *Potential Savings through WC/WDM in the Upper and Middle Vaal Water Management Areas* report compiled as part of this study. A brief description of the scenarios and the potential savings are presented in **Sections 5.2**. **Section 5.3** presents and assessment of the status of WC/WDM by comparing the actual water use with the projections. The final section of this chapter provides pertinent conclusions and recommendations relating to the findings of the Water Conservation and Water Demand Management study.

5.2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM) POTENTIAL SAVING SCENARIOS

5.2.1 Scenario description

*5.2.1.1 **Scenario C**: 5 Years water loss programme and efficiency improvement measures (referenced as the 30% saving scenario)*

This scenario assumed that the water losses can be controlled within the 5 years (2006 to 2010) and maintained afterwards as well as the implementation of water use efficiency by targeting the billed consumption. In addition to the loss management measures it was assumed that a 1% per annum efficiency can be gained from the year 2015 onwards for the entire planning period, applied to the large urban users that were assessed in the study.

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

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

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

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

*5.2.1.2 **Scenario D**: Reduction in wastage over 5 years (referenced as the 15% saving scenario)*

- Water losses can be controlled within the 5 years (2006 to 2010) and maintained afterwards (same as for Scenario C).
- No water use efficiency is introduced.

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

*5.2.1.3 **Scenario E**: Reduction in wastage over 10 years*

- Water losses can be controlled within 10 years (2006 to 2015) and maintained afterwards.
- No water use efficiency is introduced.

Scenario E is basically the same as **Scenario D** and only addresses the reduction in wastage. This scenario, however, assumes that certain actions can only be implemented over a period of 10 years, which is considered to be more easily achievable than **Scenario D,** based on practical experience gained by the project team from many WC/WDM projects.

The savings for **Scenario E** are the same as for **Scenario D**, with the exception that they are achieved over a 10 year period as opposed to a 5 year period as with **Scenario D**. **Scenario E** was not investigated further.

5.2.2 Potential savings and net system water requirements

The potential savings in water use of the urban sector were applied to the water requirement scenarios described in **Section 4.5** respectively and the summarised total system net water requirements are presented in **Tables 5.1** to **5.4.** The scenario combinations selected from the population and saving scenarios were defined in conjunction with the Crocodile (West) Reconciliation Strategy Study and covers an envelope of realistic possible future conditions. The potential savings in the water requirements are presented in **Row b** of each of the tables. **Row c** provides the total system net water requirement with the potential savings included.

Only a portion of the total southern return flows contribute to the net water requirements and the remainder forms part of the excess in the lower part of the system. With the High and Base water requirement scenarios, the WC/WDM measures applied to these scenarios result in a reduction in the excess in the lower part of the system and no adjustment is made to the net water with respect to the change in return flows. For the Low water requirement scenario however, there is minimal excess in the lower part of the system and the WC/WDM measures applied to the scenario thus result in a reduction in the return flows that reduces the net water requirements (**Row c** in **Table 5.4**).This needs to be accounted for in the net water requirements and the overall net reduction is determined in **Row d** of the same table, and **Row e** provides the total system net water requirement for the scenario.

Table 5.1: Savings and system net water requirements for WC/WDM Scenario C and High Population Scenario

Component description	Row	Calculation or Reference	Planning Years					
			2007	2010	2015	2020	2025	2030
Net system demand for **High Scenario**	a	From **Table 4.12**	2 952	3 024	3 111	3 241	3 326	3 420
Reduction in Water Requirements **Sc. C**	b	Assessment	0	185	282	351	402	402
System net demand **Sc. C**	c	(a-b)	2 952	2 840	2 829	2 890	2 925	3 019

Notes: (1) *All volumetric values are given in million m^3/annum.*

Table 5.2: Savings and system net water requirements for WC/WDM Scenario D and High Population Scenario

Component description	Row	Calculation or Reference	Planning Years					
			2007	2010	2015	2020	2025	2030
Net system demand for **High Scenario**	a	From **Table 4.12**	2 952	3 024	3 111	3 241	3 326	3 420
Reduction in Water Requirements **Sc. D**	b	Assessment	0	180	191	204	217	217
Net system demand **Sc. D**	c	(a-b)	2 952	2 844	2 920	3 037	3 109	3 204

Notes: (1) *All volumetric values are given in million m^3/annum.*

Table 5.3: Savings and system net water requirements for WC/WDM Scenario D and Base Population Scenario

Component description	Row	Calculation or Reference	Planning Years					
			2007	2010	2015	2020	2025	2030
Net system demand for **Base Scenario**	a	From **Table 4.13**	2 874	2 977	3 040	3 129	3 194	3 268
Reduction in Water Requirements **Sc. D**	b	Assessment	0	180	191	204	217	217
Net system demand **Sc. D**	c	(a-b)	2 874	2 796	2 848	2 926	2 977	3 052

Notes: (1) All volumetric values are given in million m^3/annum.

Table 5.4: Savings and system net water requirements for WC/WDM Scenario D and Low Population Scenario

Component description	Row	Calculation or Reference	Planning Years					
			2007	2010	2015	2020	2025	2030
Net system demand for **Low Scenario**	a	From **Table 4.13**	2 853	2 930	2 939	2 960	2 948	2 941
Reduction in Water Requirements **Sc. D**	b	Assessment	0	180	191	204	217	217
Reduction in Southern SDA Return Flows **Sc. D**	c	Assessment	0	27	13	32	50	72
Net reduction **Sc. D**	d	(b-c)	0	154	178	172	166	145
Net system demand **Sc. D**	c	(a-d)	2 853	2 776	2 761	2 788	2 782	2 796

Notes: (1) All volumetric values are given in million m^3/annum.

It should be noted that the savings indicated in the above four tables are less than the total savings presented in the report "*Potential Savings through WC/WDM in the Upper and Middle Vaal Water Management Areas" (***DWAF, 2006b***).* This is a report that was produced from a joint study by the Directorates: Water Use Efficiency and National Water Resource Planning, (see **Chapter 1** for a description of the various studies that were carried out in parallel by DWAF). This difference is due to the assumptions made regarding the utilisation of “own sources”, which are alternative sources of water to those of the Vaal River System.

5.2.3 Summary and comparisons for the Rand Water Supply Area

Due to the importance of the water requirements of the Rand Water supply area, a summary of the alternative water requirement scenarios for Rand Water are presented graphically in **Figure 5-1**.

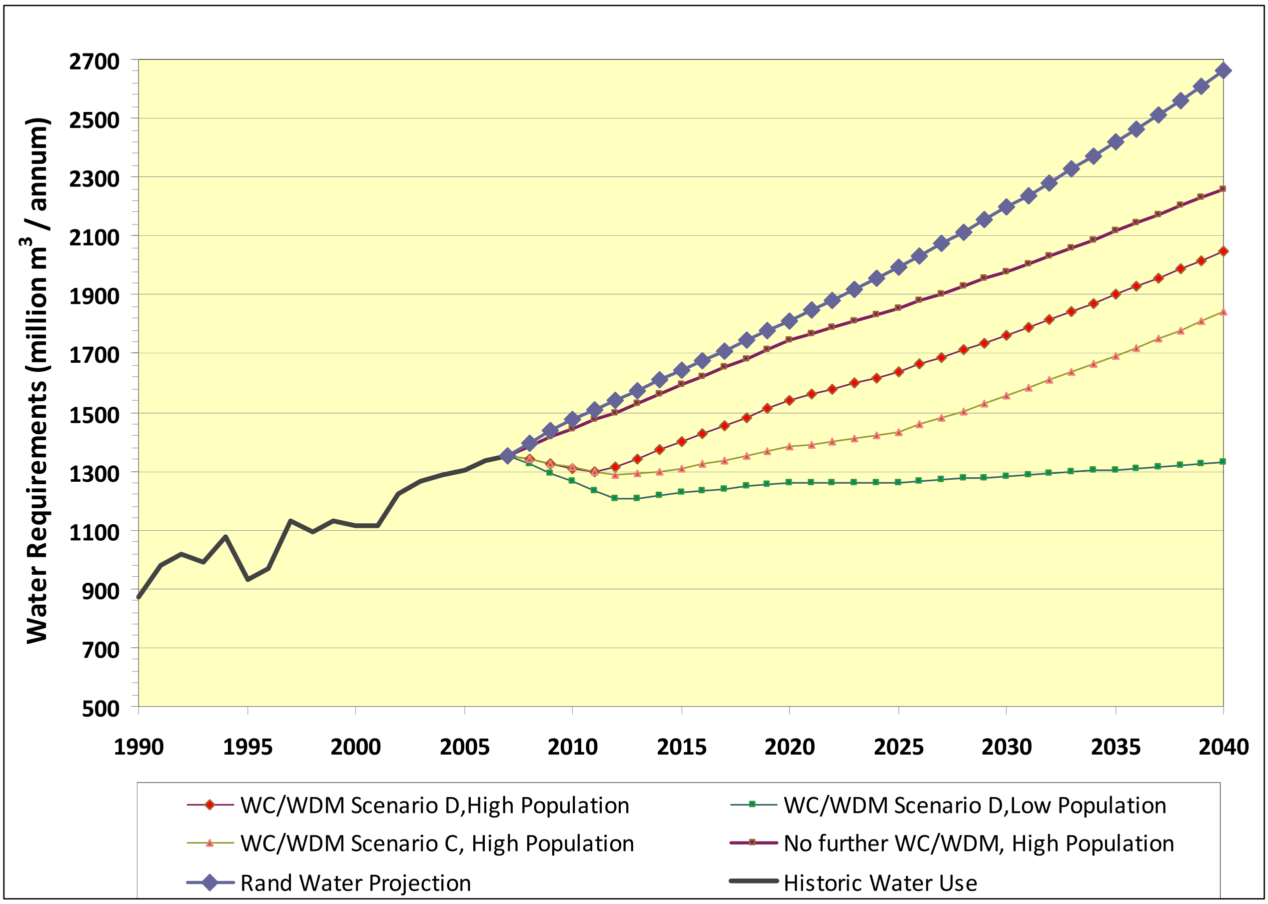


Figure 5-1: Summary of water requirement scenarios for the Rand Water Supply Area

These water requirements and return flows were used to compile the planning scenarios, which are presented in **Section 7.3**

5.3 WATER CONSERVATION AND DEMAND MANAGEMENT STATUS

During the second half of 2008 comparisons of the actual water use against the projections were carried out for the three main metropolitan municipalities in the study area, namely the Ekurhuleni, Tshwane and Johannesburg Metropolitan Municipalities and are illustrated in **Figure 5-2**, **Figure**

5-3 and **Figure 5-4** respectively. The water requirement projections are in each case illustrated for four scenarios and the actual water use until April 2008. The scenarios were as indicated below:

- No further WC/WDM Scenario.
- WC/WDM Scenario C (5 Years water loss programme and efficiency improvement measures).
- WC/WDM Scenario D (5 Years water loss programme).
- WC/WDM Scenario E (10 Years water loss programme).

All the water use scenarios were based on the High Population Scenario.

The Ekurhuleni Metropolitan Municipality has advanced with WC/WDM activities with the main focus on metering and billing, which has resulted in the water use stabilising over the past year (**Figure 5-2**). The Ekurhuleni Municipality will however need to embark on a major WC/WDM programme in order to achieve the potential savings illustrated by the WC/WDM scenarios.

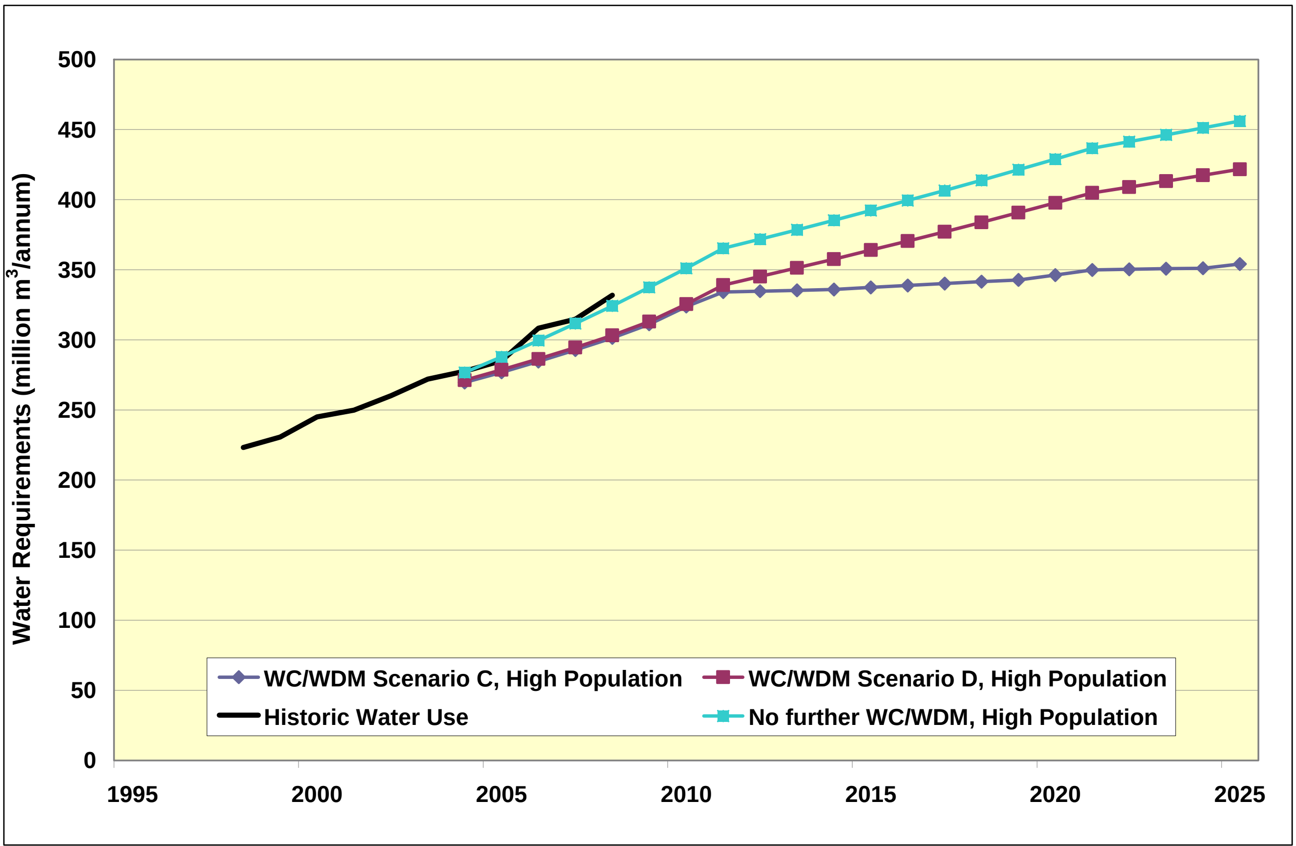


Figure 5-2: Ekurhuleni water requirement scenarios compared to actual use

The City of Tshwane Metropolitan Municipality has developed a strategy for a WC/WDM programme and commenced with improved metering and billing. The municipality needs to embark on a major WC/WDM programme based on the strategy developed for the municipality. The water use reduction in the 2007 period (**Figure 5-3**) was mainly due to the implementation of tariff increases and high rainfall.

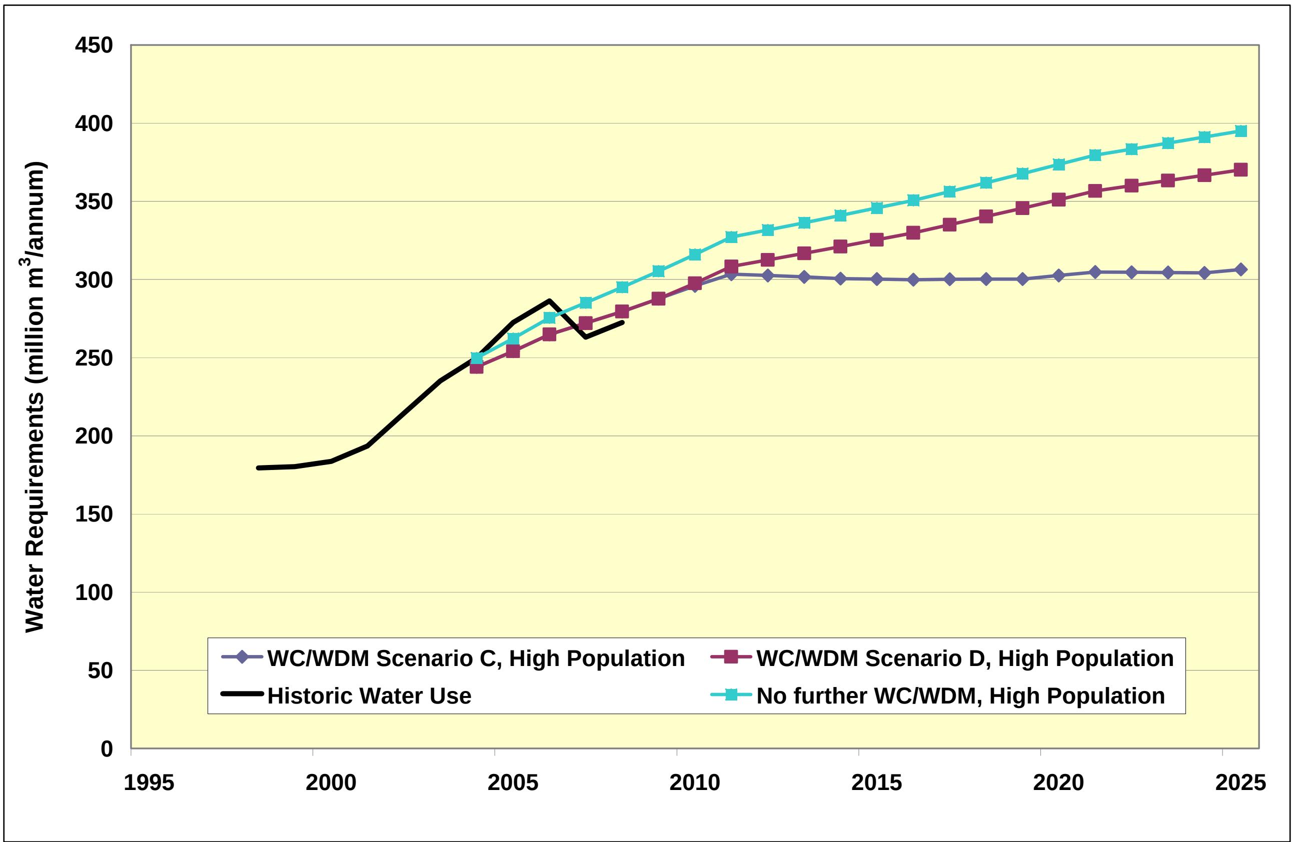


Figure 5-3: City of Tshwane water requirement scenarios compared to actual use (incl. other sources)

The Johannesburg Metropolitan Municipality has focus on metering and billing and commenced with operation Gcin'Amanzi, which includes the installation of 170 000 pre-paid meters with extensive reticulation upgrades. Results are being achieved through the project as illustrated in **Figure 5-4**, where a reduction in water use in the year 2007 is shown.

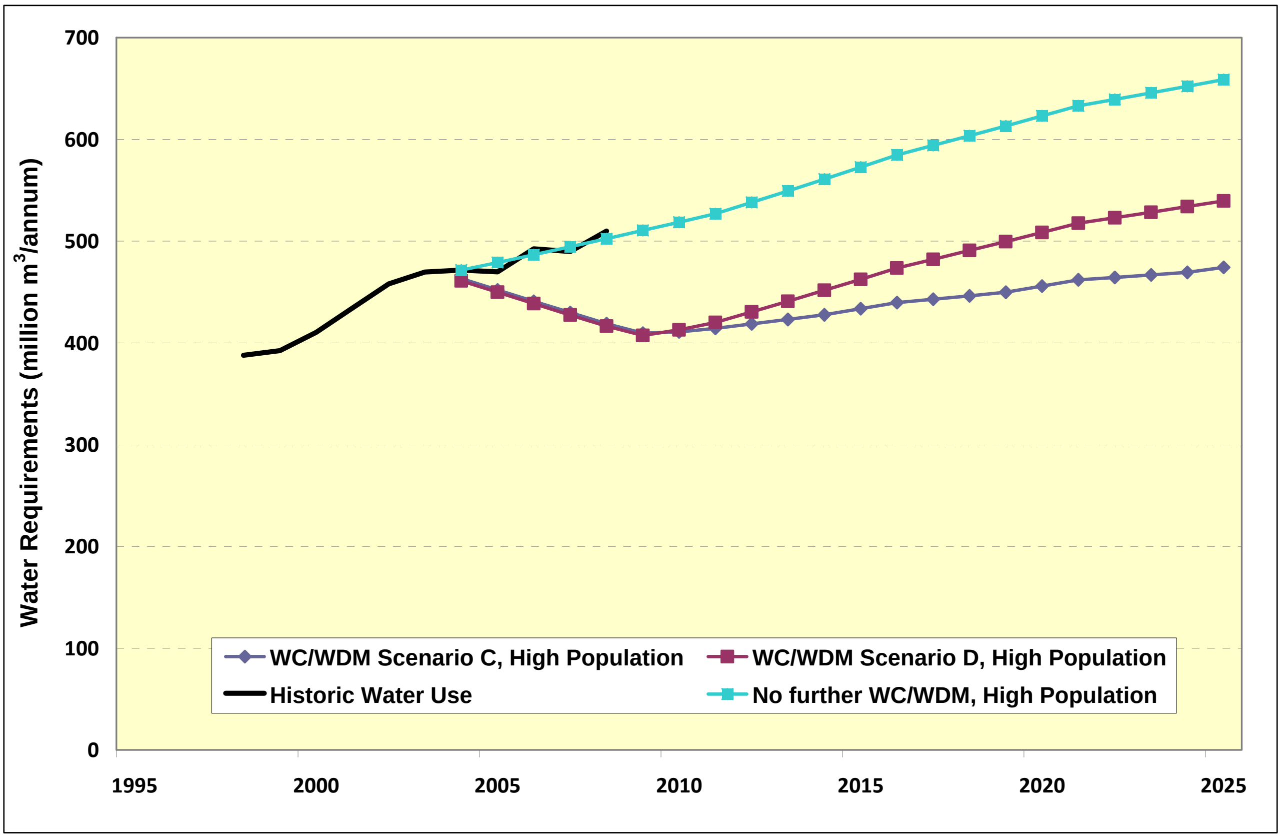


Figure 5-4: Johannesburg water requirement scenarios compared to actual use

The water requirement projections for Rand Water are illustrated in **Figure 5-5**. The actual water use projection is similar to the water requirement projection where WC/WDM initiatives are excluded, in the 2007 period.

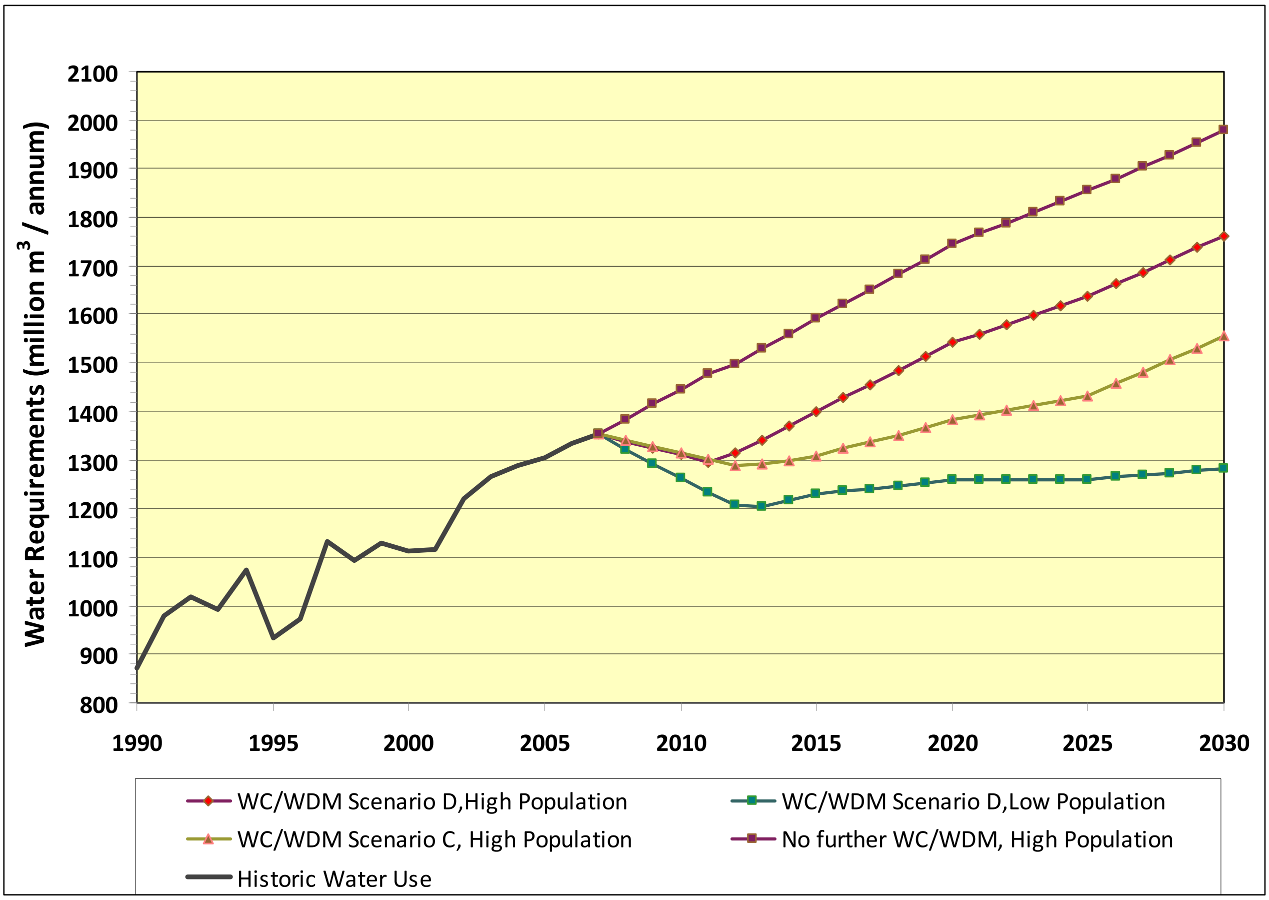


Figure 5-5: Rand Water, water requirement scenarios compared to actual use

5.4 WC/WDM RELATED CONCLUSIONS AND RECOMMENDATIONS

From the assessment of the scope for WC/WDM several key issues were identified, from which the following conclusions and recommendations were made:

- WC/WDM can provide a significant reduction in the water demands in the study area, if the measures are implemented properly and maintained indefinitely. The cost of implementing WC/WDM measures is often less that the maintenance costs, which are often overlooked, with the result that the WC/WDM interventions fail within a year or two of being implemented.
- WC/WDM can be effective and sustainable as has been shown by several large projects undertaken in the study area, including:
    - The Sebokeng/Evaton pressure management project.
    - The Soweto leak repair, retrofitting and pre-paid metering project.
    - The Kagiso pre-paid metering project.
- Garden irrigation, using potable water, is a huge problem issue in many low income areas where indiscriminate use of hosepipes and potable water is creating both supply and pressure problems. The use of hosepipes must be either banned completely in such areas,

or the use restricted to an hour or two every 2nd day during off-peak periods. Irrigation during the hottest part of the day (from 10h00 to 18h00) should be prohibited simply on efficiency grounds.

- Government Departments must co-ordinate their efforts with regard to WC/WDM. The efforts of DWAF, where the Department is spending large budgets to educate consumers on the evils of hosepipe irrigation, is being undermined by the efforts of the Department of Agriculture, as they are providing free hosepipes to the same consumers to grow vegetables. Those wishing to grow vegetables in such areas should be provided with buckets or watering cans, which can still be used with good effect without causing the system problems mentioned previously. Alternatively, roof tanks should be provided to capture rainwater, which is ideal for such irrigation.
- DWAF should encourage WDM activities – e.g. fund projects like Sebokeng, provide subsidies for roof tanks and low flush toilets, etc. The Department should not encourage use of low quality fixtures in township retrofitting projects and should rather use the highest quality pipes, meters and fittings for poor areas, since the taps and toilets in these areas experience highest use and lower quality fittings will not last.
- Lack of maintenance will result in many systems deteriorating into intermittent supply if action is not taken quickly – particularly in township systems where lack of maintenance has occurred over past 30 years.
- Municipalities should be encouraged to combine technical and financial services into a single unit, – current trend of separate billing/treasury from water supply/technical is causing major problems, and a proper water audit is often not possible, since the split between Real and Apparent losses cannot be established with confidence.

Given the results of the comparisons and based on qualitative knowledge of the initiatives undertaken by the municipalities, the following conclusions and recommendations are made:

- The current WC/WDM initiatives are not sufficient for achieving the possible projected savings.

- It was found that the municipalities generally have insufficient budget allocation for their WC/WDM programmes (approximately 20% of the required budget is allocated to WC/WDM measures).

- The major backlog in maintenance and operations of the water supply infrastructure in certain municipalities prevents the implementation of WC/WDM initiatives.

- Metering and billing issues will generally not be resolved in the near future and a different approach is required.
- The metropolitan municipalities are embarking on major WC/WDM programmes.
- Smaller municipalities require significant support at all levels (financial, human resources, logistics, political)
- Major customer awareness programmes are required and could be regarded as an initiative with possibly the biggest potential.

CHAPTER 6. TRANSFER TO CROCODILE (WEST) SYSTEM AND LEPHALALE AREA

In addition to the potable water transfer from the Vaal to the Crocodile (West) River System, which takes place via the Rand Water Supply System, the Crocodile (West) River Reconciliation Strategy (**DWAF, 2008a**) showed that additional raw water transfer will be required in future. The need for this transfer arose from the planned developments of energy industries to be located on the coal fields of the Lephalale Area. The planned developments include several power stations to be implemented by Eskom as well as the possibility of a Coal to Liquid (CTL) plants for Sasol.

Water balances of the water requirements for the current water users and the planned industries in the Lephalale Area indicated that the water resources of the Mokolo River require augmentation. The DWAF has identified that the only source of water to augment the Mokolo River System is the Crocodile (West) River System and has commissioned a feasibility study to determine the most beneficial solution to convey water from the Crocodile (West) River to the Lephalale Area. This transfer scheme will utilise any surplus water in the Crocodile (West) River System, which originates from increased return flows that are generated from the growing urban areas to be supplied mainly by Rand Water from the Vaal River System.

As discussed in **Chapter 4,** scenarios of future water requirements and return flows were derived and synchronised for the Crocodile and Vaal River Systems. It was recognised that scenarios for WC/WDM interventions influences the water balances and combinations of possible future outcomes were compiled for consideration and development of reconciliation options.

To this end, eight alternative water requirement scenarios were formulated for possible future water requirements in the Lephalale Area as presented in **Table 6.1**. The first four scenarios in **Table 6.1** assumed the proposed Coal to Liquid (CTL) plants and associated developments will not be implemented in the Lephalale Area. In these instances the proposed CTL plants will be developed in the Free State and will receive water from the Vaal River, most likely downstream of Vaal Barrage. **Scenarios 5** to **8**, are respectively the same developments for the Eskom power stations (as for **Scenarios 1** to **4**), however, in these scenarios it is assumed the proposed CTL plants will be developed in the Lephalale Area.

Table 6.1: Lephalale water requirement scenarios

Scenario	Description
Scenario 1	Matimba power station (existing technology), Medupi power station (existing technology), Exxaro supply coal for two power stations, Lephalale town for two power stations
Scenario 2	Matimba power station (existing technology), Medupi power station with flue gas desulphurisation (FGD), 1 additional new power station with FGD technology, coal supply to 3 power stations, Lephalale town for 3 power stations
Scenario 3	Matimba power station (existing technology), Medupi power station with FGD technology, 1 additional new power station with FGD technology, 2 additional new power stations with fluidised bed combustion (FBC), coal supply to 5 power stations, Lephalale town for 5 power stations
Scenario 4	Matimba power station (existing technology), Medupi power station with FGD technology, 3 additional new power stations with FGD, coal supply to 5 power stations, Lephalale town for 5 power stations
Scenario 5	Scenario 1 + Sasol (Coal to Liquid Plants) + mine + township
Scenario 6	Scenario 2 + Sasol (Coal to Liquid Plants) + mine + township
Scenario 7	Scenario 3 + Sasol (Coal to Liquid Plants) + mine + township
Scenario 8	Scenario 4 + Sasol (Coal to Liquid Plants) + mine + township

The water available from the Crocodile (West) River System to supply the above describe water transfer to the Lephalale Area (and its own water users) is dependant on the water requirement scenario (driven by the population growth scenario) as well as the assumed Water Conservation and Water Demand Management interventions. Considering all these variables a large number of possible combination scenarios (total of 96) arose, which encompasses the three population scenarios (High, Base and Low – see **Section 4.4.2**), the four WC/WDM scenarios [including the no WC/WDM case] (**Scenarios C**, **D** and **E** discussed in **Chapter 5**) in combination with the eight Lephalale development scenarios listed in **Table 6.1** above.

Water balances of selected scenario combinations were carried out as part of the Crocodile (West) River Reconciliation Strategy Study and are presented graphically in **Figures B-1** to **B-4** in **Appendix B.** Each figure represents the projected water balance for the Lephalale Area (Mokolo River System) as projected for the planning period up to the year 2030. The available water is represented by the “Mokolo Dam Yield + Crocodile surplus” line which is the sum of the Mokolo Dam yield and the water that is available for transfer from the Crocodile (West) River System. The figures also indicate the projected water requirements for the eight scenarios as listed in **Table 6.1.** Comparing the water requirements with the water available shows that additional water is required for certain water requirement scenarios. As an example, **Figure B-1** shows that sufficient water is available in the Crocodile (West) and Mokolo River systems to supply the water requirements for **Scenarios 1** to **4**. However, for the water requirement **Scenarios 5** to **8** shortfalls are projected to occur (indicated where the respective water requirement lines exceeds the availability line, “Mokolo Dam Yield + Crocodile surplus”). This shortfall has to be augmented, either directly to the Mokolo River System or can be supplied to the Crocodile (West) River System from where it can also be transferred to the Lephalale Area (in addition to the surplus that is available in the Crocodile (West) River System).

The scenario combinations represented by the water balances in **Figures B-1** to **B-4** in **Appendix B**. are described as follows:

- **Figure B-1**: Represent the case where the **High Population Scenario** occurs and where the **Scenarios D** WC/WDM measures are implemented (water losses measures implemented within 5 years).

- **Figure B-2**: Represent the case where the Base **Population Scenario** occurs and where the **Scenarios D** WC/WDM measures are implemented (water losses measures implemented within 5 years).

- **Figure B-3**: Represent the case where the **Low Population Scenario** occurs and where the **Scenarios D** WC/WDM measures are implemented (water losses measures implemented within 5 years).

- **Figure B-4**: Represent the case where the High **Population Scenario** occurs and where the **Scenarios C** WC/WDM measures are implemented (water losses measures implemented within 5 years and water use efficiency interventions is introduced).

Given the shortfalls in supply of the Mokolo and Crocodile (West) river systems, as illustrated by the above described water balance figures, the DWAF identified that the only feasible source of additional water is from the Vaal River System. Since this transfer is for industrial purposes (to supply Eskom power stations and CTL plants) this transfer would be "raw" water (water not treated to potable quality standards). The quality of the water will be such that it complies with the receiving stream water quality standards.

Although preliminary assessments of all the scenario combinations were carried out in the Crocodile (West) River, various scenarios were eliminated on the basis of similar outcomes and the perceived low probability of occurrence. **Table 6.2** therefore presents the projected raw water transfer volumes that are to be supplied from the Vaal River System for the indicated planning years and the selected scenario combinations. These results were obtained from the Crocodile (West) River Reconciliation Strategy Study (**DWAF, 2008a**) and the transfers were incorporated into the reconciliation scenarios for the Vaal River System as described in **Section 7.3**.

For presenting the results of these combination scenarios, a concise scenario definition labelling and identification system has been devised, i.e. **D,L8,Base**, which is described below:

- The first character can be either "**D**", "**C**" or "**E**" and refers to the Water Conservation and Water Demand Scenarios, where;
  - o "**C**" references the WC/WDM, Loss reduction over five years plus efficiency improvement measures - 30% saving scenario,
  - o "**D**" references the WC/WDM, Loss reduction over five years - 15% saving scenario,
  - o "**E**" references the WC/WDM, Loss reduction over ten years - 15% saving scenario.
- The second letter "**L**" referenced the requirement scenario at Lephalale and the number following the "**L**" represents the scenario as defined in **Table 6.1**.
  - o For example, "**L4**" indicate that the planned CTL plants will not be located in the Lephalale Area. The assumption is made the CTL plants will be located in Free State, receives water from or down stream of Vaal Barrage.
  - o "**L8**" represents the case proposed CTL plants are implemented in the Lephalale Area, receives water from Mokolo River System and transferred water from the Crocodile River System.
- The third term represent either of the Populations Scenarios "**Low**", "**Base**" or "**High**".

As an example, the scenario combination description of "**D,L8,Base**" refers to the case where **Scenario D WC/WDM** is implemented, the full (high) future development will take place in the

Lephalale area including the **two phases of the CLT plant** (**Scenario 8** from **Table 6.1)** and the **Base Population** Projection scenarios materialises.

Table 6.2: Raw water transfer requirements from the Vaal River System (million m^3/annum)

Lephalale Water Requirement Scenario 4	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
WC/WDM Scenario D , High Population Scenario	0.0	0.0	0.8	0.0	0.0	0.0
WC/WDM Scenario D, Base Population Scenario	0.0	0.0	12.4	16.8	0.0	0.0
WC/WDM Scenario D, Low Population Scenario	0.0	0.0	33.7	53.4	50.0	49.3
WC/WDM Scenario C, High Population Scenario	0.0	0.0	34.6	46.9	29.2	7.7
Lephalale Water Requirement Scenario 8	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
WC/WDM Scenario D , High Population Scenario	0.0	0.0	40.8	76.8	50.1	24.3
WC/WDM Scenario D, Base Population Scenario	0.0	0.0	52.4	96.8	75.4	54.6
WC/WDM Scenario D, Low Population Scenario	0.0	0.0	73.7	133.4	130.0	129.3
WC/WDM Scenario C, High Population Scenario	0.0	0.0	74.6	126.9	109.2	87.7

CHAPTER 7. FUTURE INTERVENTION REQUIREMENTS

7.1 OVERVIEW

Given the water requirement and return flow scenarios provided in **Chapter 4** and **6**, and the potential saving scenarios through WC/WDM measures presented in **Chapter 5**, the need for intervention (when further WC/WDM measure and/or the development of an augmentation scheme is required) can be determined by assessing the water reconciliation (water balance) situation over the planning period. This was undertaken by firstly defining the planning scenarios and, secondly, carrying out scheduling analysis to determine the date when further intervention should be required.

The planning scenarios are described in **Section 7.3** and the results of the scheduling analysis are presented in **Section 7.5**.

7.2 INFRASTRUCTURE INTERVENTION OPTIONS

The Vaal Augmentation Planning Study (VAPS), completed in 1996, concluded that either a further phase of the Lesotho Highlands Water Project (LHWP) or further water resource developments in the Thukela River System could be considered as alternatives for augmenting the water resources of the Vaal River System. DWAF therefore commissioned feasibility studies for both these options to establish all factors that could influence their development and determine if these options are viable.

In addition to the abovementioned bulk water augmentation schemes, consideration were also given as to what infrastructure options would be necessary to convey the raw water transfer requirements of the Crocodile (West) River System (discussed in **Chapter 6**) from the Vaal River System. More details of the transfer infrastructure options that were evaluated are presented in **Chapter 10**.

7.2.1 Thukela Water Project

Subsequent to the VAPS, DWAF undertook the Thukela Water Project Feasibility Study (TWPFS) to determine the most feasible scheme configuration for development in the Thukela River System. The study concluded that two proposed dams, one on the Bushman’s River (Mielietuin Dam) and the other on the main stem of the Thukela River (Jana Dam), with transfer infrastructure, would be the most feasible scheme configuration to provide a nominal transferable yield of 15m^3/s (473 million m^3/annum).

A further study, the "*Thukela Water Project Decision Support Phase (TWPDSP)*" (**DWAF, 2005**) study, was carried out to, among other things, undertake a Comprehensive Reserve Determination Study for the Thukela River System and compile an implementation programme for the TWP. The results from this study indicated that the first water could be delivered twelve years after the decision is taken to proceed with the development. The Historic Firm Yield of the TWP, incorporating the Ecological Water Requirements (EWRs), for the largest dam sizes (Mielietuin + Jana) were determined to be 580 million m^3/annum.

7.2.2 Lesotho Highlands Water Project Phase II

The Lesotho Highlands Water Project Feasibility Study for Phase II, was commissioned in 2005 as a joint study by the South African and Lesotho governments, with the purpose of identifying the most feasible further phases of the scheme. The second stage of the project commenced in October 2006 and was completed in 2008 and identified, among various alternatives, the preferred scheme consisting of Polihali Dam to be constructed on the Senqu River, with a gravity tunnel transferring water to Katse Dam. From Katse Dam the water is delivered to the Vaal River System through the existing delivery tunnel system. The results from the second stage of the study were made available to the Reconciliation Study Team

The implementation period required for the scheme was estimated to be ten years after the decision is taken to proceed with the scheme. The Historical Firm Yield of the Polihali Dam options was determined to be 437 million m^3/annum.

The Directorate: Options Analysis (Dir : OA) commissioned the Vaal River Water Resource Development Project (WRDP): Comparative Study between LHWP Phase II and Thukela Water in May 2008 and the main objective of the study is to undertake a technical evaluation of the two proposed schemes in order to make a recommendation as to which of the two schemes should be implemented as the next option to augment the Vaal River System.

7.3 PLANNING SCENARIOS

Five planning scenarios (referenced by Roman numerals as **Scenarios I** to **V**) were formulated for analysis and evaluation, covering a range of possible future conditions and interventions as described in the following sections.

7.3.1 Scenario I: D, L8, High Population Scenario

The following assumptions were included:

- Water requirement scenario based on the High Population Scenarios for (Vaal and Crocodile, systems and Lephalale Area). See **Section 4.4.2** for a description of the population scenarios)
- Assumption that the CTL plant is located in Lephalale Area ("L8" - see **Table 6.1** for details).
- Implementation of water loss management initiatives over the next five years (**Scenario D**) i.e. 15% WC/WDM. See **Section 5.2.1.2** for details.
- Eradication of unlawful irrigation water use in the Upper Vaal Water Management Area (WMA). This is **Irrigation Scenario 1**, presented in **Section 4.2.5**.

7.3.2 Scenario II: L8, High Population Scenarios

Same as **Scenario I,** but without any further reduction in water losses, no further Water Conservation and Water Demand Management measures.

7.3.3 Scenario III: L8, High Population Scenario (Unlawful irrigation not reduced)

Same as **Scenario I** with the following adjustments:

- No further savings in water use, no further Water Conservation and Water Demand Management measures is implemented.
- The unlawful irrigation continues to increase to reach the registered volumes by the year 2015-**Irrigation Scenario 2**, described in **Section 4.2.6**.

7.3.4 Scenario IV: D, L8, Low Population Scenario

The following assumptions were included:

- Low water requirement scenario is used (Vaal, Crocodile, Lephalale).
- Assumption that the CTL plant is located in Lephalale (L8).
- Implementation of waste management initiatives over the next five years (**Scenario D**) i.e. 15% WC/WDM.

- Eradication of unlawful irrigation water use in the Upper Vaal Water Management Area (WMA). This is **Irrigation Scenario 1**, presented in **Section 4.2.5**.

7.3.5 Scenario V: C, L8, Rand Water's Water Requirement Scenario

The following assumptions were included:

- Water Requirement Projection made by Rand Water in 2004, which represents the highest projection of water use among all the scenarios.
- Assumption that the CTL plant is located in Lephalale (L8).
- Implementation of waste management initiatives and water use efficiency measures over the next five years (**Scenario C**) i.e. 30% WC/WDM.
- Eradication of unlawful irrigation water use in the Upper Vaal Water Management Area (WMA). This is **Irrigation Scenario 1**, presented in **Section 4.2.5**.

7.3.6 System net water requirement results (Scenarios I to V)

Combining the respective water requirements and return flow components for **Scenarios I** to **V**, produce the net system demands graph as presented in **Figure 7-1**.

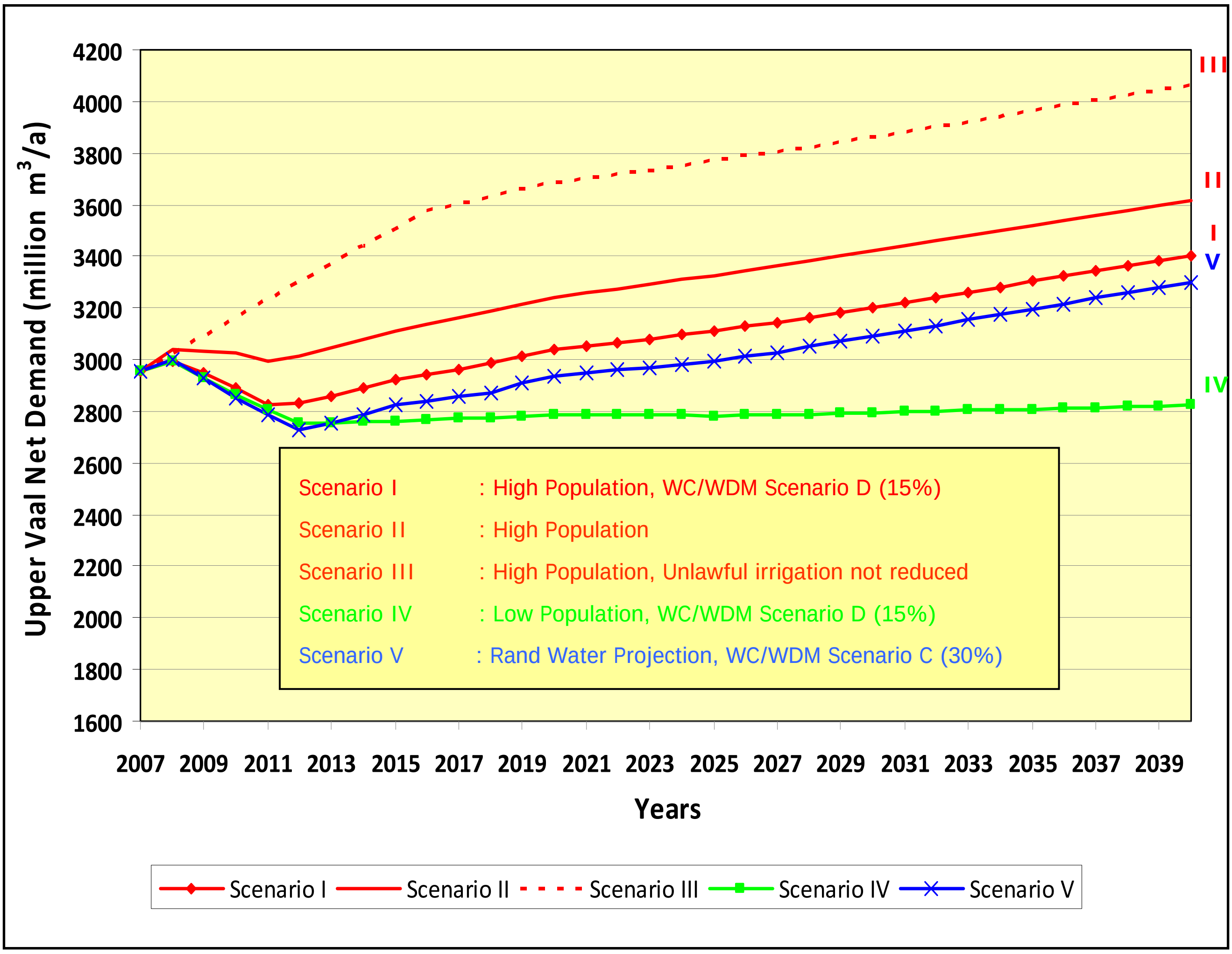


Figure 7-1: System net demand for the indicated scenarios

7.4 WATER QUALITY MANAGEMENT

It was assumed for all the scenarios that Rand Water is supplied from the Vaal Dam and that the 600 mg/l dilution rule is implemented for water quality purposes in the Vaal Barrage and downstream of the Barrage. Simulation analysis of this water quality management option revealed that for certain scenarios excess water will be available in the Middle and Lower part of the Vaal River System (downstream of and including Vaal Barrage). Utilisation of the excess was therefore considered in the projected water balances as alternative reconciliation options. The excess water is as a result of the return flows and water released for dilution which will be more than the water use downstream of the Vaal Barrage. This excess water accumulates in Bloemhof Dam and results in spills from the system. The excess water is further explained in the following sections.

7.5 SCHEDULING ANALYSIS RESULTS

Simulation analysis was carried out with the Water Resource Planning Model (WRPM) for the water requirement scenario based on the Base Population Scenario. The risk of curtailment results of the simulation was assessed and it was derived that the supply capability of the system is 2 877 million m^3/annum – assumed yield of the Vaal River System. Difference analysis was then carried out to derive the water balances for the other Planning Scenarios.

Figure 7-2 shows the net water requirements of **Scenario I** to **V** in relation to the system supply capability, from which the following observations can be made:

- The unlawful water use in the irrigation sector results in the system being in a deficit situation from the year 2007 to 2009 for all the scenarios. This illustrates the importance of curbing the unlawful irrigation water use in order to rectify the prevailing imbalance, maintain a positive water balance in the system over the medium term and prevent excessive curtailments during future drought conditions.

- Based on the projected balance situation for **Scenario I**, it is shown that the system will require intervention by the year 2014.

- If the potential savings through WC/WDM do not realised as represented by **Scenarios II** & **III,** the system is in deficit from 2007 onwards and unacceptable high the risks of drought curtailments will occur until an infrastructure options is implemented.

- The balance situation for **Scenarios IV** shows that, by eliminating wastage through WC/WDM and given that the Low Population Scenario realises, no further reconciliation interventions are required in the projection period.

- The balance situation for **Scenario V** shows that if the Rand Water projection realises, the unlawful irrigation is reduced and both waste management initiatives and water use efficiency improvements are implemented through WC/WDM, further interventions are only required in 2018.

  Note: The normal to above average rainy seasons in the recent past years has overshadowed the fact that the system is in a "deficit" because of the unlawful abstraction of the irrigation sector. The favourable short term conditions have prevented the need for implementing drought curtailments.

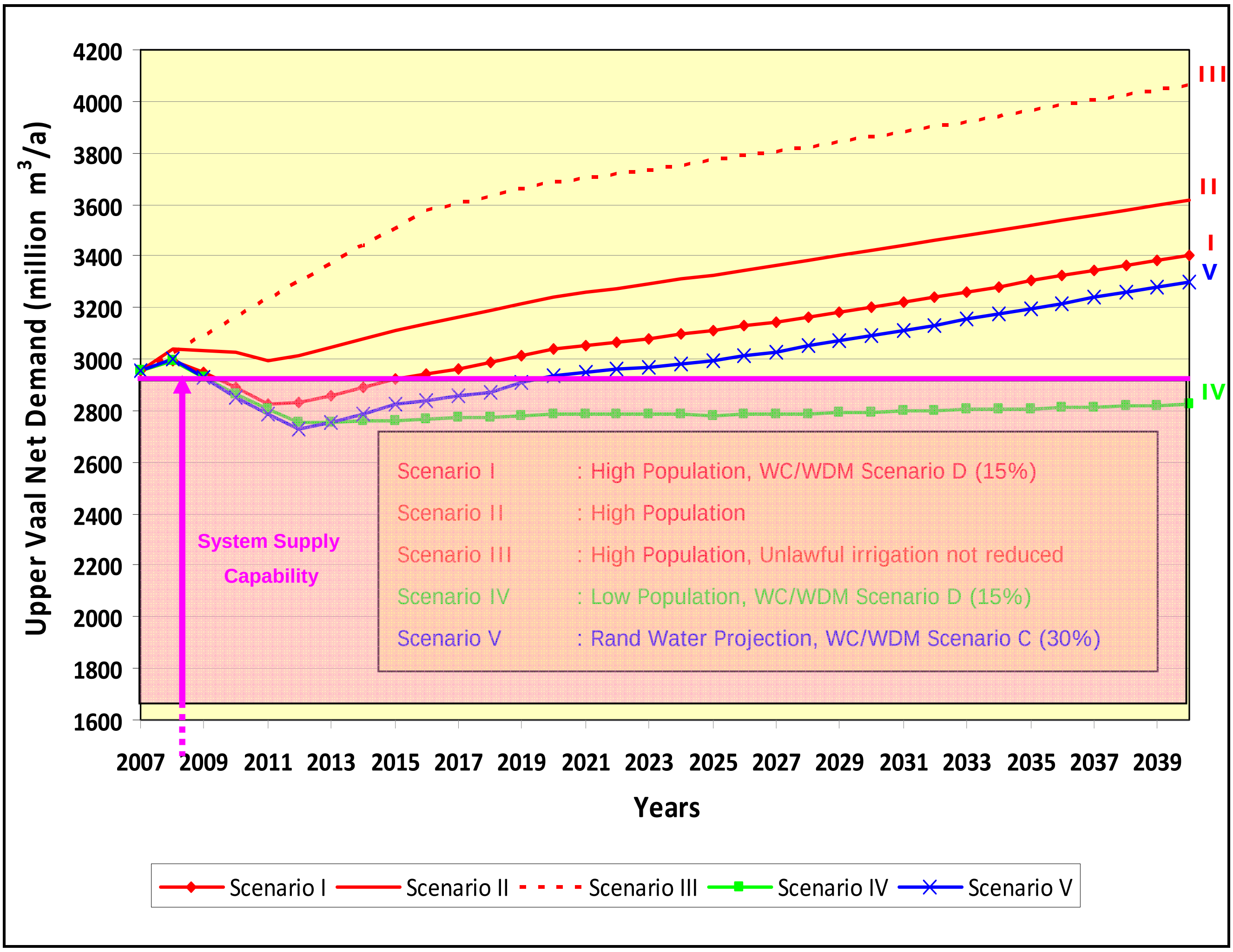


Figure 7-2: Net system demand and system supply capability

7.6 RECONCILIATION OPTIONS

Several reconciliation options were formulated based on the scenarios described in **Section 7.3** and the augmentation options presented in **Section 7.2**, and these are presented in the subsequent sections.

7.6.1 Scenario I: D, L8, High Population Scenario

Figure 7-3 presents the reconciliation situation based on the net water requirements of **Scenario I** which represent the case where unlawful irrigation is eradicated and the implementation of waste management initiatives over a period of 5 years i.e. 15% saving. The Thukela Water Project (TWP) was selected as the infrastructure intervention option and the earliest possible delivery date of the

TWP is 2019, due to the project's implementation period requirements and the system thus experiences a deficit in supply for the period 2014 to 2019.

The TWP components were implemented in two phases, firstly the Jana Dam option, which is scheduled to deliver water in the year 2019 and secondly the Mielietuin Dam option, delivering water from 2034 onwards. The significantly larger Jana Dam is implemented first due to the significant increase in rate of the net system demand for this scenario. The impact of not implementing WC/WDM i.e. water loss management over a five year period, is also illustrated in the figure and is discussed in **Section 7.6.2.**

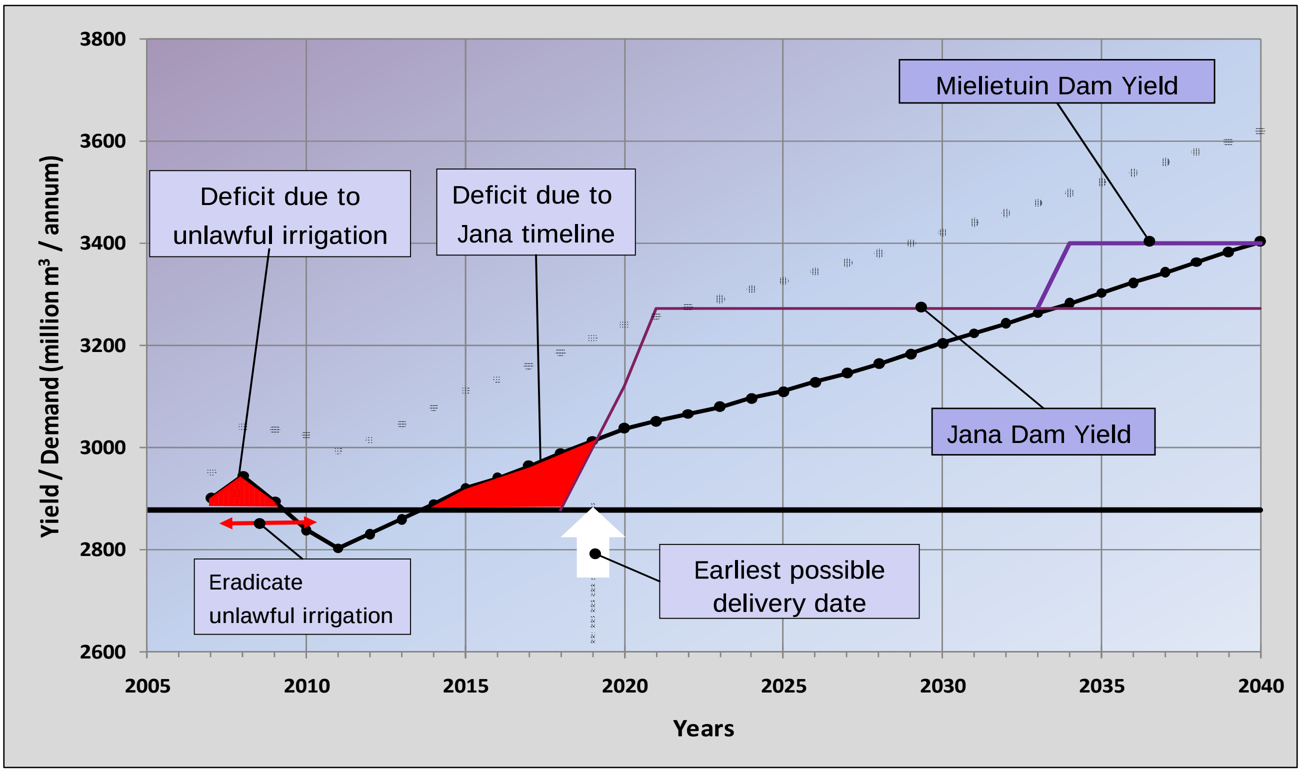


Figure 7-3: Vaal River System water balance diagram for Scenario I (D, L8, High Population Scenario) with the Thukela Water Project

There are significant volumes of excess water available in the Middle and Lower Vaal as a result of the urban return flows, the mine dewatering discharges and the 600mg/l dilution rule that has been implemented for water quality management purposes. The mine dewatering discharges contain high salinity concentrations, which add to the volume of water needed for dilution. The initial quantification of the excess water was derived from simulation analysis of the Base Population Scenario and then the excess of all the other scenarios were calculated based on difference analysis. Additional simulation analysis were carried out for the High Population Scenario as described in **Chapter 9** of the report. The excess was found to increase over time as illustrated in **Figure 7-4**.

Given the excess in the middle and lower portion of the Vaal River System and the requirement for raw water transfer to the Crocodile (West) River System (as described in **Chapter 6),** it was assumed that the raw water transfer will be provided from the middle and lower Vaal River System excess. This is illustrated in **Figure 7-4** where the required transfer volumes to the Crocodile (West) River System is subtracted from the "Total excess available". It should be noted that the raw water transfer volume required in the Crocodile (West) River System decreases after 2020 which is due to the increase in return flows in the Crocodile System (Gauteng North) and the constant Lephalale Area water requirement beyond 2020. (The Lephalale Area water requirement scenario is shown on **Figure B-1** of **Appendix B.**)

The impact of treating the total available excess and re-using the treated effluent to supply the demands in the Upper Vaal was investigated and is discussed below.

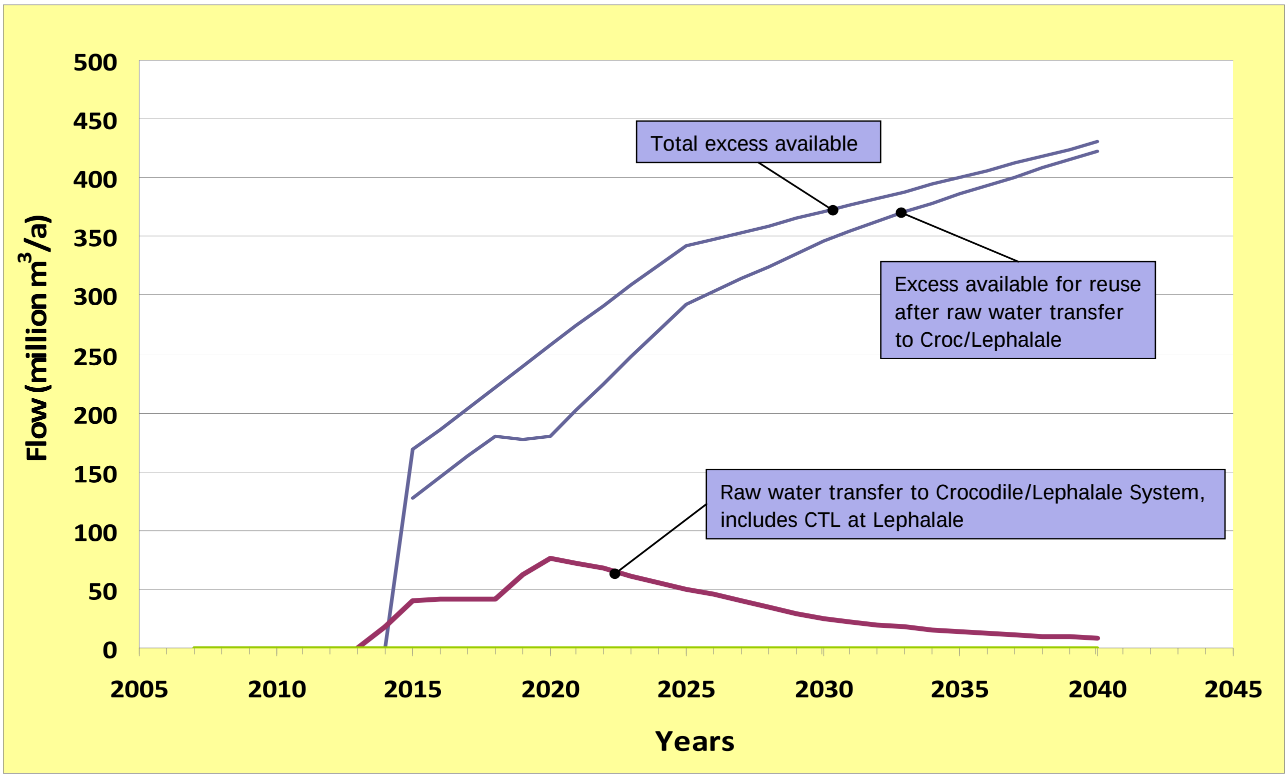


Figure 7-4: Excess effluent available in the Middle and Lower Vaal River (Scenario D, L8, High Population Scenario)

Figure 7-5 presents the reconciliation situation based on the net water requirements of **Scenario I** and the re-use of the available excess in the Lower Vaal. From the figure it can be seen that as a result of the additional volume made available through the re-use of effluent, the date where augmentation is required has been postponed to 2031. The deficit that was shown to occur in the 2014 to 2019 period (see **Figure 7-3**) is no longer present and is as a result of the relatively short implementation period of the re-use scheme. Only the implementation of Mielietuin Dam is required (TWP) to ensure sufficient water supply for the projection period.

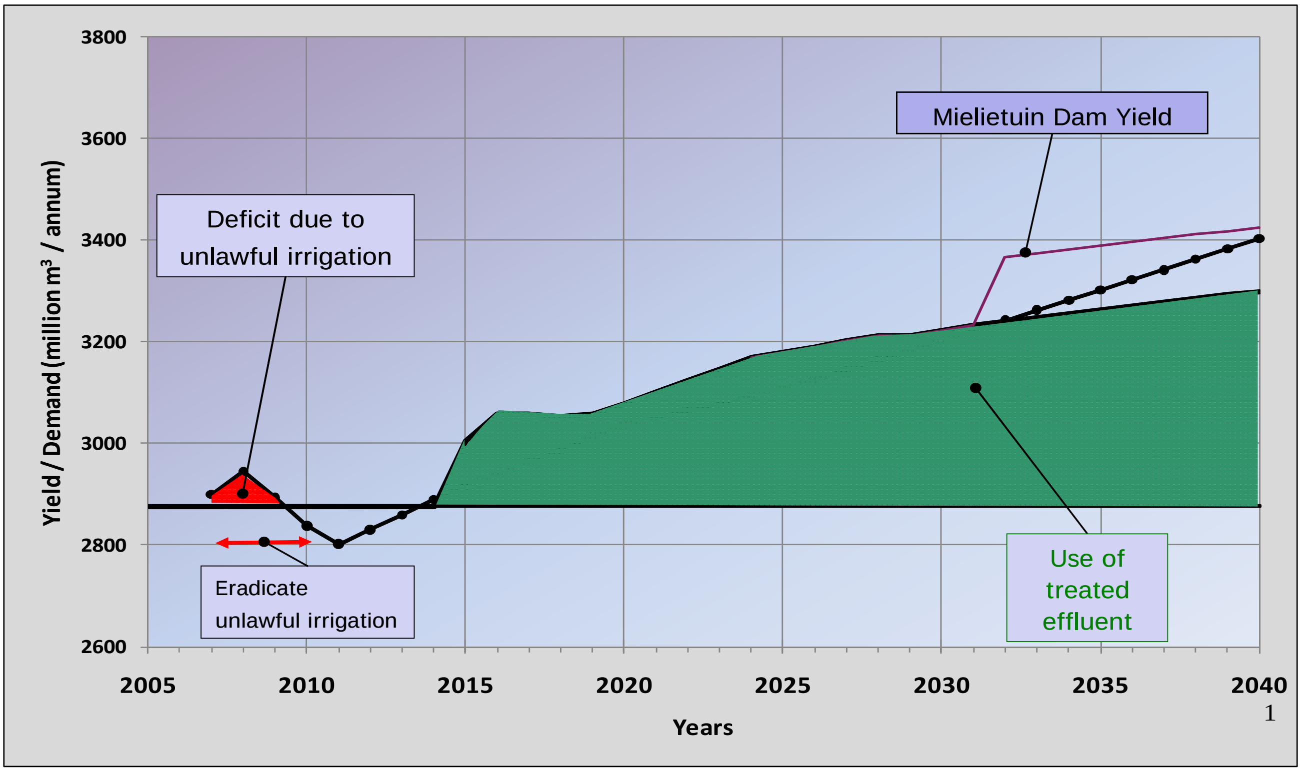


Figure 7-5: Vaal River System water balance diagram for Scenario I (D3, L8, High Population Scenario, with Thukela Water Project and Re-use of excess water

It should be noted that the above balance diagram have been compiled based on simplistic difference analysis which require verification through simulation analysis with the WRPM. In addition the water requirement and the system availability line on the graph run parallel to each other, indicating a sensitive balanced situation that could be found to be different than what is reflected in Figure 7-5.

The more sophisticate simulation analyses were carried out and the scenarios and results are discussed in **Chapter 9**.

7.6.2 Scenario II: L8, High Population Scenario (No further WC/DM)

Figure 7-6 presents the reconciliation situation based on the net water requirements of **Scenario II** i.e. excluding any further WC/WDM measures. From the figure it can be seen that the impact of not implementing WC/WDM is substantial, in that both the TWP and Lesotho Highlands Water Project (LHWP) Phase II are required to ensure sufficient water supply for the planning period. Due to the project's implementation period requirements, the system experiences substantial supply deficits for the period 2007 to 2021.

The TWP components are implemented in two phases, firstly the Jana Dam option delivering in the year 2019 and shortly afterwards the Mielietuin Dam option delivering from 2022 onwards. Further augmentation is again required in 2029, which is provided through the implementation of LHWP Phase II. The full yield of LHWP Phase II is much larger than the deficit for Scenario II in 2040 and further refinement in the sequence of options and scheme sizes would be investigated during design and implementation studies.

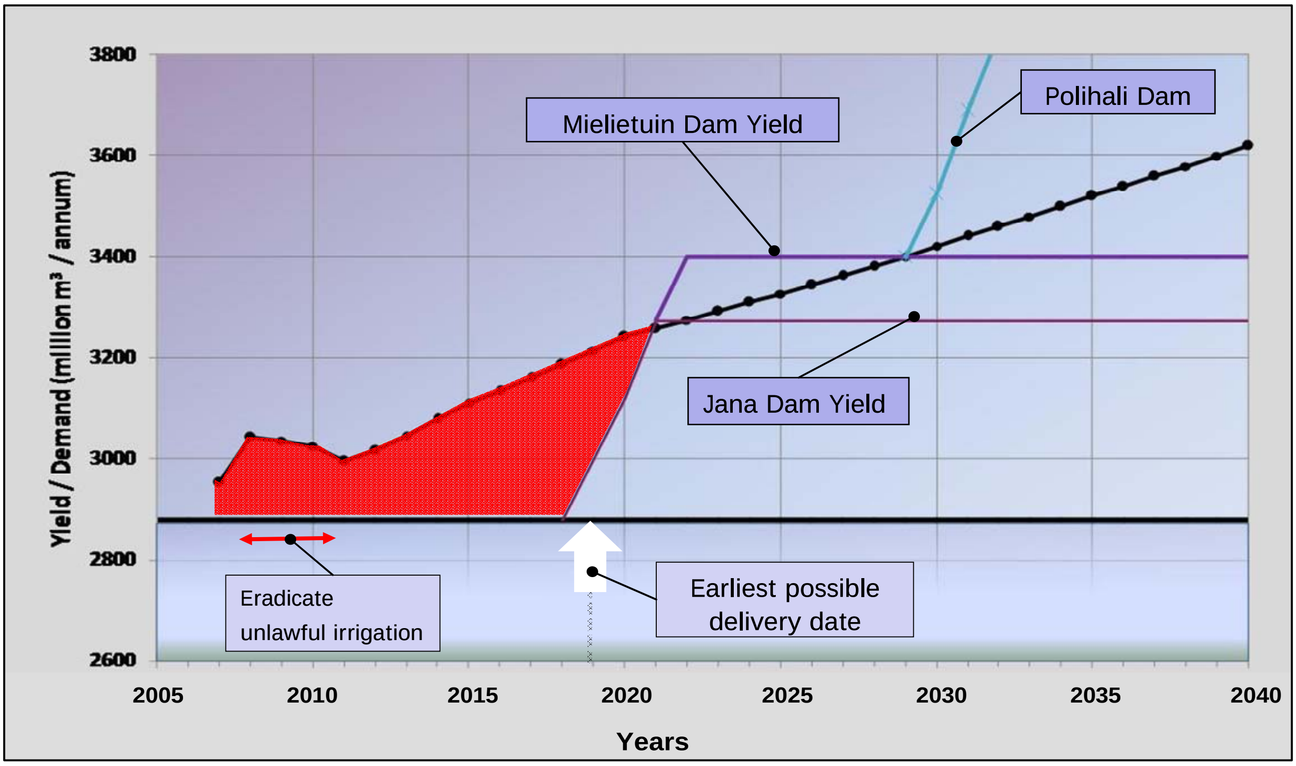


Figure 7-6: Vaal River System water balance diagram for Scenario II (L8, High Population Scenario) with TWP and LHWP Phase II

The impact of treating and re-using the excess available in the Middle and Lower Vaal was also considered and **Figure 7-7** presents the reconciliation situation based on the net water requirements of **Scenario II** and the re-use of the available excess in the Middle and Lower Vaal. It can be seen that the additional volume made available through the re-use of effluent has a significant impact on the water balance and only the implementation of Jana Dam is required (TWP) to necessary to ensure sufficient water supply for the projection period. The deficit occurring in the 2014 to 2021 period is also significantly reduced due to the relatively short implementation period required for the re-use scheme.

The full yield of Jana Dam is much larger than the water requirements for the projection period and further optimisation of the configuration and size of the scheme components would need to be conducted during implementation.

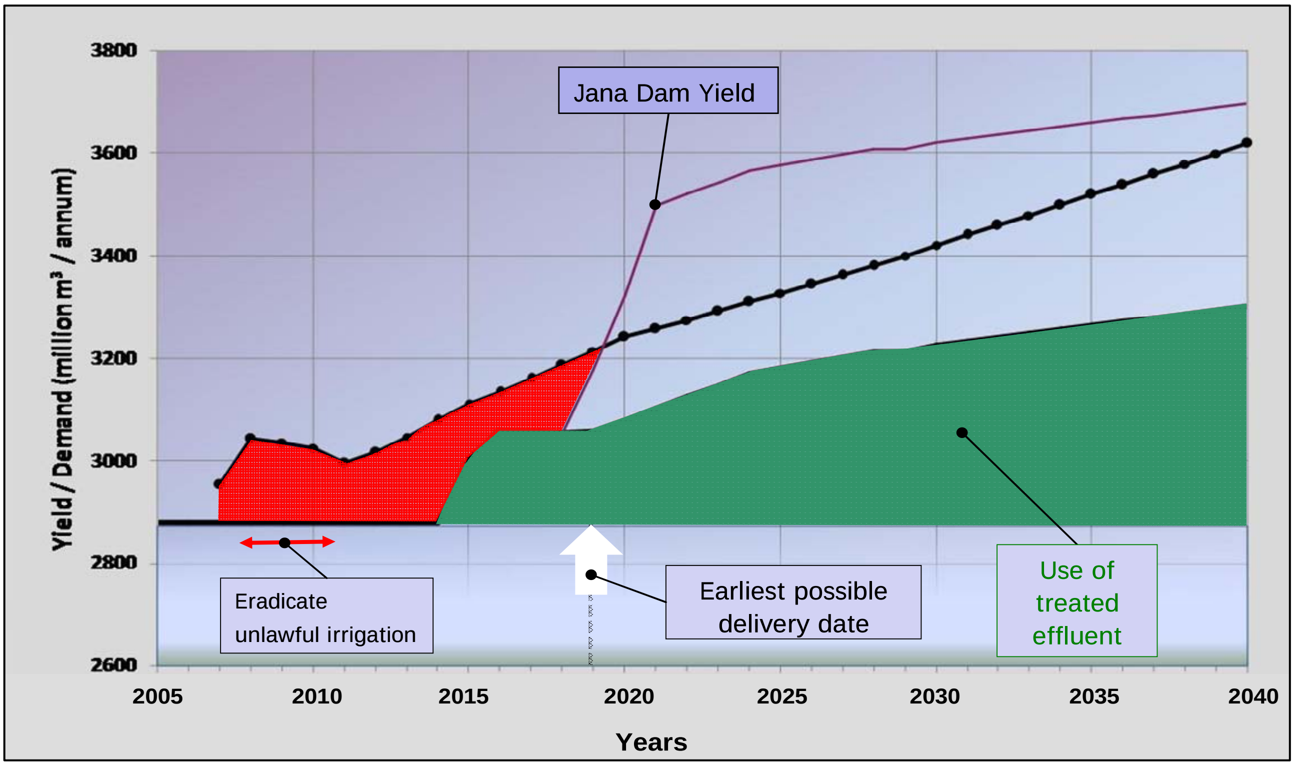


Figure 7-7: Vaal River System water balance diagram for Scenario II (L8, High Population Scenario) with TWP and Re-use of excess effluent

Scenario III: L8, High Population Scenario (Unlawful irrigation not reduced)**Figure 7-8** presents the reconciliation situation based on the net water requirements of **Scenario III** i.e. excluding the implementation of WC/WDM and the unlawful irrigation is not reduced. The impact of not implementing WC/WDM initiative and also not reducing the unlawful irrigation is substantial and require the implementation of both the TWP and Lesotho Highlands Water Project (LHWP) Phase II. The system experiences substantial deficits from 2007 to 2024 and then again from 2029 for the remainder of the projection period.

The scenario emphasises the importance and necessity of the implementation of WC/WDM measures and the eradication of the unlawful irrigation.

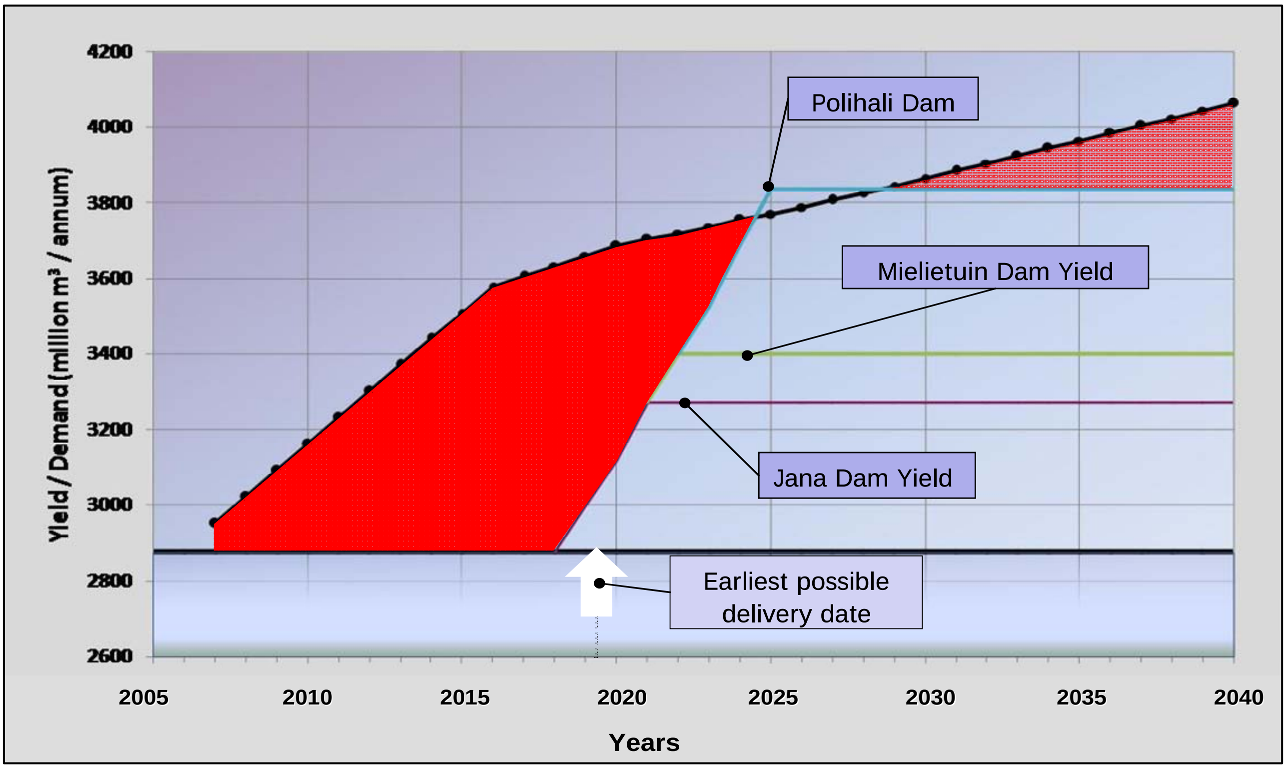


Figure 7-8: Vaal River System water balance diagram for Scenario III (L8, High Population Scenario- unlawful irrigation not reduced) with TWP and LHWP Phase II

The impact of treating and re-using the excess effluent available in the Middle and Lower Vaal was also investigated as illustrated in **Figure 7-9**. The additional volume made available through the treatment of effluent has a beneficial impact on the projected water balance in that with both the TWP and LHWP Phase II implemented the deficit that occurred from 2029 (see **Figure 7-8**) no longer exists.

The full yield of LHWP Phase II is significantly larger than the water requirements in the year 2040 and further optimisation of the schemes would thus be required for this scenario. The deficit occurring in the 2014 to 2021 period is also reduced due to the relatively short implementation period required for the re-use scheme.

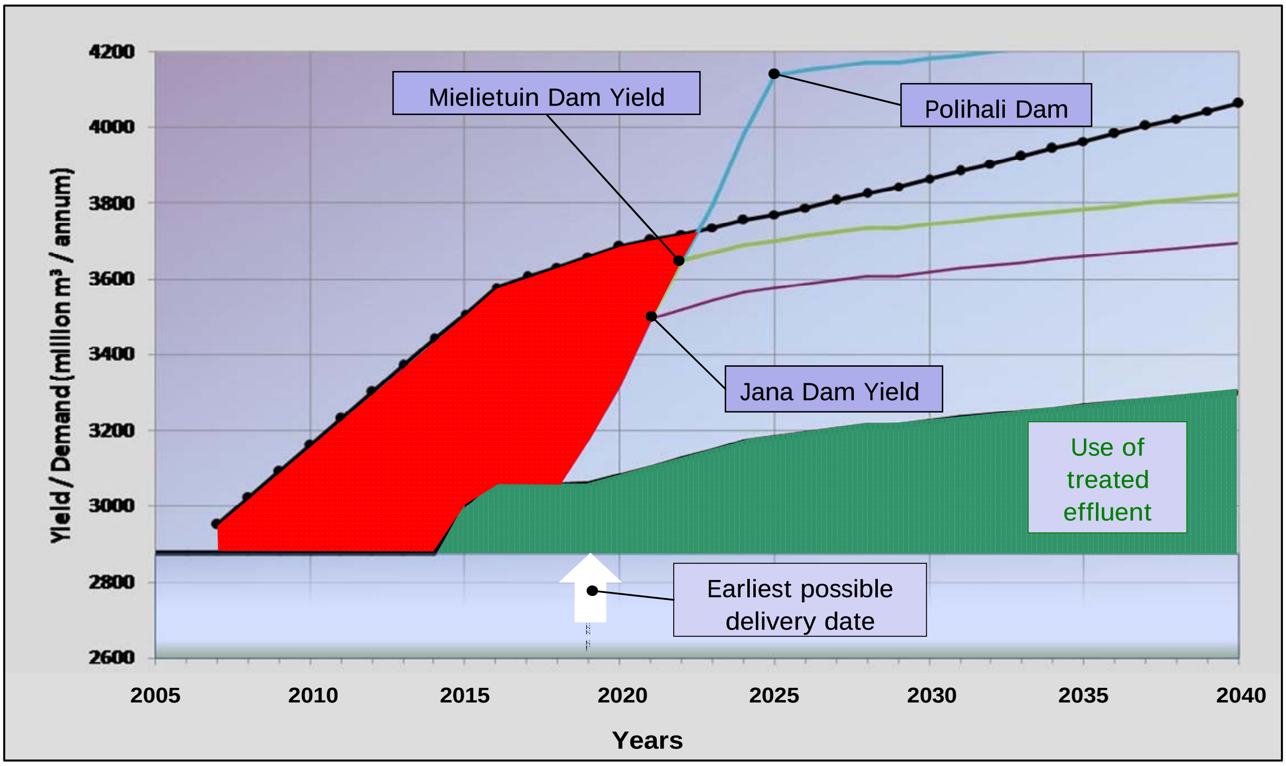


Figure 7-9: Vaal River System water balance diagram for Scenario II (L8, High Population Scenario - unlawful irrigation not reduced) with TWP and LHWP Phase II and Re-use

7.6.3 Scenario IV: D, L8, Low Population Scenario

Scenario IV was compiled to illustrate the Vaal River System water balance for the situation should the Low Population Scenario realises, the unlawful irrigation is removed and the **Scenario D** WC/WDM is implementation.

Figure 7_10 illustrates the projected water balance and indicates that no augmentation is required over the planning period should the indicated water requirement scenario realise over the projection period.

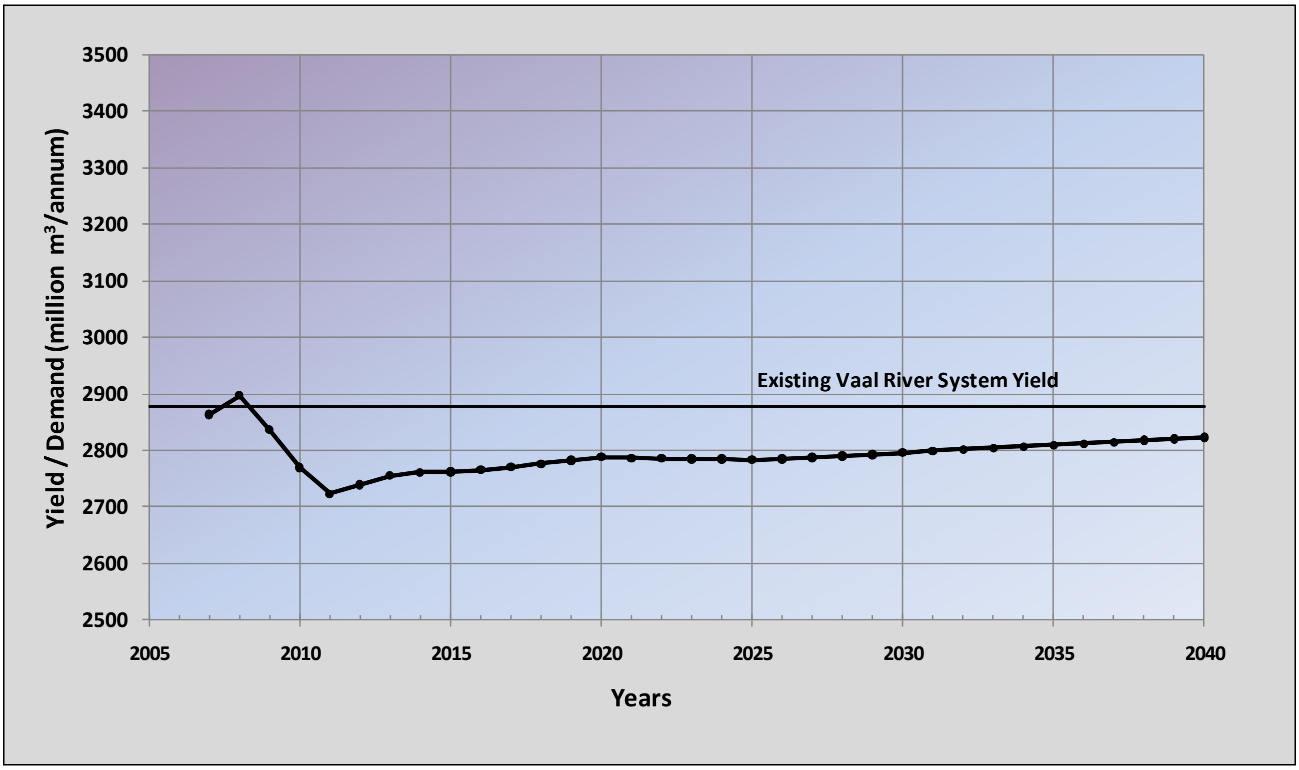


Figure 7-10: Vaal River System water balance diagram for Scenario IV (D, L8, Low Population Scenario)

7.6.4 Scenario V: C, L8, Rand Water's Water Requirement Scenario

Scenario V consists of Rand Water's high water requirement projection with effective waste management measures and improved water use efficiency implemented over a period of 5 years (30% saving) and eradication of unlawful irrigation water use. The treatment and re-use of the total excess effluent available in the Middle and Lower Vaal was also incorporated to determine the net system water requirement projection.

The results are illustrated in **Figure 7-11** and it can be seen that augmentation is required in the year 2018. The implementation of the TWP at its earliest possible date is sufficient to achieve a positive water balance in the system until the year 2039.

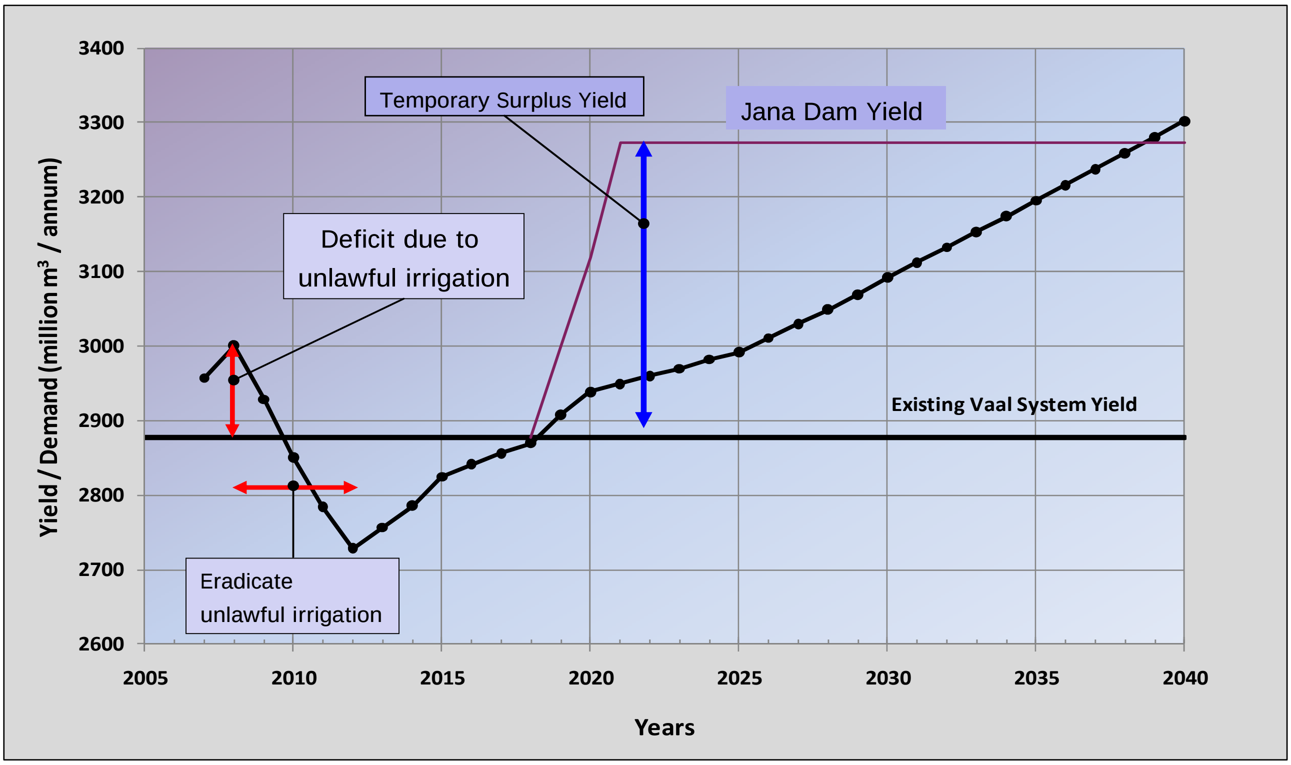


Figure 7-11: Vaal River System water balance diagram for Scenario V (C, L8, Rand Water's Scenarios) and the TWP and Re-use

In conclusion, the results for the water balances of the scenarios were used to formulate the following perspective on the augmentation requirements for the Vaal River System:

- Eradication of the unlawful water use in the irrigation sector is essential to obtain a positive water balance in Vaal River System.
- Water Conservation and Water Demand Management initiatives to reduce the losses in the system are necessary to reduce the risk of drought curtailments until the next large augmentation scheme can be implemented by the year 2019.
- Planning activities required to implement the next bulk augmentation scheme should continue to ensure delivery is possible by 2019.
- Re-use of effluent improves the water balance and contributes to reduce the risk of drought curtailments until the next bulk augmentation scheme can deliver water. (Further refined analysis of re-use scenarios are described in **Chapter 9**.

CHAPTER 8. PERSPECTIVE ON WATER QUALITY MANAGEMENT

8.1 OVERVIEW

Water quality management was investigated in detail as part of the parallel "***Integrated Water Quality Management Plan***" (IWQMP) study and has been reported on in a separate series of reports. At the time of writing this report, the IWQMP (**DWAF, 2008c**) study was completed, and the results were available for consideration in the ***Second Stage Reconciliation Strategy***. The following section, therefore, provides a brief discussion of the main issues and findings regarding water quality management.

8.2 WATER QUALITY MANAGEMENT CONSIDERATION

A water quality situation assessment of the Vaal River System was carried out as part of the IWQMP development. During this process the following was undertaken:

- The available water quality data was collected and analysed for the Vaal River main stem and the major tributaries.
- An initial set of Resource Water Quality Objectives (RWQOs) were set up for the Vaal main stem and the major tributaries.
- The current water quality data was analysed and compared to the RWQOs to identify water quality variables of concern.

This process identified that salinity (as represented by Total Dissolved Solids), eutrophication and microbiological water quality as the major water quality issues that need to be addressed by the strategy.

The salinity in the Grootdraai Dam and Vaal Dam catchments is currently adequate and meets the water user requirements. However the water quality in both these dams is influenced by the water quality of the transfers from Lesotho, Thukela, Zaaihoek and the Usutu transfer schemes. Currently this transfer water is of a good quality and assists in maintaining the current water quality in these dams. However the water quality in Grootdraai Dam is under threat from mining in particular decants from closed mines in the catchment. The salinity deteriorates significantly from the Vaal Barrage to Bloemhof Dam due to the urbanisation of the catchment, return flows from wastewater treatment works, industrial discharges and mine dewatering discharges. The current status does not meet the RWQOs set for this reach of river.

The water quality assessment showed that Vaal Dam, Vaal Barrage and Bloemhof Dam are eutrophic to hypertrophic. The average phosphorus concentrations exceed the proposed RWQOs significantly. The eutrophic conditions in the middle reaches of the Vaal River have impacted on the performance of the water treatment plants of Midvaal and Sedibeng Water. Additional treatment processes to deal with the colour and odour associated with the eutrophic waters has had to be installed. The major source of the nutrients is the wastewater treatment works (WWTWs) effluent discharges and the management and maintenance of the sewerage systems. A number of WWTWs are not performing according to specifications.

The available microbiological database does not support an extensive assessment of the entire Vaal River System. The database does however identify "hot spots" located in the tributaries close to WWTWs discharges. The microbiological water quality in the main stem of the Vaal River however in general meets the full contact recreation water quality requirement for E-Coli.

Management strategies were developed to address salinity, eutrophication and microbiological quality. The salinity management strategies assessed included:

- Ongoing dilution with releases from Vaal Dam to maintain the TDS concentration in the outflow from the Vaal Barrage at 600 mg/l.
- Desalination of all the major saline mine water and industrial discharges to potable standard for re-use in the Rand Water distribution system. **The implications of this scenario in relation to the High Population water requirement scenarios has been evaluated in more detail through simulation analysis as described in Chapter 9.**
- Desalination of selected saline mine discharges to potable standard for re-use in the Rand Water distribution system.

The nutrient management scenarios considered were:

- Flow manipulation in the middle reaches of the Vaal River to break down stratification and reduce residence time to limit the algal bloom development.
- Phosphorus reduction programs through more stringent phosphorus discharge standards. The reductions could not be easily assessed as the nutrient and eutrophication models available are not as well developed and applied as the salinity simulation models.

The microbiological management scenarios considered were to audit the WWTW and sewerage systems in terms of current performance and future planning.

CHAPTER 9. SIMULATION ANALYSIS OF RE-USE OPTION

9.1 SIMULATION ANALYSES PROCEDURE

Given the potential benefits water re-use could have on the ability to achieve a positive water balance in the system over the short term (as presented through the projected annual water balance scenario results in **Section 7.6)** and the potential benefits in improving the water quality of the Middle and Lower Vaal River System, simulation analyses were carried out with the Water Resource Planning Model (WRPM) to assess the required dates of when augmentation will be required for specific combination scenarios. The key results needed from the simulation analysis were the date when the next bulk augmentation scheme (first scheme) is needed as well as the date when a further subsequent scheme (second follow-on scheme) would be required.

To determine these implementation dates simulation analyses were carried out in accordance with the steps described below:

Simulation step 1: Select the water requirement scenario and analyse the system for the planning period up to 2040 without implementing any future infrastructure augmentation option. Assess the simulated storage levels in Bloemhof Dam and if it is shown that excess water is available, follow Simulation step 2.

Simulation step 2: Derive a time series of estimated excess water, typically increasing from zero in 2013 to the maximum volume in 2040, and re-analyse the configuration from **Step 1** by imposing the excess time series as an additional abstraction on the system. Assess the simulated storage of Bloemhof Dam and adjust the excess time series iteratively until the dam is drawn empty at five percent of time in any year of the planning period. Produce the projected drought curtailment results from the accepted simulation and obtain the date when the next augmentation scheme need to be implemented. This is based on the standard risk criteria defined for the Vaal River System.

Simulation step 3: Implement the selected augmentation scheme (Thukela Water Project or Lesotho Highlands Phase II) at the date determined in **Step 2**. If the required implementation date from **Step 2** is earlier than the date the scheme can physically deliver water, implement the scheme at the earliest practical date. In this configuration the selected augmentation reservoir will commence filling at a predefined date and water is delivered to the Vaal River System on the implementation date. The system is then analysed and the drought curtailment result is produced to obtain the date when a subsequent follow-on scheme is required.

Simulation step 4: Repeat the analyses of previous steps with the selected effluent re-use option and derive the respective required implementation dates for the next and subsequent augmentation schemes.

The resulting implementation dates, obtained from the simulation analyses process, were provided to the team responsible for the *Integrated Water Quality Management Plan Study* (**DWAF, 2008c**) for further economic evaluations.

9.2 SIMULATION ANALYSES SCENARIO DESCRIPTION AND RESULTS

The analysis procedure presented in the previous section was applied for the Planning **Scenario I**, which was defined in **Section 7.6.1** and repeated here:

- Water requirement scenario based on the High Population Scenarios for (Vaal and Crocodile, systems and Lephalale Area). See **Section 4.4.2** for a description of the population scenarios.)
- Assumed that the CTL plants are located in Lephalale Area ("L8" - see **Table 6.1** for details).
- Implementation of waste management initiatives over the next five years (**Scenario D**) i.e. 15% WC/WDM. See **Section 5.2.1.2** for details.
- Eradication of unlawful irrigation water use in the Upper Vaal Water Management Area (WMA). This is **Irrigation Scenario 1**, presented in **Section 4.2.5**.

For all the simulation analysis the dilution rule was applied where water is released from Vaal Dam to maintain the TDS concentration in and downstream of the Vaal Barrage at 600mg/l and Rand Water abstracts water from Vaal Dam.

Assessment of the required implementation date for the next augmentation option (either the TWP or LHWP Phase 2)

The date when the next augmentation scheme (either the Thukela Water Project or Phase 2 of the Lesotho Highlands Water Project) is required was determined to be the year 2015 for the case where no effluent re-use takes place and 2016 for the scenario where the mine water discharges are desalinated and re-used. Both these dates are earlier than the practical implementation date of 2019 and indicate the system will experience higher risks of drought curtailments that what is acceptable for three years until an augmentation scheme can deliver water in 2019.

The reason for only a one year postponement in the date augmentation is required, for the case where the re-use option is implemented, is due to the high rate of change (year-on-year increase) of the **gross** water requirement for the High Scenario and the comparable small volume of additional water (year-on-year) available from the re-use of water. (Note that the year-on-year increase in water for re-use consists of the increasing flows from the WWTWs and the increasing dilution volume due to the diffuse pollution from the expanding urbanised areas.) Furthermore, in the simulation analysis the system storage has already been reduced to levels where drought curtailments are necessary, prior to the date re-use commences, with the result that the small year-on-year increases in the re-use volume is not sufficient to recover the system storage levels to such an extent that the risk of drought curtailments are reduced to acceptable levels.

It should be noted that there was no excess water available in Bloemhof Dam for the case where the mine water effluent was re-used, which indicates all available water was efficiently utilised. However, the risk of drought curtailments remained higher than what is acceptable from 2016 onwards. (Note that the re-use of the mine water effluent also reduced the pollution load with the result that the releases required for dilution is substantially reduced as well.)

Compared to the simplified annual water balance method results, presented in **Section 7.6.1** and illustrate in **Figures 7.4** and **7.5**, it can be seen that the benefit for the re-use of mine water effluent was overestimated in the annual balance method (**Figure 7.5** indicates the next scheme is only required in the year 2031).

The above describe dynamic of the system's behaviour can only be evaluated by undertaking simulation analysis and points to the limitations of the simplified annual water balance assessment method to evaluate the benefits and constraints of re-use options in the Vaal River System.

Assessment of the implementation date for the subsequent (after TWP or LHWP Phase 2) augmentation option

Simulation analyses were repeated for the two cases, with and without mine effluent re-use, however in this instance the Lesotho Highlands Water Project Phase II was implemented as follows; Polihali Dam commenced impoundment in May 2019 and delivery to Katse Dam in May 2020. The aim with the analysis was to determine the required implementation date of the scheme to follow LHWP Phase II.

The simulation analysis results of the projected storage volumes in Bloemhof Dam from **Step 1** indicated that there is significant unused water in the dam that is increasing over the analysis period. (Note that the pollution (salinity content) from the mine and the growing urban areas causes increasing diffuse pollution from paved surfaces contributes to the increasing dilution releases.) This emphasises the effect of the 600 mg/l dilution operating rule coupled to the increasing urban return flows and mine water effluent causing an imbalance in the Vaal River System with unused water in the lower part of the system. This unused excess water represents a disadvantage to the Vaal River users and is effectively a “loss” to the Vaal River System.

The implication of this loss was assessed by carrying out the analyses in **Steps 2** and **3.** The effect of the loss is represented by the required implementation date of the subsequent augmentation scheme (the loss influences the next augmentation date).

The results for the case where no re-use is implemented showed that without re-use the implementation of the LHWP Phase II scheme (Polihali Dam and tunnel) substantially reduces the risk of drought curtailment (compared to the option without LHWP Phase II), however, the criteria for acceptable drought curtailment risks is violated continuously from the year 2015 and up to the end of the analysis period (2040). This implies the loss, due to excess water in Bloemhof Dam, is such that the subsequent augmentation scheme needs to be implemented as soon as possible.

The results of the case where re-use of mine water effluent is implemented showed that there is no excess in Bloemhof Dam and there is therefore no loss of water from the system. The required implementation date of the subsequent scheme was determined to be in the year 2038.

The following conclusions can be made from the results:

- For the High Population water requirement scenario, re-use of mine water as a stand alone first intervention is not sufficient to reduce the risk of drought curtailments over the next ten years - such that the implementation date of the next (first) augmentation scheme can not be postponed beyond 2019.

- The combined effect of the next (first) augmentation scheme and re-use of mine water effluent has the benefit that the subsequent (follow-on) augmentation scheme is postponed until 2038.

- The simplified water balance method is not suitable to assess the implication of water re-use and water quality management options for the Vaal River System. Scheduling analysis to determine the required implementation date for augmentation options has to be performed using the simulation analysis method in the cases where re-use scenarios and related water quality management measures has to be evaluated.

- **The consequence of the simulation analysis results is that both the re-use of mine water effluent and the next augmentation scheme is required in combination to improve the water supply situation over the long term. These interventions combined have the benefit that the capital expenditure of the subsequent follow-on scheme can be postponed for many years. These results were provided to the IWQMP study for further economic assessments of re-use as a water quality management option.**

CHAPTER 10. FEASIBILITY ASSESSMENT OF TRANSFERRING WASTE WATER FROM THE VAAL TO THE CROCODILE (WEST) CATCHMENT

10.1 OVERVIEW

The Crocodile (West) River System Reconciliation Strategy Study identified that additional raw water transfers is required to maintain a positive water balance for the period until the year 2030 (see **Chapter 6** for details). The Directorate: National Water Resource Planning requested the Vaal Reconciliation Study Team to undertake an investigation into a scheme to collect and transfer treated from Waste Water Treatment Works (WWTWs), currently discharging into the Vaal River System, to the Crocodile (West) catchment.

The investigation included the following components:

- Conceptual design and costing of transfer infrastructure
- Desktop assessment of the impact of removing effluent form the receiving scheme

The intention is that the transfers water will be discharged into a tributary of the Crocodile (West) River and flow into the Hartebeespoort Dam.

This chapter provides a summary of the findings from the investigations

10.2 ASSESSMENT

10.2.1 Conceptual design and costing of transfer infrastructure

In order to conduct the conceptual design and costing of the transfer infrastructure, the required transfer volumes in the Crocodile (West) River catchment were obtained from results of the Crocodile (West) River Reconciliation Strategy Study (**DWAF, 2008a**). A range of transfer volumes were selected to cover the scenarios and included the following:

- Case 1: 30 million m^3/annum transfer volume.
- Case 2: 70 million m^3/annum transfer volume.
- Case 3: 140 million m^3/annum transfer volume.

Suitable WWTWs were selected that contain significant inflow volumes and that are positioned close to the catchment divide in order to minimise pipe lengths and pumping heads. Olifantsvlei, Bushkoppies and Goudkoppies WWTWs, which are situated close to one another in the Klip River

Catchment south west of Johannesburg, were selected based on the criteria requirements. The discharge volumes for the three WWTW's are illustrated in **Table 10.1**.

Table 10.1: WWTW discharge volumes (2007)

WWTW	Discharge (million m^3/annum)
Goudkoppies	47.9
Bushkoppies	65.6
Olifantsvlei	86.6
Total	**200.0**

The Hartebeespoort Dam is about 60 km north of the three WWTWs and to transfer the water into the tributaries upstream of the dam required the following infrastructure:

- A collection system consisting of pump stations at the WWTWs and appropriately sized conveyance pipelines to transfer the water into a balancing/storage pond at a central collection point.
- At the central collection point, water treatment facilities will be developed for the polishing of the effluent in order to reduce the nutrients loads as a measure to achieve the receiving stream's RWQOs.
- An additional pump station and pipeline to convey the polished effluent into a tributary river from where the water flows into Hartebeespoort Dam

Two alternative central collection points were identified i.e. the outlet of Goudkoppies WWTWs and the outlet of Olifantsvlei WWTWs. The required infrastructure components were investigated for each of the central collection points and an order of magnitude of capital cost and operational and maintenance costs for the two systems was calculated.

A summary of the capital costs associated with the two central collection point options for the three cases is illustrated in **Table 10.2** and the associated operating costs are illustrated in **Table 10.3**.

Table 10.2: Summary of capital costs (Olifantsvlei Option)

Case	1 (30 million m^3/annum)		2 (70 million m^3/annum)		3 (140 million m^3/annum)	
	Goudkoppies	Olifantsvlei	Goudkoppies	Olifantsvlei	Goudkoppies	Olifantsvlei
Collection & Transfer (R million)	565.6	674.4	932.8	1 073.5	932.8	1 415.8
Treatment (R million)	24.3	24.3	50.8	50.8	95.8	95.8
Total (R million)	**598.9**	**698.7**	**983.6**	**1 124.3**	**1 511.6**	**1 511.6**

Table 10.3: Operating and Maintenance costs (summary)

Case	1 (30 million m^3/annum)		2 (70 million m^3/annum)		3 (140 million m^3/annum)	
	Goudkoppies	Olifantsvlei	Goudkoppies	Olifantsvlei	Goudkoppies	Olifantsvlei
Cost (R/m^3)	0.48	0.49	0.47	0.42	0.48	0.39

10.2.2 Impact of removing effluent from the receiving stream

A desktop assessment of the impact of removing effluent from the receiving stream (Klip River) was conducted. The change in flow due to the proposed abstraction for the three cases was assessed by making use of the two Rand Water gauge stations in the Klip River, located downstream of the three WWTWs.

The approach followed was to subtract the historic WWTW discharges from the monthly flow of the two gauges in order to establish the contribution of the catchment to the flow values. For each of the cases (Case 1, 2 and 3) a volume of 30, 70 and 140 million m^3/annum was subtracted from the current WWTW discharge of 200 million m^3/annum respectively and a revised flow was calculated by adding the remaining flow to the catchment contribution for each of the cases.

The impact of the TDS concentrations in the Klip River outflow was also assessed simulation analysis by applying the WRPM.

The following conclusions could be made based on the assessment:

- The impact of the 30 million m^3/annum and 70 million m^3/annum transfer on the Klip River Flows are low.
- The impact of the 140 million m^3/annum on the Klip River flow is significant in the short term. It is expected that the effluent from the WWTWs discharging into the Klip River will increase in future and therefore the impact will reduce over time.
- The WRPM simulations showed that the impact on the TDS concentrations in the Klip River outflow were insignificant.
- The transfer scheme will remove nutrient load from the Vaal River System and thus reduce eutrophication in the main stem of the Vaal River.

In summary no fatal flaw could be identified in the study and further planning investigations is recommended to be undertaken for this transfer scheme.

CHAPTER 11. STRATEGIC PERSPECTIVE ON WATER RESOURCE MANAGEMENT

11.1 OVERVIEW

The size of the Vaal River System, the various inter-basin transfers coupled with the extensive bulk water distribution infrastructure and the geographical location of the water users in relation to the position of the water resource components provides for a complex mix of variables that influences both the water demand and availability.

Ensuring that sufficient water is available to supply the future water requirements in the supply area of the Vaal River System requires a five pillar strategy consisting of the following main components:

- ***Water use compliance enforcement to eradicate unlawful water use.***
- ***Water Conservation and Water Demand Management measures to reduce losses and improve efficiency.***
- ***Utilisation of treated effluent and other discharges, especially those from the mines.***
- ***Implementation of infrastructure augmentation option.***
- ***Management of the water quality in the system.***

The above measures originate from the understanding of the supply situation in the Vaal River System as discussed in detail in the report. Specific recommendations for the management of the Vaal River System are described in the subsequent sections.

11.2 ERADICATE UNLAWFUL WATER USE

The eradication of the unlawful water use, mainly in the irrigation sector, is an essential strategy that has to be implemented in order to rectify the current deficit (negative water balance) in the Vaal River System. The legal actions and procedures that will be implemented, should be designed to achieve legal precedence to protect the entitlements of lawful water users, and assist in compliance monitoring and water use regulation in future.

The Department has already initiated a process where all legal and compliance enforcement measures are being investigated and preparations made for an enforcement campaign.

11.3 IMPLEMENT WATER CONSERVATION AND WATER DEMAND MANAGEMENT MEASURES

Even if it is assumed that the unlawful irrigation is eradicated, the high demand scenario shows that shortages will develop long before 2019, which is the earliest date for a new transfer scheme to deliver water. Even with a water loss control project that may save in the order of 15%, shortages will still develop by 2015 (see **Figure 7.3**).

It is deemed practical to successfully implement measures to save 15% within this time period, but not the larger 30% (that may only be achievable over the longer term) and in this strategy it is assumed that the 15% saving scenario will be achieved.

However, successful implementation is going to be very challenging. The users are spread out over a very large area with many metros and municipalities involved, as well as a number of water boards.

The responsibility for the implementation of WC/WDM measures reside primarily with the municipalities and their water service providers. DWAF and provincial government should provide an active supporting role by engaging with municipalities to overcome their constraints and possibly provide resources to implement WC/WDM measures in the supply area.

The report "*Potential Savings through WC/WDM in the Upper and Middle Vaal Water Management Areas*" (**DWAF, 2006b**), provides detail information on the types of WC/WDM measures that should be considered in each target municipality. This serves as a point of departure for the development of projects and securing the required finances to implement WC/WDM measures.

11.4 UTILISATION OF TREATED EFFLUENT AND OTHER DISCHARGES

The results from the simulation analysis presented in **Chapter 9** show that the re-use of mine water effluent in combination with other interventions could have a significant benefit by postponing the need for further augmentation after the implementation of Phase II of the Lesotho Highlands Water Project.

The *Crocodile (West) River Reconciliation Strategy* indicated that raw water transfers into that system would be necessary to provide sufficient water for the proposed electrical power generation and possible Coal to Liquid industries envisaged at the coal fields near the town of Lephalale (see **Chapter 6** for details). The only source for the water is the Vaal River System and a scheme to pump water from selected sewage works (currently discharging to the Vaal) into the Crocodile catchment has been investigated at reconnaissance level of detail (see **Chapter 10** for details).

Given the various options and associated implication (costs of treatment as well as environmental considerations) of utilising the excess, it is recommended that a feasibility study be commissioned to evaluate all alternative options for re-use and to compare the advantages and disadvantages of the various alternatives with the aim of finding the optimum solution.

11.5 INFRASTRUCTURE AUGMENTATION OPTIONS

Previous investigations by DWAF identified that there are two alternative infrastructure options available to serve as the next augmentation scheme for the Vaal River System, which are the Thukela Water Project or a further phase of the Lesotho Highlands Water Project.

Detailed feasibility studies have been completed for both options and the Directorate: Option Analysis has commissioned the *Vaal Augmentation Comparison Study* to determine, on technical grounds, which of the two options should be selected as the next scheme to augment the Vaal River System.

The outcome of the above-mentioned study lead to the decisions by the Minister of the Department of Water Affairs and Forestry and ratified by Cabinet (in December 2008), to proceed with the negotiations with the Government of Lesotho for the implementation of the Phase 2 of the Lesotho Highlands Water Project.

The negotiations with the government of Lesotho should take into consideration the augmentation implementation requirements of the Reconciliation Strategy and submit the appropriate water demand (transfer) schedule to Lesotho. This revised transfer schedule should also be the basis of calculating the payment tariffs including the Royalty payments of the scheme.

11.6 WATER QUALITY MANAGEMENT INTERVENTION

The short and medium term water quality management interventions derived from the "***Integrated Water Quality Management Plan***" (IWQMP) study (**DWAF, 2006a**) are summarised below.

The immediate to short term management strategy is:

- Continue with dilution of the Vaal Barrage water with releases from Vaal Dam. This approach does not result in the RWQOs set for the Vaal main stem being met. A waste discharge

charge will be levied on discharges to offset the economic dis-benefit of the downstream users.

- Implement an upgraded monitoring programme.
- Selection of target saline effluent treatment schemes.
- Incorporated into the dilution releases will be the flow manipulation required to manage the algal blooms in the middle reaches of the Vaal River.
- Audit WWTWs and develop perspectives on hotspots requiring urgent action.
- Document and pilot protocols for flow manipulation releases as a strategy in Middle Vaal from Vaal Barrage to Bloemhof Dam.
- Source control, through Water Use Licence Application and Integrated Water and Waste Management Plans.
- Implement monitoring plan of nutrient sources.
- Implement upgraded monitoring and reporting plan.

The medium to long term management strategy is:-

- Implement target saline effluent treatment schemes.
- Implement waste discharge charges.
- Continue monitoring/assessment.
- Implement WWTP retrofit and upgrading projects in the hot spot areas.
- Nutrient Balance Study.
- Set up nutrient balance model – Vaal Barrage to Bloemhof Dam.
- Apply model to investigate alternative management strategies such as:
- Stricter discharge standards.
- Modified hydrodynamics.
- Phosphorus free soaps and detergents.
- Economic impacts of eutrophication on water users to be quantified.

11.7 INSTITUTIONAL ARRANGEMENTS

From the above discussions it is clear that co-operation of the institutions responsible for the entire water supply chain is essential and vital to achieve the intended objectives.

Creating an environment where partnerships can be formed to tackle specific actions recommended should be encouraged.

It is recommended that a Strategy Steering Committee (SSC) be established to oversee the implementation and monitoring of the strategy.

The Strategy Steering Committee will have as its main functions and objectives:

- To ensure implementation of the recommendations of the Reconciliation strategy.
- To update the Strategy to ensure that it remains relevant.
- To ensure that the Strategy and its recommendations are appropriately communicated.

The successful development and implementation of the Reconciliation Strategy requires the main stakeholders in the study area to be actively involved in SSC. Partnerships have been established with the main stakeholders, through the Study Steering Committee and other forums and need to be continued in the Strategy Steering Committee.

11.8 SUMMARY OF RECOMMENDED ACTIONS AND RESPONSIBILITIES

11.8.1 Apply all the necessary resources to eradicate the unlawful water use as a national priority by 2011.

Action: DWAF

11.8.2 Implement Water Conservation and Water Demand Management measures to reduce losses and reduce the urban demand by at least 15% by 2014.

Action: All Metropolitan Municipalities.

11.8.3 The Department to assist the Municipalities in the implementation and supply resources (including possible options of funding) for the required Water Conservation and Water Demand Management measures.

Action: DWAF

11.8.4 Undertake a feasibility study into the use of the excess water, with as first priority the water pumped from the gold mines.

Action: DWAF

11.8.5 Implement the next infrastructure augmentation option.

Action: DWAF

11.8.6 Constitute the Strategy Steering Committee.

Action: DWAF

CHAPTER 12. STRATEGY MAINTENANCE RECOMMENDATIONS

From the start of the study it was envisaged that the Reconciliation Strategy should not be stagnant and regular revisions would be required in future to ensure the strategy remain relevant. Several aspects have been identified that should be considered in the future maintenance of the strategy and are presented in the subsequent sections.

12.1 MONITOR NET SYSTEM WATER DEMAND

In the past, annual monitoring was carried out only for the main water users receiving water from the Vaal River System. Due to the importance of urban return flows, and the impact WC/WDM could have on the return flows, it is required to also implement continuously monitoring of the return flows and to use the information to update the net water requirements of the system. This will enable regular updates of the water balance and monitoring of the situation against the scenarios presented in the document. It is recommended that System Water Balance Status Reports be compiled annually to maintain a continuous record of the water balance, and detect deviations from the scenarios.

(It should the noted that in the past WC/WDM did not play a significant role as an intervention measure and the monitoring of the demand alone was sufficient since the assumption that the return flows will remain to be a constant fraction of the demand was valid. This assumption will not be appropriate in future where intensive WC/WDM initiatives will be implemented.)

It is proposed that the System Water Balance Status Reports incorporate water requirement and return flow information for each of the respective municipalities, i.e. Johannesburg, Tshwane, Ekhuruleni, Emfuleni, Rustenburg, Mogale, Govan Mbeki, Matjhabeng and Randfontein. Although not all of these municipalities return water to the Vaal River System, the information will be used to understand the impact of WC/WDM and to compile a similar report for the Crocodile (West) River System.

12.2 REVIEW RECONCILIATION OPTIONS BASED ON RESULTS FROM RESERVE STUDY

The Comprehensive Reserve Determination Study (commissioned by the DWAF Directorate: RDM in August 2006) will produce Ecological Water Requirement Scenarios towards the end of 2010, and the implication thereof on the reconciliation options will have to be determined and evaluated.

12.3 INTEGRATION OF THE VAAL AND CROCODILE (WEST) STRATEGIES

The interdependency of the Vaal River and Crocodile (West) River systems and their respective Reconciliation Strategies was clearly demonstrated in the report. Future revisions of the strategies for these systems have to be coordinated and activities need to be synchronized to ensure coherent scenarios are formulated and the strategy revisions reflect the prevailing situations of both systems.

Consideration should be given to have shared representation on the respective Strategy Steering Committees of the two systems.

12.4 COMPLETE THE VALIDATION STUDIES FOR THE MIDDLE AND LOWER VAAL WMAS

The completion of the validation studies in the Middle and Lower Vaal Water Management Areas is required to obtain a reliable estimate of the situation regarding the irrigation water use in those areas. A product of the validation studies should be an assessment of the lawful water use. The results from the validation studies should be used to revise the projected water balance of the system.

12.5 MONITORING OF POPULATION INFORMATION

In addition to the monitoring of the water requirements it is proposed that the population statistics from Stats SA be monitored to detect deviations from the figures that were assumed in the scenarios applied for the development of the Reconciliation Strategy. Particular focus should be given to the population changes in the Gauteng Province. The frequency of the comparisons will depend on the update cycle of Stats SA.

CHAPTER 13. REFERENCES

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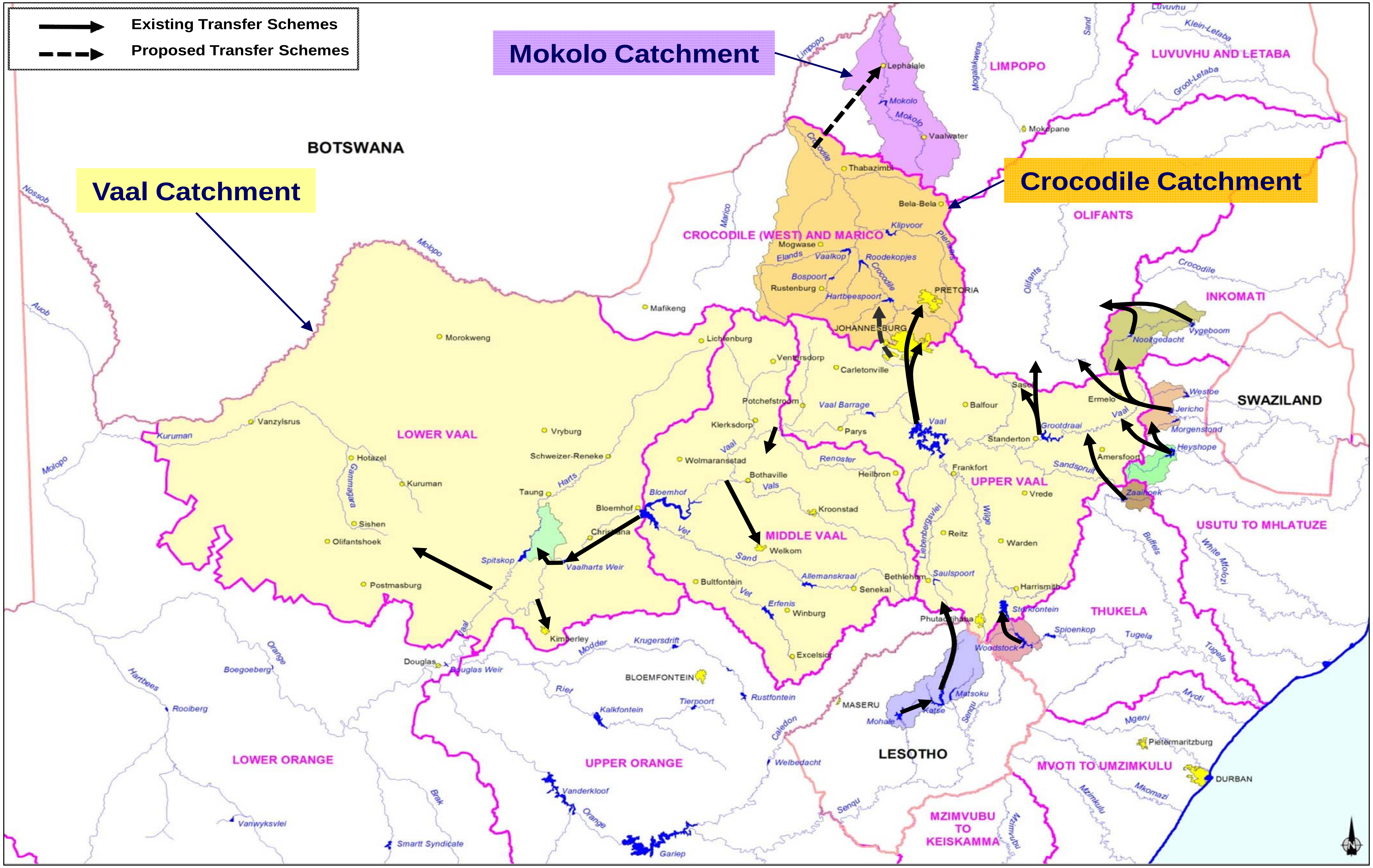
Appendix A

Figures

No:	Description
A-1	Map of the study area, Integrated Vaal River System



VAAL RIVER SYSTEM: LARGE BULK WATER SUPPLY RECONCILIATION STRATEGIES

Integrated Vaal River System

A-1

Appendix B

Water Balances for the Crocodile/Mokolo Dam System

B-1	Water balance at Lephalale - Scenario D:High
B-2	Water balance at Lephalale - Scenario D:Base
B-3	Water balance at Lephalale - Scenario D:Low
B-4	Water balance at Lephalale - Scenario C:High

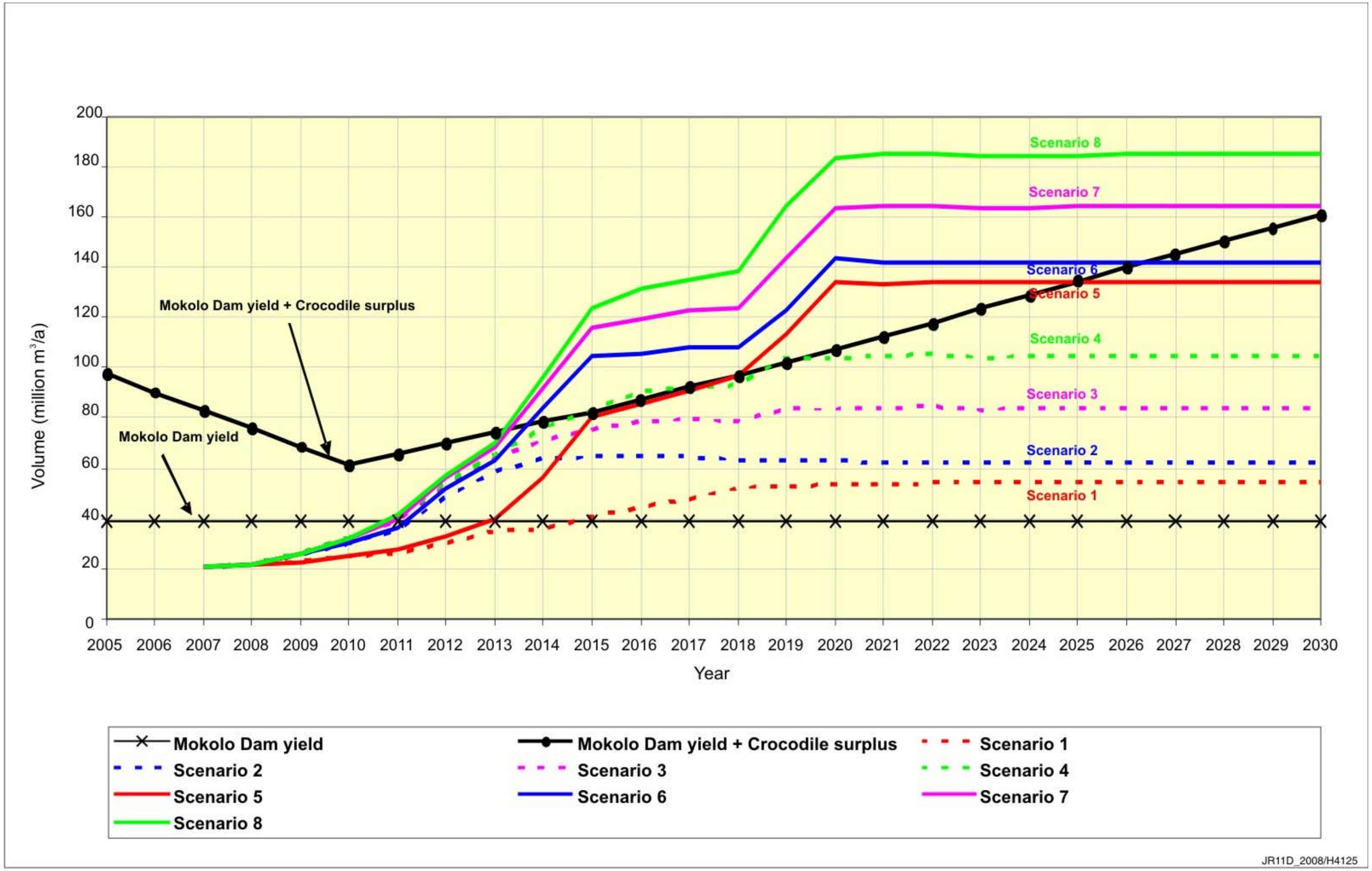


Figure B-1: Water Balance at Lephalale - Scenario D: High (DWAF, 2008a)

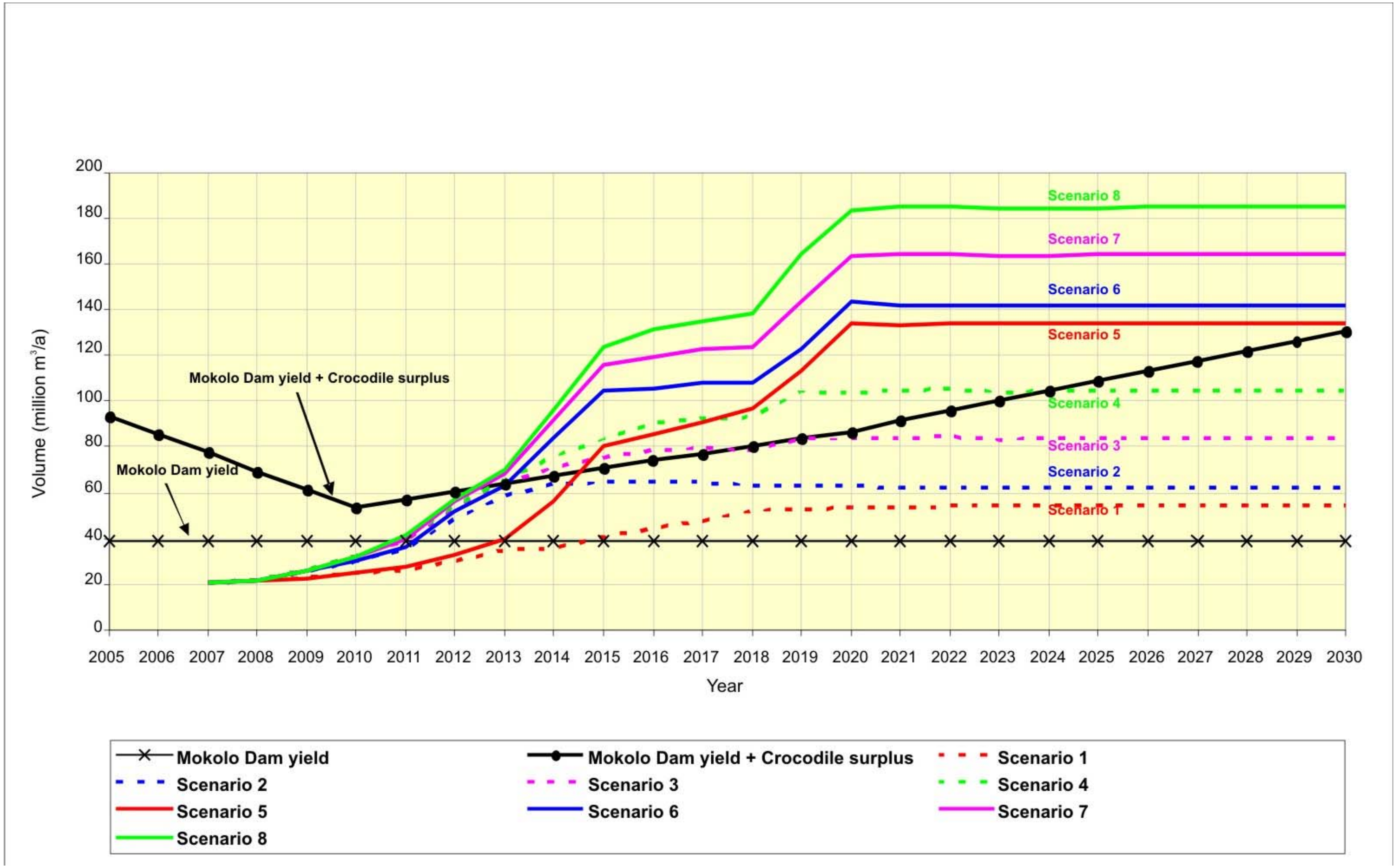


Figure B-2: Water Balance at Lephalale - Scenario D: Base (DWAF, 2008a)

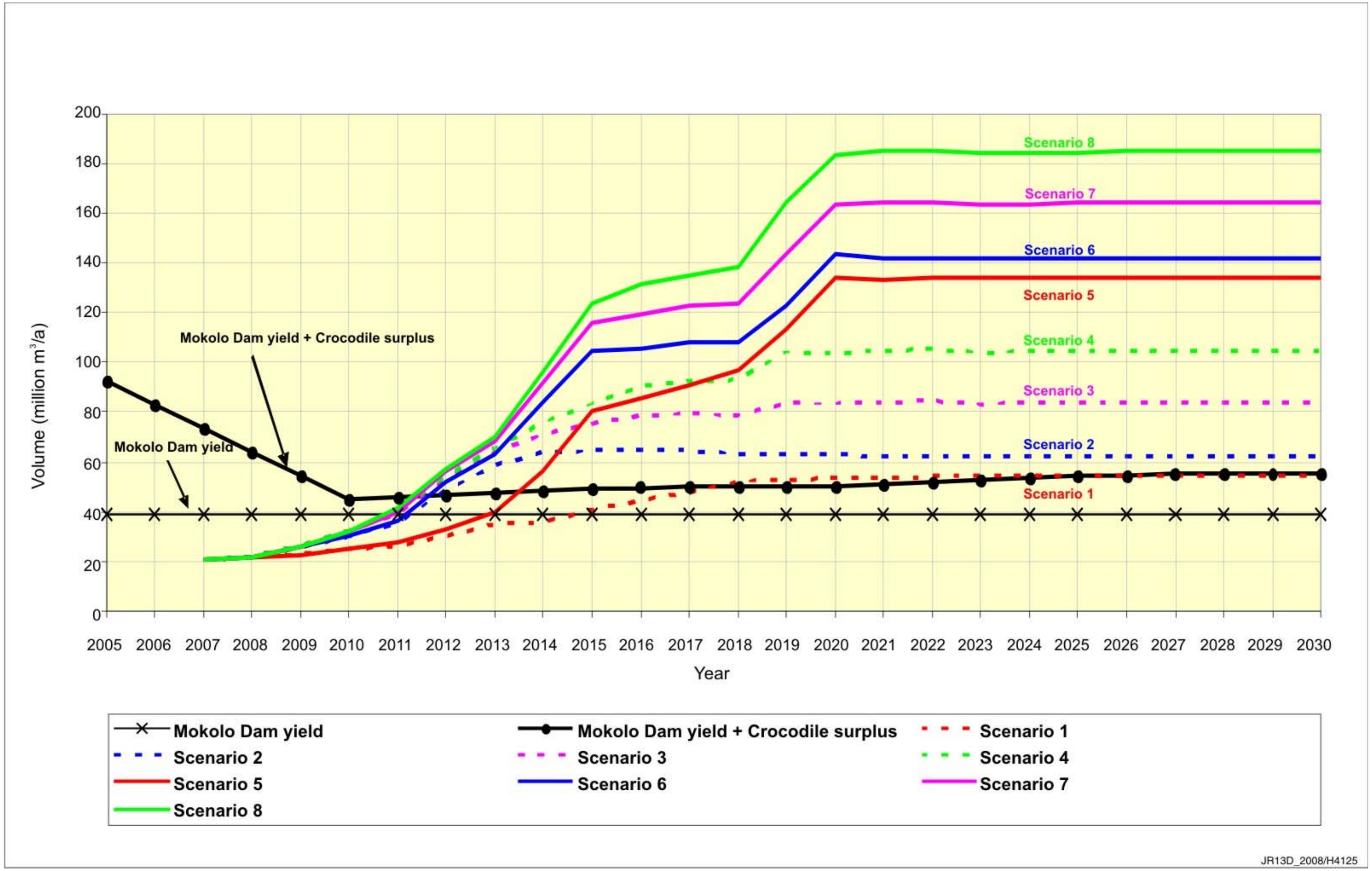


Figure B-3: Water Balance at Lephalale - Scenario D: Low (DWAF, 2008a)

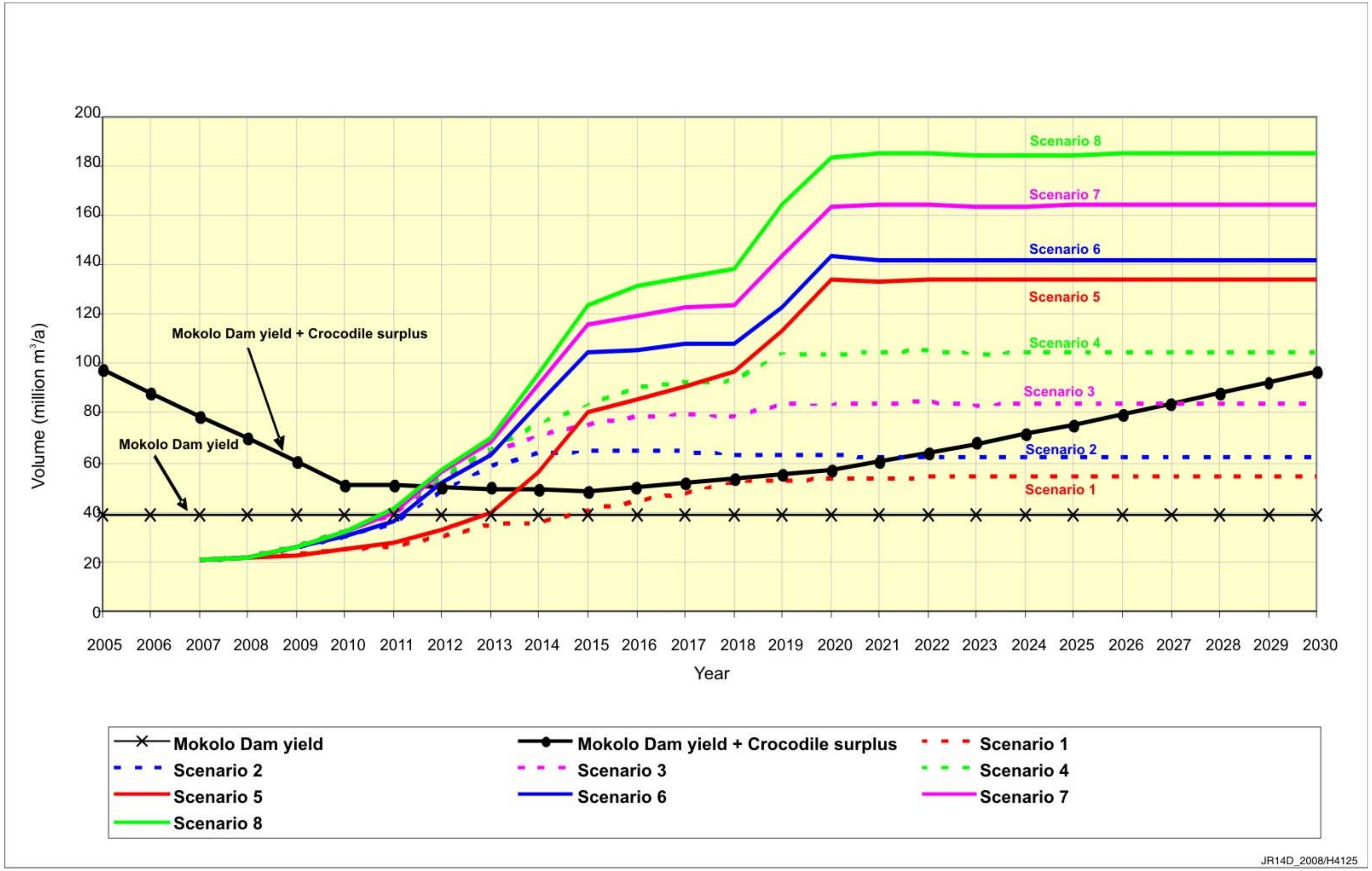


Figure B-4: Water Balance at Lephalale - Scenario C: High (DWAF, 2008a)