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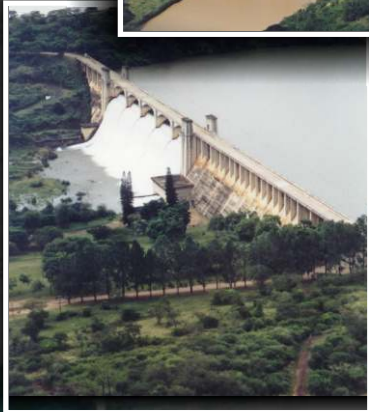


water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA
DIRECTORATE: NATIONAL WATER RESOURCE PLANNING

Water Reconciliation Strategy Study for the Kwazulu Natal Coastal Metropolitan Areas

*Second Stage
Reconciliation Strategy*



MARCH 2010

SUBMITTED BY:



WATER RECONCILIATION STRATEGY STUDY FOR THE KWAZULU- NATAL COASTAL METROPOLITAN AREAS

LIST OF REPORTS

Report No:	Title
PWMA 11/000/00/2609	Water Quality Review
PWMA 11/000/00/2509	First Stage Strategy: Water Requirements
PWMA 11/000/00/2809	First Stage Strategy: Water Conservation & Demand Management
PWMA 11/000/00/2709	First Stage Strategy: Infrastructure
PWMA 11/000/00/0907	First Stage Reconciliation Strategy
PWMA 11/000/00/1007	Second Stage Reconciliation Strategy
PWMA 11/000/00/1107	Executive Summary

Above list of reports effective as at March 2010

WATER RECONCILIATION STRATEGY STUDY FOR THE KWAZULU-NATAL COASTAL METROPOLITAN AREAS

SECOND STAGE RECONCILIATION STRATEGY

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Prepared by:

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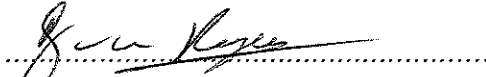
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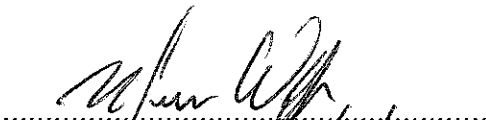


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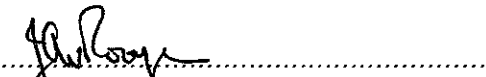
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EXECUTIVE SUMMARY

Introduction

*The KwaZulu-Natal Coastal Metropolitan Area consists of the area from Pietermaritzburg to Durban from west to east and from Kwadukuza (Stanger) in the north to Amanzimtoti in the south. It includes the eThekweni Metropolitan and the Msunduzi and Ilembe Municipalities, geographically depicted in **Figure A-1** and schematically presented in **Figure A-3**.*

The bulk water supply system of the KwaZulu-Natal coastal metropolitan area consists of an extensive network of water conveyance and treatment infrastructure (pipelines and aqueducts) transferring water from the main storage reservoirs, Midmar, Albert Falls, Nagle and Inanda Dams in the Mgeni River System and Hazelmere Dam on the Mdloti River to the users. Furthermore, the Mooi-Mgeni Transfer Scheme augments the supply of the upper Mgeni River (Midmar Dam) and in the far north of the study area, KwaDukuza in the iLembe DM, currently receives water from the Mvoti River.

This metropolitan area is the third largest contributor to the national economy and has the second largest population concentration in the country. It is the economic hub of KwaZulu-Natal and is very important for the economic well being of the province. This area is experiencing rapid growth in water demand because of the influx of people from the rural areas, economic growth, and development initiatives like the Dube Trade Port.

In order to reconcile future water requirements with the available water resources, the Department of Water Affairs(DWA) initiated this reconciliation strategy study as the next step in finding appropriate water supply solutions for the region.

The key objectives of the Study were to identify, evaluate and prioritise interventions to reconcile the water requirements with the available water resources up to the year 2030. This was achieved by means of a transparent and open process which was made possible through collaboration with stakeholders and institutions involved in the water supply cycle. The strategy received collective endorsement from the role players and several of the recommended actions have already commenced.

Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas	Second Stage Reconciliation Strategy
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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 (DWA) 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 accounts for all major aspects that influence the bulk water supply situation in the study area.

The focus of the assessments for the strategy included the following:

- *Develop water requirement and return flow scenarios by focusing on the eThekweni and Msunduzi municipal areas.*
- *Determine the potential for Water Conservation and Demand Management by concentrating on the main urban areas.*
- *Assessment of the irrigation water requirements in the various catchments.*
- *Identify and assess possible infrastructure intervention options including potential large scale water reuse options.*
- *Identify and assess several reconciliation options based on the water requirement scenarios and the identified augmentation options.*
- *Provide an initial indication of how the implementation of the Ecological Water Requirements (EWR) could influence the projected water balance situation.*

In support of the above described technical work, an integrated stakeholder engagement process was followed.

Water Requirement Scenarios

Irrigation

*The irrigation water requirements in the different catchments in the study area were estimated by comparing the data sources from various previous studies to the available information from the Water Allocation Registration Management System (WARMS) database. The comparisons were discussed with the water resource managers of the respective regional office in order to establish the most appropriate data. The irrigation requirements for the main catchments as obtained from the six different data sources that were evaluated are summarized in **Table 4.1** in the document.*

Urban Water Requirement Scenarios

*The main urban demand centers in the study area are currently supplied from four main river systems, namely the Mgeni, Mdloti, Mvoti and the Thukela River System as illustrated in **Figure A-3 in Appendix A**. The water requirements for the various demand centers will be presented according to each of the sub-systems.*

Mgeni River System

*Urban water requirement scenarios were developed for the Msunduzi Local Municipality (LM) and eThekweni Metropolitan Municipality (MM) (main water users in the study area) by applying the Water Requirement and Return Flow Model (**DWA, 2004b**) for the planning period up to 2030. One of the driver variables in the model is population and scenarios were developed from a detailed assessment of the various population databases by Dr. McCarthy (KwaZulu-Natal demographic specialist) as part of the study (**DWA, 2007d**).*

*The Water Requirement and Return Flow Model was configured for 53 Sewage Drainage Areas (SDAs) and calibrated for the year 2006. The calibration involved changing model parameters to match both the water use and return flows observed for each SDA for the year 2006. The Water requirement projections were derived for three scenarios as illustrated in **Table 1**.*

*The total gross water requirement projection for the Mgeni River System was developed by combining the water requirement projections of both the Msunduzi and eThekweni municipal areas with the projections derived by Umgeni Water for the portions of uMgungundlovu DM and Ugu DM that are supplied from the Mgeni River. The water requirement projections for the three scenarios are illustrated in **Figure 4.8** in the document. The Umgeni Water projection for the Mgeni System is also illustrated.*

Table 1: Mgeni River water requirement scenarios

Scenario	Description
<i>Scenario A</i>	<p>High population projection</p> <p>Improved water supply services</p> <p>Indirect water use increased in identified SDAs according to economic analysis (Hammarisdale, Cato Ridge, Hillcrest, Southern, Umhlanga, Phoenix, Verulam, Tongaat)</p> <p>Indirect water use in remaining SDA's increased by the same ratio as the direct water use requirements</p>
<i>Scenario B</i>	<p>Low population projection</p> <p>Improved water supply services</p> <p>Indirect water use increased in identified SDAs according to economic analysis (Hammarisdale, Cato Ridge, Hillcrest, Southern, Umhlanga, Phoenix, Verulam, Tongaat)</p> <p>Indirect water use in remaining SDA's increased by the same ratio as the direct water use requirements</p>
<i>Scenario C</i>	<p>Medium population projection</p> <p>Improved water supply services</p> <p>Indirect water use increased in identified SDAs according to economic analysis (Hammarisdale, Cato Ridge, Hillcrest, Southern, Umhlanga, Phoenix, Verulam, Tongaat)</p> <p>Indirect water use in remaining SDA's increased by the same ratio as the direct water use requirements</p>

Mdloti River System

The majority of the water supplied from the Mdloti River through the Hazelmere Dam is to the northern parts of eThekweni MM and Siza Water (supply Ballito and Dolphin Coast areas). The remainder is supplied to Ndwedwe, Groutville and periodic transfers to KwaDukuza. Existing water

requirement projections were adapted from the Water and Sanitation Master Plan for the iLembe District Municipality (**Scenario M-A**) (DWA, 2007b) and from Umgeni Water (**Scenario M-B**). The water requirement projections for the Mdloti System are illustrated in **Figure 4.9** in the document.

Mvoti River System

Water is currently supplied from the river abstraction on the Mvoti River to KwaDukuza. Water requirement projections for KwaDukuza and the surrounding towns were obtained from the Water and Sanitation Master Plan for the iLembe District Municipality (DWA, 2007b). The purpose of the master plan was to plan bulk supply schemes to all areas in iLembe. The projections were therefore compiled for the total water requirements that would ultimately be required by 2036. It was assumed that the total bulk supply scheme would take time to implement and that the current water use of 10.5 million m³/annum would increase to what was projected by 2012. The water requirement projection is illustrated in **Figure 4.10** in the document.

Lower Thukela River System

The lower Thukela River System is defined as the river section between Kranskop and the Thukela Mouth in this report. A water requirement projection for the Lower Thukela supply area (**Scenario T-A**) was adopted from the iLembe Master Plan (DWA, 2007b). The projection shown in **Figure 4.11** of the document excludes the existing demands and only includes the projected growth in demands in order to compare the projection to the existing available yield in the Lower Thukela System.

Potential Savings through Water Conservation and Water Demand Management Measures

The Msunduzi LM and eThekweni MM where the main focus of the study as they hold the greatest potential for savings. This does not mean that the smaller areas should not undertake WC/WDM, but potential savings in these areas were assumed to be small compared with the greater supply area. 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 the water requirements of Scenario A and were labeled **Scenarios A.1, A.2 and A.3** respectively. The description and saving results from the scenarios are as follows:

- **Scenario A.1:** 5 years water loss programme
- **Scenario A.2:** 5 years water loss programme and efficiency.
- **Scenario A.3:** 10 years water loss programme

A summary of the estimated savings in water requirements of the three above-mentioned scenarios for the Mgeni River System are presented in **Table 2**.

Table 2: Savings for the indicated planning years: Scenario A.1, A.2 and A.3 compared to Scenario A

Scenarios	Planning Years					
	2007	2011	2016	2021	2026	2031
A.1	5.4 (1.5%)	33.8 (8.6%)	42.7 (9.9%)	44.9 (9.5%)	47.2 (9.3%)	49.6 (9.1%)
A.2	5.4 (1.5%)	33.8 (8.6%)	61.4 (14.3%)	91.9 (19.4%)	113.0 (22.2%)	121.7 (22.4%)
A.3	5.4 (1.5%)	20.1 (5.1%)	39.2 (9.1%)	44.9 (9.5%)	47.2 (9.3%)	49.6 (9.1%)

- Notes:
- (1) All volumetric values are given in million m³/annum.
 - (2) Values in brackets give the percentage reduction in the total system urban demand from **Scenario A**.

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 for the Mgeni, Mdloti, Mvoti and Lower Thukela River Systems. 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 following infrastructure intervention options were considered:

- **Mooi-Mgeni Transfer Scheme Phase 2 (Spring Grove Dam):** The scheme consists of the Spring Grove Dam on the Mooi River with a pump station and transfer infrastructure to transfer the water to Midmar Dam on the Mgeni System. The yield of the Spring Grove Dam has been determined as 60 million m³/annum. The implementation timeframe for the scheme is 4 years.
- **Mkomazi-Mgeni Transfer Scheme Phase 1 (Smithfield Dam):** The scheme consists of an initial dam on the Mkomazi River near Smithfield, with a pump station and transfer tunnel to

transfer the water to the Mgeni System. The yield of the Smithfield Dam has been determined as 147 million m³/annum. The implementation timeframe for the scheme is 10.5 years.

- **Mvoti River development Option (IsiThundu Dam):** *The Mvoti Development Scheme consists of a dam on the Mvoti River near IsiThundu; abstraction works, a pump station, transfer infrastructure. The yield of the IsiThundu Dam has been estimated as 46.3 million m³/annum. The scheme has an implementation time frame of 10 years.*
- **Lower Thukela Scheme:** *The Lower Thukela Scheme includes the utilisation of the unused yield in the Lower Thukela and consists of abstraction works, pump station and transfer infrastructure. The maximum available yield in the Lower Thukela was estimated as 77 million m³/annum. The yield included the available yield in the Lower Thukela of 45 million m³/annum and the unused allocation of Mhlathuze Water of 32 million m³/annum. The scheme has an implementation plan of 5 years.*
- **Waste Water Reuse Options:** *The option includes the indirect re-use of the treated effluent from the Kwamashu (location allows supply to both the Mgeni supply area and the north coast metropolitan area), Northern and the North Coast waste water treatment plants (Tongaat, Verulam and Phoenix). The implementation timeframe is 5 years.*

Both the infrastructure and the WC/WDM options were evaluated economically by calculating the net present values (NPV) and the comparative Unit Reference Values (URV) at a reconnaissance level of detail.

Desalination of Sea Water

A study to investigate the feasibility of desalination of sea water as an option to provide additional domestic water is being undertaken by Umgeni Water. Initial results suggest that desalination of sea water is becoming economically competitive and should be investigated further.

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:** *The option of utilising the Lower Thukela Scheme for supplying and supporting the Mvoti and Mdloti supply areas respectively was investigated. The various interventions for the Mgeni System were also investigated. The water requirement projection **Scenario A.1** was used for the Mgeni System.*

- **Scenario II:** *The option of utilising only the currently existing yield of the Lower Thukela Scheme (45 million m³/annum) and developing the Mvoti River for supplying and supporting the Mvoti and Mdloti supply areas respectively was investigated. The purpose of **Scenario I and II** was to investigate the two alternative options in order to observe their respective constraints and opportunities. The water requirement projection **Scenario A.1** was used for the Mgeni System.*
- **Scenario III:** *The purpose of **Scenario III** was to investigate the impacts of the implementation of efficiency measures through WC/WDM. **Scenario III** was similar to Scenario I with **Scenario A.2** used as the water requirement projection.*
- **Scenario IV:** *The scenario assumed that the treated wastewater from some of the WWTW's supply the estuarine water requirements for the Mdloti and Tongati Rivers. The scenario was conducted for investigative purposes and was not taken further. The water requirement projection **Scenario A.1** was used for the Mgeni System.*
- **Scenario V:** *The purpose of the scenario was to determine the impact on the water resources if the projected return flow growths of the re-use options and additional identified re-use options are included. The water requirement projection **Scenario A.1** was used for the Mgeni System.*
- **Scenario VI:** *The purpose of the scenario was to determine the impact on the water resources systems if the re-use options were excluded as interventions in order to illustrate the importance of re-use.*
- **Scenario VII:** *The purpose of this scenario was to establish the interventions required to supply the water needs of a large proposed theme park development north of the Thukela River in the Ilembe Municipal Area. The information for the proposed developments was obtained from the "Ngcebo 3: Bulk Water Services: Planning Report" (Ilembe, 2008), which became available after the First Stage Reconciliation Strategy was finalised.*

*The reconciliation scenario results are described in **Section 9** of the document and shows that interventions are urgently required to address the current shortages as indicated by the water balances. The implementation of various augmentation options to reconcile the future water requirement and resource availability are necessary to maintain an acceptable assurance of supply. The main findings from the reconciliation scenario results and the strategy recommendation are presented in subsequent sections.*

Rainwater Harvesting

Rainwater harvesting (rainwater collection with for instance roof tanks) is another method of extending the water resource that was investigated by the study. A preliminary analysis was conducted using conventional methods of yield determination, to assess the yield (Historic Firm Yield (HFY)) that could be achieved through rainwater harvesting in the eThekweni Municipal Area as part of the First Stage Reconciliation Strategy. Although it proved to not have a major impact on reduction of municipal water demand, rainwater harvesting does have considerable benefits. It would allow users to limit their dependence on formal water supply, it could assist with subsistence food gardening, in times of severe water restrictions it would provide important relief for basic needs and above all it would stimulate a culture of efficient water use.

Rainwater harvesting was investigated in more detail during the development of Second Stage Reconciliation Strategy. An analysis was conducted where rainwater harvesting is utilised as a conjunctive use with a reliable alternative source such as normal municipal reticulation (lower assurance of supply). This also included an economic analysis where the benefits of rainwater harvesting were assessed from both a user's perspective and the municipality's perspective. The findings from this analysis were more favourable than the analysis conducted using conventional methods of yield determination.

Perspective on Water Quality Management

Water quality data and water quality reports from previous studies were used to develop an understanding of the water quality profiles of the major rivers in the study area. The situation assessment indicated that, with respect to salinity and nutrients (Phosphate and Nitrate), the Mkomazi, Mooi, Mdloti and Mvoti River Systems are acceptable. An increasing trend in nutrients and ammonium concentration have however been observed in the Mooi River.

The water quality in the upper Mgeni River (Midmar Dam) is good, however the situation deteriorates further downstream. The water quality deteriorates significantly a distance below Nagle Dam, where the Mgeni River is joined by the Msunduzi tributary. The water quality is very poor with high conductivity, very high faecal contamination indicating sewage pollution, very high nitrate concentrations, high ammonium, high phosphorus and high turbidity occurring mainly due to the confluence with the Msunduzi River.

Conclusions

Given the results from the reconciliation scenarios as well as the economic comparisons, water quality and other considerations presented in the document the following conclusions can be made:

- *The short-term shortages in the water balance of all the systems in the study area need to be managed and the only measure that can alleviate the problem is through the implementation of WC/WDM measures as well as early drought restrictions in the water use.*
- *The implementation of interventions to reduce water losses in the urban areas will reduce the shortages in the Mgeni River and Mdloti River systems, however, the water balance remains negative even if the waste management measures for **Scenario A.1** are implemented. It is therefore essential to augment the system as a priority action.*
- *To this end, the Mooi-Mgeni Transfer Scheme Phase 2 (Spring Grove Dam) and the raising of Hazelmere Dam should be implemented immediately to provide additional resources and will prevent unacceptable high risks of water restrictions during drought periods.*
- *The water balance of the Mvoti River System shows there are currently shortages and the implementation of the North Coast Pipeline for short-term support to Kwadukuza (from the Mdloti System) and support over the long term to the Mdloti System (bi-directional pipeline) should be implemented. (The North Coast Pipeline will link the Mdloti and Mvoti systems.)*
- *The available water in the Lower Thukela River System can be utilised to alleviate the shortages in the Mdloti and Mvoti River systems over the medium term and has the benefit of a significantly shorter implementation period compared to the Mvoti River Development Option (IsiThundu Dam).*
- *Large volumes of treated wastewater are available for re-use through further treatment and direct and indirect supply options have been identified to augment the Mgeni and Mdloti River systems. Re-use options have significantly shorter implementation periods compared to the large dams and the preliminary economic evaluations indicate that the re-use options are comparable to the dam schemes.*
- *The Mkomazi River Transfer Scheme (Smithfield Dam) and the Mvoti River Development (IsiThundu Dam) are necessary developments to reconcile the water balance over the long term. Due to the long lead times for implementing these schemes it is advisable to proceed*

with detailed feasibility studies of both options and have the flexibility to expedite or delay the decision to implement based on the water supply status in future.

- *Implement mechanisms for the monitoring and management of the poor water quality in the Msunduzi and lower Mgeni River System. This should also be implemented in the Mooi River System, where the water quality is deteriorating.*
- *Rainwater harvesting is a viable alternative supplementary source if used in conjunction with the normal municipal supply and is economic beneficial to both the municipality and the end user.*
- *Desalination of sea water appears to be approaching economic viability and should be further investigated.*

Strategy Recommendations

The study identified a number of specific actions, required for sustainable management of the water resources in the KZN study area. These are summarised as follows:

1. Priority infrastructure implementation projects

(a) Urgently Implement the Mooi-Mgeni Transfer Scheme (Spring Grove Dam and transfer system). The Department has recently directed the Trans-Caledon Tunnel Authority (TCTA) to implement Phase-2 of the Mooi-Mgeni Transfer Scheme (MMTS-2 - Spring Grove Dam and associated transfer infrastructure).

Action: National Water Resource Infrastructure Branch / TCTA

Timing: Immediate

(b) Implement the Raising of Hazelmere Dam without delay.

Action: National Water Resource Infrastructure Branch

Timing: Immediate

(c) Implement the North Coast Pipeline for short term support to KwaDukuza and long term support to the Mdloti System (bi-directional pipeline). Undertake planning and implement water treatment and related infrastructure to utilise the additional yield from the raised Hazelmere Dam.

Action: Umgeni Water

Timing: To start immediately

2. Priority Feasibility Studies

(a) *Proceed with the Feasibility Study of the Mkomazi River Transfer Scheme.*

Action: DWA Directorate: Option Analysis

Timing: Begin study immediately

(b) *Commission a feasibility study of the Thukela and Mvoti systems for supply to the Northern Areas. Details regarding the structure of further planning activities will be decided among the relevant directorates of DWA. Umgeni Water may assist with transfer infrastructure.*

Action: DWA Directorate: Option Analysis to coordinate

Timing: Begin study immediately

(c) *Commission a feasibility study for water re-use options for supply to the Mgeni River System and the North Coast (consider current and future wastewater sources).*

Action: eThekweni Metro with support from DWA and Umgeni Water

Timing: Study already underway

(d) *Commission a feasibility study for the desalination of sea water for supply to the Mgeni River System and the North Coast.*

Action: DWA, eThekweni Metro and Umgeni Water

Timing: Begin study immediately

3. Water Use Efficiency

(a) *Ethekweni and the other municipalities implement further WC/WDM measures. A detailed action plan must be developed urgently.*

Action: Ethekweni, Ilembe, Msunduzi, Ugu and Umgungundlovu municipalities as well as DWA Directorate Water Use Efficiency

Timing: Immediate

(b) *Rain Water harvesting should be actively encouraged. Current projects by Ethekweni serve as examples and the lessons learned will inform further initiatives and programs. Further activities should be initiated and coordinated by the Directorate Water Use Efficiency of DWA.*

Action: DWA Directorate Water Use Efficiency

Timing: Ongoing

4. Institutional Arrangements

(a) *Constitute the System Operation Management Forum and promote active involvement in the operational management of the Mgeni and Mdloti river systems among the relevant institutions. The representatives should include decision makers, managers responsible for system operation and representation from bulk water users such as industry and agriculture.*

Action: DWA KZN Regional Office

Timing: Immediate

(b) *Convert the Study Steering Committee into a Strategy Steering Committee as soon as the Reconciliation Strategy has been finalised.*

Action: DWA Directorate: National Water Resource Planning and Study Steering Committee

Timing: At the end of the study

(c) *Establish a forum where information on projects and measures to save water are discussed and experiences are exchanged.*

Action: Umgeni Water to coordinate

5. Communication

(a) *Embark on a well structured media campaign to support all the short term actions.*

Action: DWA KZN Regional Office and municipalities

Timing: Immediate.

Stakeholder Participation

During the course of the study several Stakeholder Participation meetings were held for different purposes. A Study Steering Committee (SSC) was established to guide the development of the Reconciliation Strategy, representing industrial, agricultural, environmental, water service providers and local government sectors. The following Stakeholder Participation meetings were held:

- *Public Meeting No. 1 (20 June 2007)*
- *SSC Meeting No. 1 (18 October 2007)*
- *SSC Meeting No. 2 (28 February 2008)*
- *Public Meeting No. 2 (31 March 2008)*

- *SSC Meeting No. 3 (11 August 2008)*
- *SSC Meeting No. 4 (3 December 2009)*

In addition, eight Study Technical Committee (STC) meetings were held where the technical progress of the study was presented and discussed in detail with the key partner organisations.

Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas

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APPENDIX A: MAPS AND DIAGRAMS

APPENDIX B: RAINWATER HARVESTING REPORT

Acronyms

DM	District Municipality
DWA	Department of Water Affairs
EWR	Ecological Water Requirement
HFY	Historic Firm Yield
ISP	Internal Strategic Perspectives
KZN	KwaZulu-Natal
LM	Local Municipality
MM	Metropolitan Municipality
MMTS	Mooi-Mgeni Transfer Scheme
NPV	Nett Present Value
NWRIB	National Water Resources Infrastructure Branch
NWRP	National Water Resource Planning
OA	Options Analysis
RDM	Resource Directed Measures
RDP	Reconstruction and Development Programme
SDA	Sewage Drainage Area
SRP	Soluble Reactive Phosphorous
SSC	Study Steering Committee
TCTA	Trans-Caledon Tunnel Authority
URV	Unit Reference Value
UW	Umgeni Water
WC/WDM	Water Conservation and Demand Management
WSA	Water Services Authority
WSP	Water Services Provider
WARMS	Water Allocation Registration Management System
WRYM	Water Resources Yield Model
WWTW	Waste Water Treatment Works
UARL	Unavoidable Real Losses

Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs (DWA) has identified the need for the Reconciliation Study in the report “Internal Strategic Perspective for the Mvoti to Mzimkulu Water Management Area” (DWA, 2004a). The motivation for the study has arisen from the rapidly growing water requirements of the Kwa-Zulu Natal (KZN) metropolitan area which are a result of the expanding economy, urbanisation of the population in the KZN Province and improved water supply services. Water Conservation and Water Demand Management initiatives by eThekweni District Municipality and other Water Service Authorities (WSAs) were successful in slowing the increasing water requirement trend, however, water balance projections (water requirements versus availability comparisons) indicates potential shortfalls in supply is expected to occur and that there is an imminent need for management intervention.

DWA and other institutions involved in the management of the water resource and supply systems of the KZN Metropolitan Area have in the past carried out various studies on intervention measures to improve the water supply situation. The knowledge base that has been created by these studies provides a sound and essential platform from which the Reconciliation Strategy has been developed. In order to harness this information a Literature Review Report (DWA, 2007a) was compiled to summarise the available information in one document and also present a synthesis of the information by highlighting the pertinent aspects of Integrated Water Resource Management that were assessed and incorporated in the reconciliation strategy.

The reconciliation strategies for the KwaZulu-Natal Coastal Metropolitan Area were developed in two stages. The first stage involved developing and assessing scenarios of possible future reconciliation options which were then presented to DWA 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 MAIN OBJECTIVES OF THE STUDY

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2030. The development of the strategy requires reliable information on the water requirements and return flows (wastewater), the available water resources for the current situation as well as likely future scenarios for a planning horizon of twenty to thirty years. The following main aspects were covered in the study:

- Update the current and future urban and agricultural water requirements and return flows;
- Assess the water resources and existing infrastructure;
- Formulate reconciliation interventions, both structural and administrative/regulatory;
- Document the reconciliation process including decision processes that are required by the strategy; and
- Conduct stakeholder consultation in the development of the strategy.

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 page after the cover page of the report. The information from the task reports was combined to formulate the Second Stage Reconciliation Strategy, the main deliverable from the study, which is presented in this report.

1.3 STUDY AREA

The focus study area stretches from the KwaZulu-Natal North Coast to the Mgeni System (including the Mooi-Mgeni Transfer) with a transfer of water to the South Coast (commissioned by 2010). The area includes portions of the Mngungundlovu, iLembe and Ugu District Municipalities, the Msunduzi Local Municipality and the eThekweni Metropolitan Municipality's area of jurisdiction, see **Figure A.1** in **Appendix A** for a map of the study area. The study area was divided into two components, namely the total area from where the water is sourced (Source Study Area) and the area to which water is supplied (Primary Study Area).

The bulk water supply system of the KwaZulu-Natal coastal metropolitan area consists of an extensive network of water conveyance and treatment infrastructure (pipelines and aqueducts) transferring water from the main storage reservoirs, Midmar, Albert Falls, Nagle and Inanda Dams

in the Mgeni River System and Hazelmere Dam on the Mdloti River to the water users. Furthermore, the Mooi-Mgeni Transfer Scheme augments the supply of the upper Mgeni River (Midmar Dam) and in the far north of the study area Kwadukuza, in the iLembe DM, receives water from the Mvoti River.

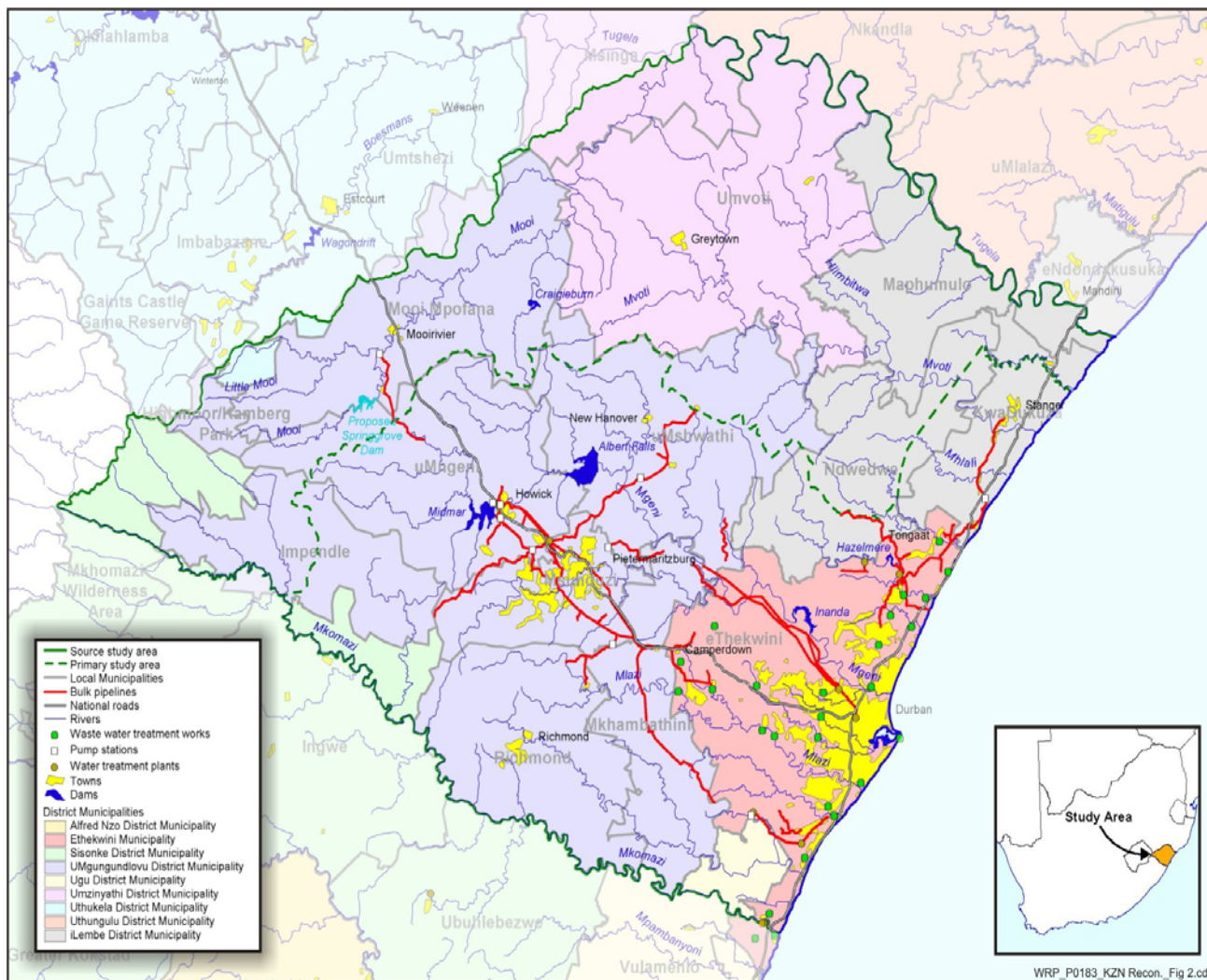


Figure 1.1: Study Area

1.4 PURPOSE AND LAYOUT OF THIS REPORT

This report describes the Second Stage Reconciliation Strategy for the KwaZulu-Natal coastal metropolitan areas and serves as a summary document that collates information of other technical reports that were compiled in the study.

Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas	Second Stage Reconciliation Strategy
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The introduction, given in **Section 1**, is followed by descriptions of the study procedure and the reconciliation strategy development methodology in **Section 2** and **Section 3** respectively. **Section 4** describes the water requirement and return flow scenarios on which the water conservation and water demand management scenarios, presented in **Section 5**, were based. The infrastructure intervention options to augment the study areas water needs are discussed in **Section 6**. The results from the first six chapters are used to determine the requirements for future interventions to reconcile the demand with the available supply, as presented in **Section 7** to **Section 9**. A brief perspective on water quality management aspects are provided in **Section 11**. The report concludes with four chapters covering: conclusions, stakeholder engagement process during the study, strategy recommendations and finally, the references used in the report are presented in **Section 15**.

2 STUDY PROCEDURE

The study has been structured into three phases as shown in **Figure 2.1**. The **first phase** is the Inception Phase, where the focus was on collecting and assimilating available information and initiating the stakeholder engagement process. The **second phase** involved developing the First Stage Reconciliation Strategy (**First Stage Strategy**) that focused on identifying local drivers responsible for the present growth in water and by using local economic factors, socio-economic household profiles, socio-political interventions by government and local demographic trends, water requirement scenarios up to 2030 were derived. For the **third phase**; the Second Stage Reconciliation Strategy (**Second Stage Strategy**), the comments received from the First Stage Strategy as well as additional information that became available was incorporated and the strategy was refined in view of identified issues.

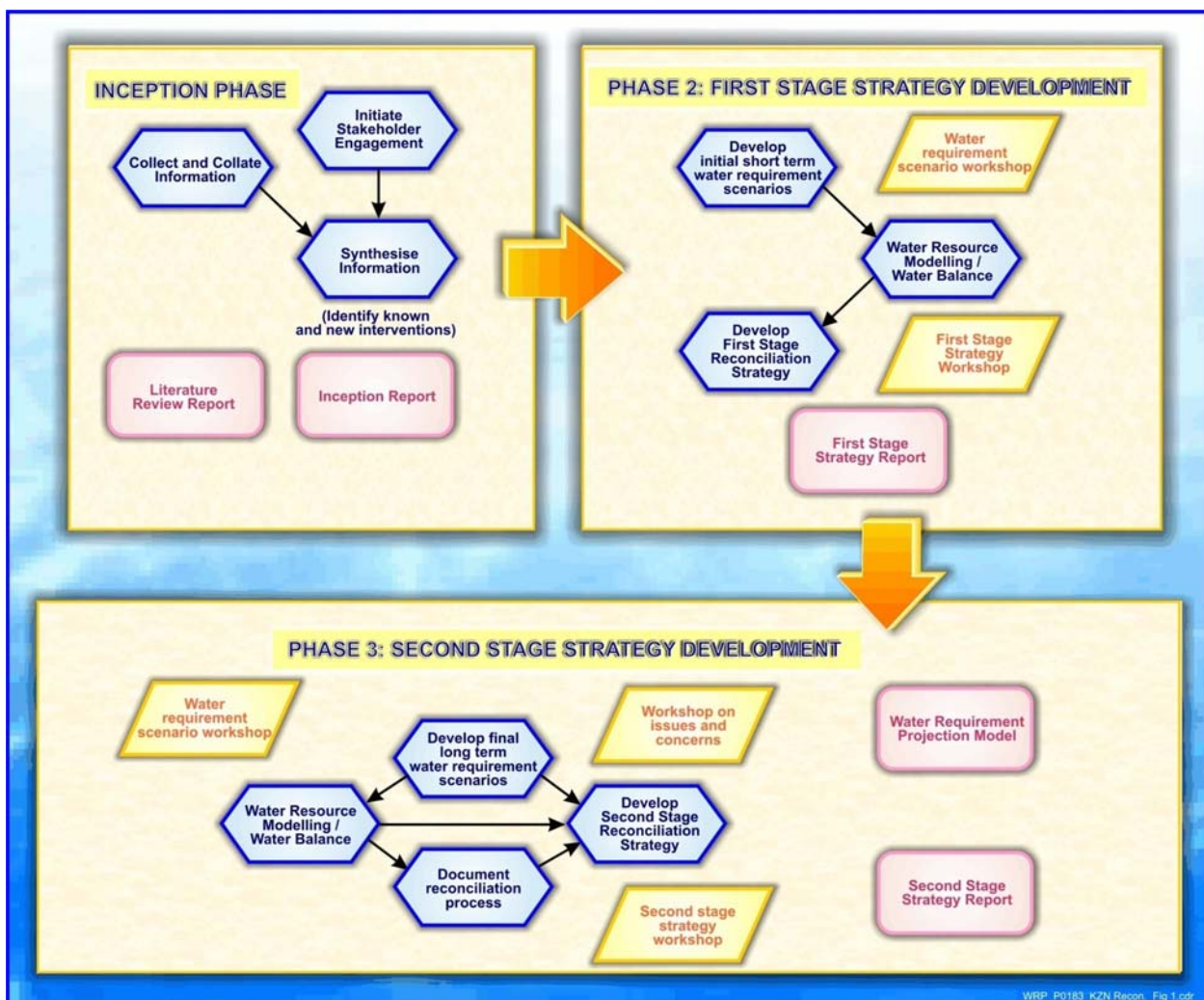


Figure 2.1: Schematic presentation of the Reconciliation Study structure

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

- Developed water requirement and return flow scenarios by focussing the assessments on the eThekweni, Msunduzi and ILembe municipal areas.
- Assess the irrigation water requirements in the study area by comparing the data sourced from the Water Allocation Registration Management System (WARMS) database to the information obtained from various studies conducted in the study area.
- Determined the potential for Water Conservation and Water Demand Management (WC/WDM) 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.
- Identified and assessed possible infrastructure intervention options including the potential of large scale water re-use options that could have water quality and water supply benefits.
- Identified and assessed several reconciliation options based on the water requirement scenarios and the identified augmentation options.
- Provided an initial indication of how the implementation of the Ecological Water Requirements (EWR) could influence the projected water balance situation.

The successful development and implementation of such water reconciliation strategies requires the main stakeholders in the study area to be actively involved in both processes. During the first phase of the project, partnerships were established with the main stakeholders, which included the WSA's (Msunduzi Local Municipality, eThekweni Metropolitan Municipality, iLembe District Municipality and Ugu District Municipality), Umgeni Water and Siza Water. The organisations were consulted with regard to information sourcing for the various study tasks and they also contributed towards the transparent process of developing the first stage strategy.

In support of the above described technical work, an integrated stakeholder engagement process, which consolidated the communication needs, was followed as depicted graphically in **Figure 2.2**.

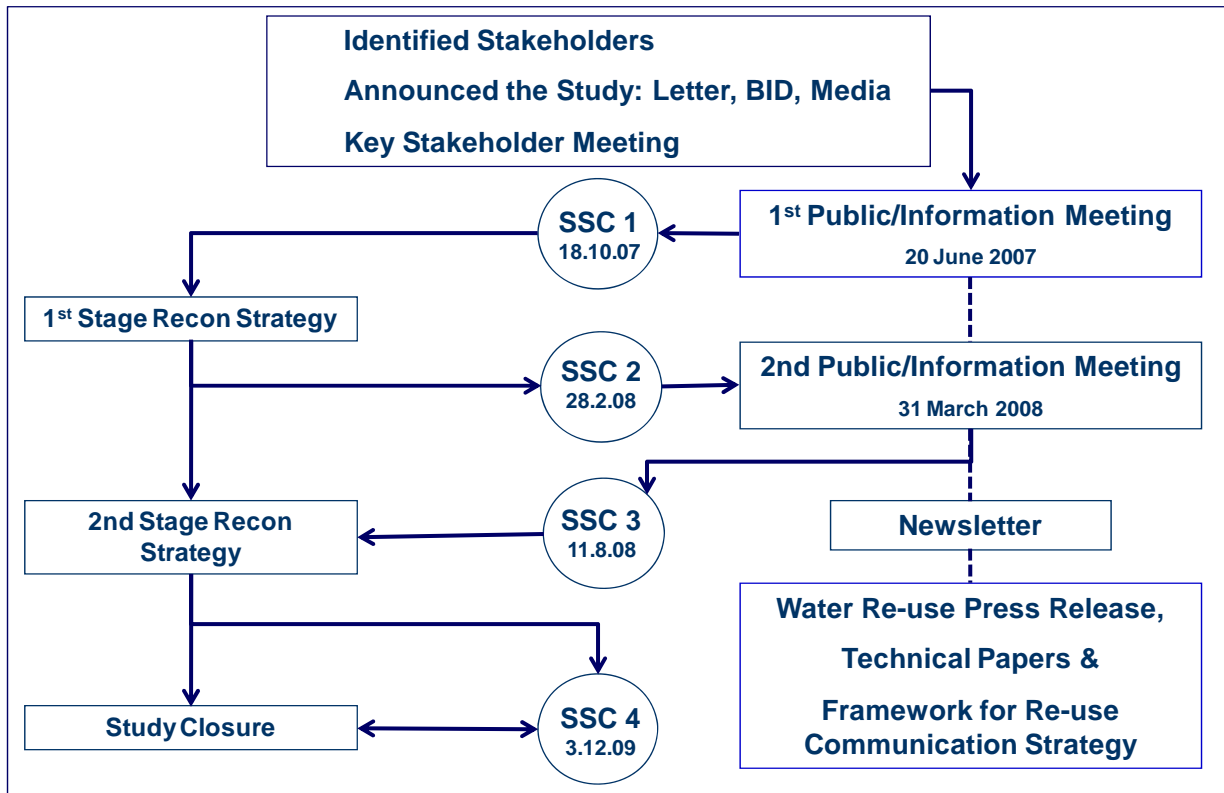


Figure 2.2: Stakeholder engagement process.

3 RECONCILIATION STRATEGY DEVELOPMENT METHODOLOGY

3.1 OVERVIEW

The development of strategies to reconcile the water requirements with the available water in the various river systems in the KwaZulu-Natal Coastal Metropolitan Areas has to be founded on a sound understanding of the projected future water balance up to the year 2030. 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 a 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. DWA has over the years developed sophisticated analysis techniques and decision support systems to determine the water availability. The approach taken in this study was 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 none of the hydrology databases for the various systems 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, estimating the irrigation water requirements, identifying potential large bulk water re-use opportunities and obtaining preliminary indications of the reconciliation situation in meeting the Ecological Water Requirements (EWR). A desktop collation and assessment of all readily available “high level environmental information” that was required for the study was carried out for the main river systems in the study area, namely the Mvoti, Tongati, Mdloti, Mgeni; and the Mkomazi river systems.

Once the quantification of the above-mentioned “demand side” components had been completed, scenarios were defined to represent possible future conditions for the different river systems. These scenarios were then analysed according to the available water resources and the years in which intervention measures should be commissioned were established. These interventions could be measures on either side of the water balance, such as more intensive water conservation projects or the development of an infrastructural solution in the form of new water resource augmentation schemes. An economic analysis was conducted for the various intervention options

and scenarios by calculating the Unit Reference Values (URV's) for each of the options and scenarios for comparative purposes.

Based on the outcome of the water balances developed for the various river systems and the investigation of the various intervention options, the First Stage Reconciliation Strategy was developed.

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

3.2 URBAN WATER REQUIREMENT 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 occur in the country and the region. 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 river systems in the study area.

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 (**DWA, 2004b**). 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.

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 (see **Section 4.2**).

3.3 ASSESSMENT OF THE IRRIGATION WATER REQUIREMENTS

Water requirements of the irrigation sector have been the subject of various studies in the past. Information from the separate studies conducted on the different river system catchments in the study area were used in recent water resources planning investigations. The water use registration process commissioned by DWA has generated a further source of information in the form of the Water Allocation Registration Management System (WARMS). At the time the

irrigation water requirement task was carried out, no validation studies had been commissioned by DWA in the different catchments within the study area. As a result the approach followed to assess the irrigation water use in the different catchments was to compare the data sources from previous studies with the available information in the WARMS database. These comparisons were then discussed with the water resource managers of the respective regional office to decide on the most appropriate data to be use for this study.

3.4 POTENTIAL SAVINGS FROM WATER CONSERVATION AND WATER DEMAND MANAGEMENT

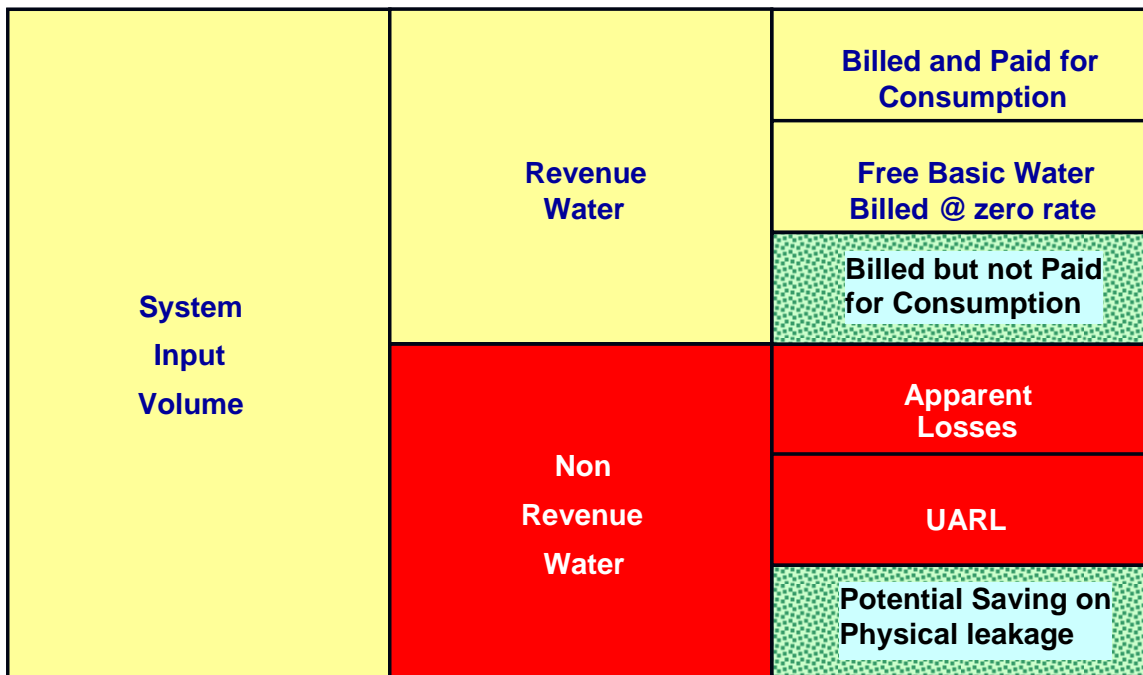
The purpose of the task was to determine the potential water conservation and water demand management (WC/WDM) savings that could be achieved in the main urban centres and key demand centres in the study area. The reader is referred to the First Stage Strategy: Water Conservation and Demand Management Report (**DWA, 2008a**) of the same study for more detail. The demand centres that were focussed are shown in **Table 3.1** and the total consumption of the demand centres was 349.19 million m³/a in 2006.

Table 3.1: Major municipal demands considered in the study

Municipality	Water Use in 2006 (million m³/a)
eThekwini Metropolitan Municipality (Durban)	290.68
Msunduzi Local Municipality (Pietermaritzburg)	50.64
iLembe District Municipality (KwaDukuza)	4.65
Siza Water Company (Ballito and Dolphin Coast in iLembe DM)	3.22
Total	349.19

A standard water balance was undertaken for each of the municipalities, 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 would require substantial financial and human resources for implementation, a schedule (projection) of future savings were made, resulting in the development of three scenarios (see **Section 5.1** for a description of these scenarios).

3.5 RECONCILIATION FOR A PRELIMINARY RESERVE SCENARIO

Reserve assessments have been undertaken within the study area but are limited to mainly rapid or desktop levels (low confidence estimates). At the time of the study, the DWA Directorate: Resource Directed Measures (RDM) was planning to commission high confident reserve determination studies for Mvoti, Mkomazi, Mgeni, Mhlali and Mhlatane systems; lower confidence reserves for the Mbokkodwini, Toti, Little Toti and Lovu systems and monitoring programmes for the Mhlanga, Tongati and Mhloti systems.

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 the RDM office and incorporated into the Water Resources Yield Model (WRYM). The information was compared to the information in existing WRYM configurations of the various systems. The information was then updated where required and a revised yield analysis was then conducted for the updated systems.

Specific results of scenarios relating to the EWR are provided in **Section 10.2** for the Mgeni River System and in **Section 8.8** as part of the reconciliation scenarios for the Mloti River System. An overarching strategic perspective on the EWR, in terms of future studies and the implementation, is provided in **Section 10.2**.

3.6 DETERMINATION OF THE REQUIRED INTERVENTION DATES

The water requirement and return flow scenarios (discussed in **Section 4**) and the potential saving scenarios through WC/WDM measured (discussed in **Section 5**) were used to determine various demand projection scenarios. These were then imposed on the existing yields of the associated river systems and the need for intervention (when further WC/WDM measures and/or the development of an augmentation scheme is required) were determined by assessing the water reconciliation (water balance) situation over the planning period for each of the river systems.

3.7 ECONOMIC EVALUATION OF THE INTERVENTION OPTIONS

The following possible intervention options were identified (see **Section 6** for more detail):

- Mooi-Mgeni transfer scheme, Phase 2.
- Mkomazi-Mgeni transfer scheme, Phase 1.
- Mvoti-River – IsiThundu Dam.
- Lower Thukela scheme.
- Waste water re-use options.
- Desalination plant.

Both the infrastructure and the WC/WDM options were evaluated by calculating the net present values (NPV) and the comparative Unit Reference Values (URV) at a reconnaissance level of detail (high level economic comparison). The URV for each option was calculated for the same

base year (September 2007) by escalating the costs obtained from previous studies. The base date for these previous studies varied from 1996 to 2004.

An engineering assessment was conducted for the options that had not been previously investigated and the NPV and URV was then calculated for each of the option. The results of the economic analysis are discussed in **Section 10**.

3.8 ENVIRONMENTAL CONSIDERATIONS

A desktop collation and assessment of all readily available “high level environmental information” that was required for the study was conducted for the main river systems in the study area. The type of information obtained included: land cover, sensitive landscape, rivers, natural history sites, red data species, threatened species, biodiversity hot spots etc. This background environmental information was used to assess the proposed water reconciliation strategies. Gaps in the available environmental database and further environmental studies or data collection exercises were identified for the options and strategies that were proposed.

The pertinent environmental perspectives relating to the development options were presented in the First Stage Strategy: Infrastructure report (**DWA, 2008c**).

3.9 STRATEGY DEVELOPMENT

The required intervention dates were established by assessing the water balance situation for the various river systems. The most suitable intervention options were identified by considering both the economic analyses results and the implementation time frames for each of the options. Various planning scenarios that included different development options were analysed in order to identify the opportunities and constraints of the various development options. The Reconciliation Strategy was developed based on the assessment.

The reconciliation scenario descriptions and results are presented in **Section 7** of the report.

4 WATER REQUIREMENT AND RETURN FLOW SCENARIOS

This section describes the water requirement and return flow scenarios that were developed in the study covering irrigation water requirements in **Section 4.1** as well as urban water requirements and return flows in **Section 4.2**.

4.1 IRRIGATION WATER REQUIREMENTS

The information applied in the assessment of the irrigation water requirements were obtained from six different sources each covering a portion of the study area except for the WARMS database, which contained data for the entire area. The sources of data and information included the following:

1. Data extracted from the Water Allocation Registration Management System (WARMS). WARMS is an active database that is updated continuously and it should be noted that the data applied in this assessment was dated August 2007.
2. Mgeni River System Analysis Study by BKS (1989 development level).
3. Mooi-Mgeni Transfer Phase 2 Feasibility using WARMS data (2005 development level).
4. Mvoti River Dam Feasibility Study by Ninham Shand (1995 development level).
5. Hazelmere Dam Raising Study conducted by Knight Piésold Consulting (2000 development level).
6. Mkomazi-Mgeni Transfer Scheme Pre-feasibility by Ninham Shand (1995 development level).

Discussions were also held with officials from the DWA Regional Office to clarify analogies and finally it was confirmed that the data that was applied in the yield estimates (yield analysis results obtained from various studies) was acceptable (and in some cases conservative) for the purposes of developing the reconciliation strategy.

For the purpose of presenting a summary of the irrigation water requirements, the study area was divided into nine main catchments and 21 sub-catchments. These sub-catchments are presented on a map, see **Figure A-2** in **Appendix A**. The estimates of the water requirements from the indicated sources are presented as bar diagrams to provide a visual comparison of the water use volumes for each catchment.

Table 4.1 summarises the irrigation water requirements for the five main catchments as obtained from the different data sources that were evaluated. The recommended irrigation requirements are mainly based on the latest results from the WARMS database.

Table 4.1: Irrigation water requirements

Catchment Description	Irrigation Water Requirements for different data sources (million m ³ /annum)					
	WARMS (2006)	BKS (1989)	WARMS (2005)	Mvoti Dam Feasibility (1995)	Hazelmere Dam Raising (2000)	Mkomazi-Mgeni Transfer Scheme Pre-feasibility (1995)
Mkomazi	27.8	18.1	-	-	-	49.7 [#]
Mooi	68.7	67.3	96.5 [#]	-	-	-
Mgeni	55.9	60.2 [#]	52.1	-	-	-
Mdloti	6.2 [#]	14.8	-	-	12.6	-
Mvoti	25.6	-	-	29.4 [#]	-	-
Total	184.2					

Note: # = Irrigation water requirements applied in the yield analysis of the respective systems.

The reader is referred to the First Stage Strategy: Water Requirements Report (**DWA, 2008b**) for further details relating to the irrigation water requirements.

4.2 URBAN WATER REQUIREMENTS AND RETURN FLOWS

The urban sector represents the largest water user group in the study area and substantial increases in their water use have occurred in the past, which is as a result of the urbanisation of the population coupled with the expanding economic activities in the metropolitan areas of the KZN Province.

Scenarios of water requirements and return flows were developed for the planning period up to the year 2030 based on the procedure briefly described in **Section 3.2** - for details see the First Stage Strategy: Water Requirements Report (**DWA, 2008b**).

The primary drivers of the increase in water use were identified as population growth and the provision of improved water supply services. A demographic assessment was therefore carried out and future population scenarios were developed by Dr. McCarthy (KwaZulu-Natal demographic specialist) as part of the study (**DWA, 2007d**). The population scenarios, coupled with the economic outlook for the area, were applied to developed scenarios of domestic (household) and

commercial water requirement up to the year 2030. At the same time coherent scenarios of future return flows (treated wastewater) were produced for consideration in the development of reconciliation strategies.

The main demand centres in the study area are currently supplied from four main river systems, namely the Mgeni, Mdloti, Mvoti and the Lower Thukela, as illustrated in **Figure A-3** in **Appendix A**. The water requirements for the various demand centres are presented according to these sub-systems in sections **4.2.2**, **4.2.3**, **4.2.4** and **4.2.5** respectively.

4.2.1 Demographic assessment and future population scenarios

A number of demographic databases were available for this study, all using the 2001 STATS SA Census data as the common data source. From these a base dataset was prepared for the year 2006 and three future population scenarios (high, medium and low) were produced by considering key variables including the possible impact of AIDS, land use and urbanisation trends, anticipated political imperatives as well as the economic prospects of the area.

The population growth within the various suburbs in the eThekweni municipal area and also in surrounding towns function differently due to various factors such as the N3 Pietermaritzburg to Durban growth corridor, new international airport on North Coast, property developments etc. As a result the coastal metropolitan area were divided into four sub-regions according to the population growth characteristics (see **Figure 4.1**). The four sub-regions with their respective suburbs are:

1. **Inner:** Umhlanga, Durban North, KwaMashu, Pinetown, Bellair, Rossburgh, Chatsworth and Mobeni.
2. **South:** South of Mobeni including Umlazi, Amanzimtoti, Illovo, Mgababa and Umkomaas.
3. **North:** Umdloti and northwards including Pheonix, Inanda, Verulam, Tongaat and KwaDukuza.
4. **West:** West of Kloof: Including Hillcrest, Mphumalnga, Fredville, Cato Ridge, Camperdown/ Mkhambathini, Msuduzi/Pietermaritzburg and Mgeni municipality.

The population projections established for the four sub-areas for the three scenarios are shown in **Table 4.2**. From the table it can be seen that the increase in population for the entire study area is at a minimum of 600 000, and a maximum of 1,5 million over thirty years for the scenarios. Almost half of this growth (in any scenario) is projected for the north alone, and over two thirds for the west and the north combined. The variance between the scenarios (sensitivity) for the four sub-regions is different. For example in central Durban sub-region there is little variance, the difference

between high and low scenarios over 30 years being only 0,1 million people; where by contrast in the north the difference is 0,9 million people. The reader is referred to the Demographic Projections report of the same study for further details (DWA, 2007d).

Whilst the projected population growth has significant implications for water resources planning, probably more important will be the changing household/homes structure of the population. Over the past decade the major theme of change in this regard has been the extension of services to formerly un-served informal settlements, and/or the movement of households out of un-served shacks into low cost formal, serviced homes. It is projected that this theme will continue for at least two decades more. As a result, the actual water consumption seems destined to increase more rapidly than population.

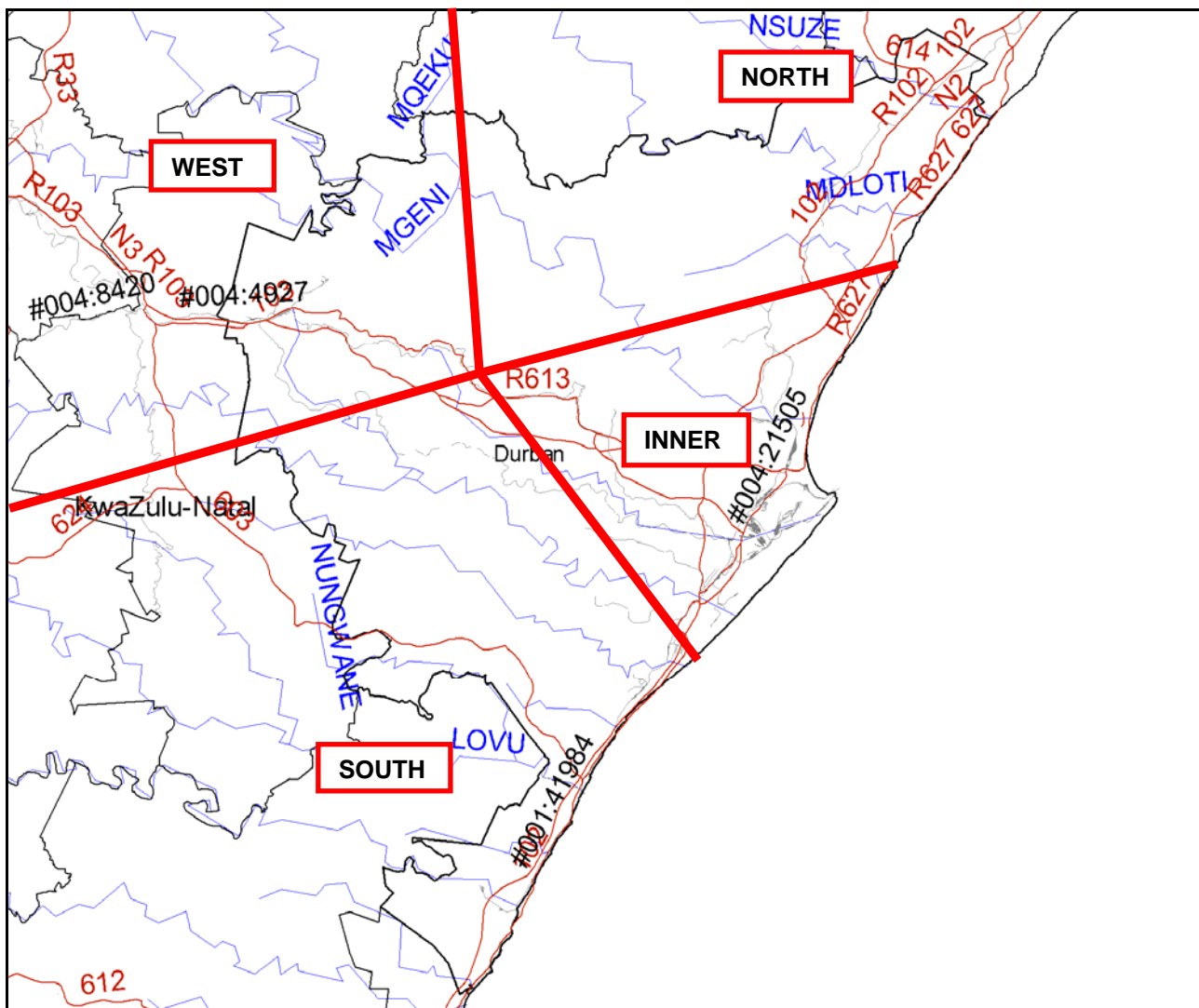


Figure 4.1: Map of sub-area components

Table 4.2: Projected population growth

Year	Scenario	Population (million)				
		Inner	South	North	West	TOTAL
2001		1.0	1,3	1,3	1,3	4,9
2005	Low	1.0	1,3	1,3	1,3	4,9
	Medium	1.0	1,3	1,4	1,4	5,1
	High	1.0	1,3	1,4	1,4	5,1
2010	Low	1.0	1,3	1,4	1,4	5,1
	Medium	1.0	1,4	1,5	1,4	5,3
	High	1.0	1,4	1,5	1,6	5,5
2015	Low	1.0	1,3	1,5	1,4	5,2
	Medium	1	1,4	1,5	1,5	5,4
	High	1,1	1,4	1,6	1,6	5,7
2020	Low	1.0	1,4	1,5	1,5	5,4
	Medium	1.0	1,4	1,6	1,5	5,5
	High	1,1	1,5	1,7	1,6	5,9
2025	Low	1.0	1,4	1,6	1,5	5,5
	Medium	1,1	1,4	1,7	1,6	5,8
	High	1,1	1,5	1,8	1,7	6,1
2030	Low	1.0	1,4	1,6	1,5	5,5
	Medium	1,1	1,5	1,8	1,7	6,1
	High	1,1	1,5	1,9	1,8	6,3

It is important to note that additional demographic information became available subsequent to the development of the First Stage Strategy, which included the STATSSA “Dwellings 2007” estimates, eThekweni Metro Planning Unit population estimates for 2006 and the Department of Transport (DoT) population estimates (developed by Global Insight consultancy). These were compared to

the projections developed in the First Stage Strategy and the STATSSA and eThekweni Metro figures were found to be similar and there was thus no reason to amend the initial population scenarios.

4.2.2 Water requirements and return flows for the Mgeni River System supply area

The Mgeni River system supplies water from Midmar, Albert Falls, Nagle and Inanda dams to the Msunduzi Local Municipality (LM) and the eThekweni Metropolitan Municipality (MM). Water is also supplied to a portion of the uMgungundlovu District Municipality (DM), large rural areas surrounding Pietermaritzburg and will also soon supply a portion of Ugu DM, along the South Coast. The largest portion of the current urban water requirements are eThekweni MM (80%) and Msunduzi LM (14%).

The water requirements and return flows for the eThekweni and Msunduzi Municipal areas were determined with the Water Requirement and Return Flow database model, which was developed for DWA as part of the Crocodile (West) River Return Flow Assessment Study (**DWA, 2004b**). The model uses Sewage Drainage Areas (SDAs) as modelling component where a sewer pipe network system collects the wastewater for treatment at the waste water treatment works before it is discharged. There were fifty three SDAs identified in the two municipal areas, as illustrated graphically in **Figure 4.2**. The various SDAs in each of the municipal areas are listed in **Table 4.3**. Some of the SDAs identified are not linked to waste water treatment works and have been indicated as such. The demands of these SDA's amount to 9% and 25% of the total demand for eThekweni MM and Msunduzi LM respectively (12% of the combined demand).

Table 4.3: List of Sewage Drainage Areas according to Municipal Areas

Municipality	Sewage Drainage Areas	Number of SDAs
eThekweni	Southern Works, Umhlathuzana, Central, Kingsburgh, Amanzimtoti, Isipingo, Northern, New Germany, KwaMashu, Umbilo, Mpumalanga, Kwadengezi, Dassenhoek, Hillcrest, Hammersdale, Phoenix, Umhlanga, Umdloti, Verulam, Tongaat Southern, Tongaat Central, Tongaat Central Below, Gennazano, Fredville, Cato Ridge and 19 SDA's without waste water treatment works.	44
Msunduzi	Darville and 8 SDA's without waste water treatment works.	9
TOTAL NUMBER OF SEWAGE DRAINAGE AREAS		53

The methodology that was followed to derive the water requirements and return flow projections for the two municipal areas involved the following steps:

- Populate the data for each SDA in the database model with population data for the year 2006 and five yearly intervals up to 2031 for each scenario.
- 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 2006 to the SDAs, using GIS area intersection analysis.
- Collate the discharge volume data of the year 2006 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 2006.
- Generate the projected water requirements at five year intervals from 2006 for the planning period up to 2031, using the parameters as calibrated for the 2006 year. The population was grown according to the growth rates of the three scenarios discussed in **Section 4.2.1**.

The above steps were carried out for all 53 SDAs and the results were incorporated into a spreadsheet database.

The reader is referred to the Water Requirements Report of the same study for more detail on the above methodology (**DWA, 2008b**).

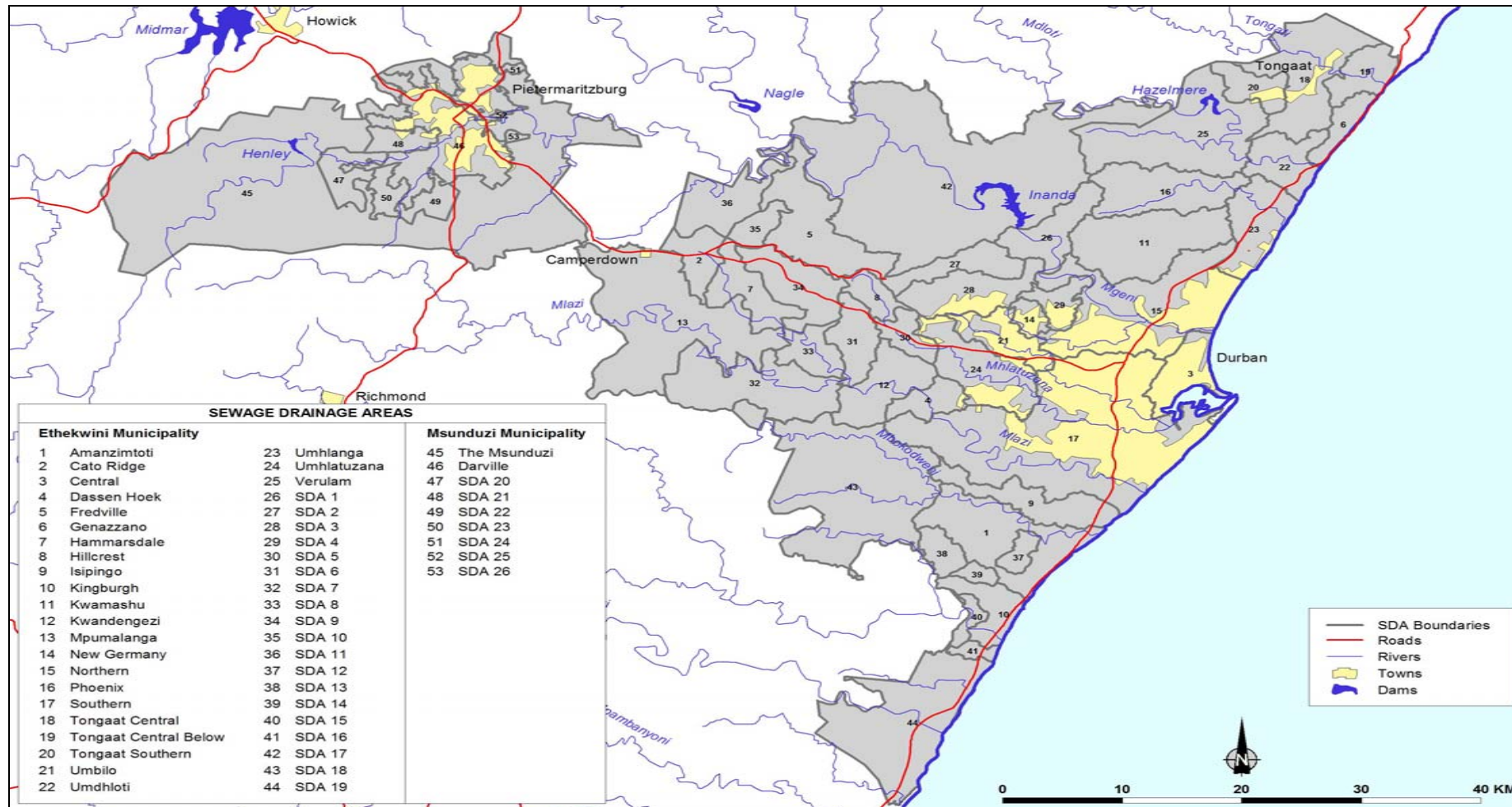


Figure 4.2: Location of the Sewage Drainage Areas within the eThekweni and Msunduzi Municipal areas.

The population growth data (described in **Section 4.2.1**) was applied to the 2006 population data for each SDA in the water requirement generation database model for the high, low and middle road scenarios. It has been established that the biggest driver of water demand increases has been from upgraded service levels to the low income housing sector. This was accounted for in the model, according to the Reconstruction and Development Programme (RDP) housing implementation programmes that have been scheduled in the eThekweni and Msunduzi municipal areas. Based on discussions with the municipalities, the implementation of 12 000 RDP houses per annum by eThekweni MM (**Moodliar, 2008**) and 1 000 RDP houses per annum by Msunduzi LM (**Subramanian, 2007** and **Enoch, 2007**) were accounted for in the water requirement projection.

The indirect water use in the different SDAs was generally increased by the same ratio as the direct water requirements. The economic analysis however identified certain areas where substantial industrial/commercial growth will take place in certain years, which was additionally accounted for. The demand and return flow projections were generated for the planning period up to the year 2031, according to the steps listed in the previous section. The various demand and return flow scenarios that were generated are shown in **Table 4.4**.

Scenario A was regarded as the base scenario to be used for planning purposes. A summary of the water requirement projections for the eThekweni and Msunduzi municipal areas for the three scenarios are shown in **Figure 4.3** and **Figure 4.4** respectively. The annual average growth rate in water requirements for the eThekweni and Msunduzi municipal areas between 2006 and 2031 are 1.66% and 2.19% respectively for **Scenario A**. The direct water consumption component consists of between 60% - 65% of the total consumption in the eThekweni and Msunduzi areas.

Table 4.4: Water requirement projection scenarios

Scenario	Description
Scenario A	<p>High population projection</p> <p>Improved water supply services</p> <p>Indirect water use increased in identified SDAs according to economic analysis (Hammarisdale, Cato Ridge, Hillcrest, Southern, Umhlanga, Phoenix, Verulam, Tongaat)</p> <p>Indirect water use in remaining SDA's increased by the same ratio as the direct water use requirements</p>
Scenario B	<p>Low population projection</p> <p>Improved water supply services</p> <p>Indirect water use increased in identified SDAs according to economic analysis (Hammarisdale, Cato Ridge, Hillcrest, Southern, Umhlanga, Phoenix, Verulam, Tongaat)</p> <p>Indirect water use in remaining SDA's increased by the same ratio as the direct water use requirements</p>
Scenario C	<p>Medium population projection</p> <p>Improved water supply services</p> <p>Indirect water use increased in identified SDAs according to economic analysis (Hammarisdale, Cato Ridge, Hillcrest, Southern, Umhlanga, Phoenix, Verulam, Tongaat)</p> <p>Indirect water use in remaining SDA's increased by the same ratio as the direct water use requirements</p>

The total return flow projections for the eThekweni and Msunduzi municipal areas are presented in **Figure 4.5** and **Figure 4.6** respectively. An increase from 180 million m³/annum to 230 million m³/annum in eThekweni; and 28 million m³/annum to 40 million m³/annum in Msunduzi is illustrated for **Scenario A** (planning period 2006 – 2031).

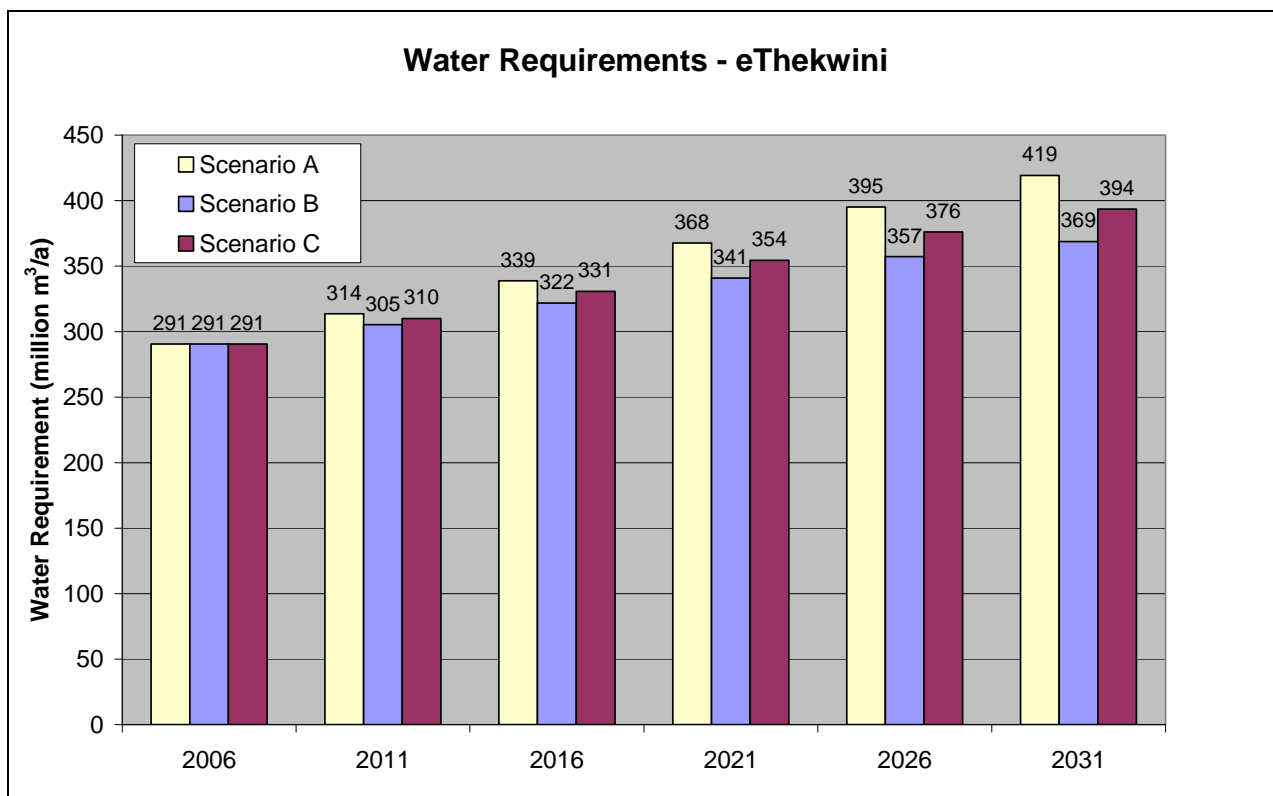


Figure 4.3: Water requirement projections in the eThekweni Municipal Area

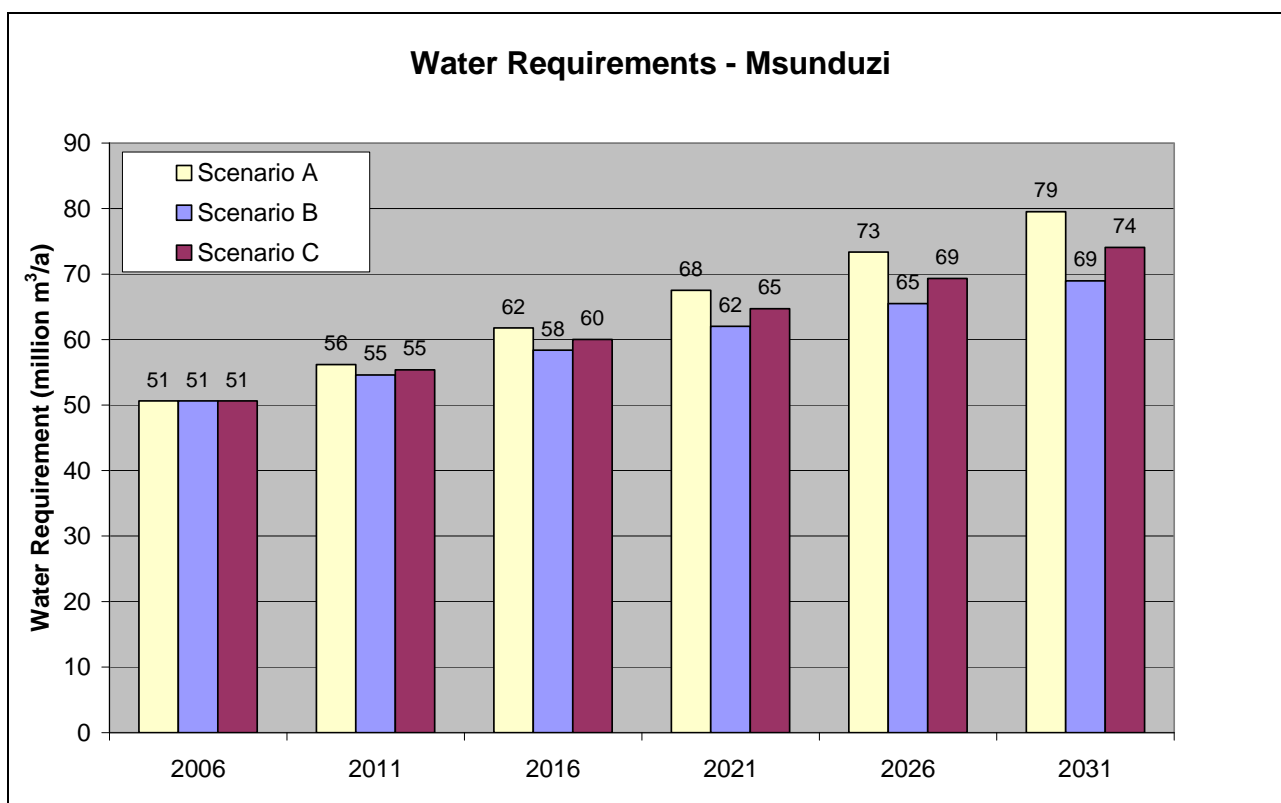


Figure 4.4: Water requirement projections in the Msunduzi Municipal Area

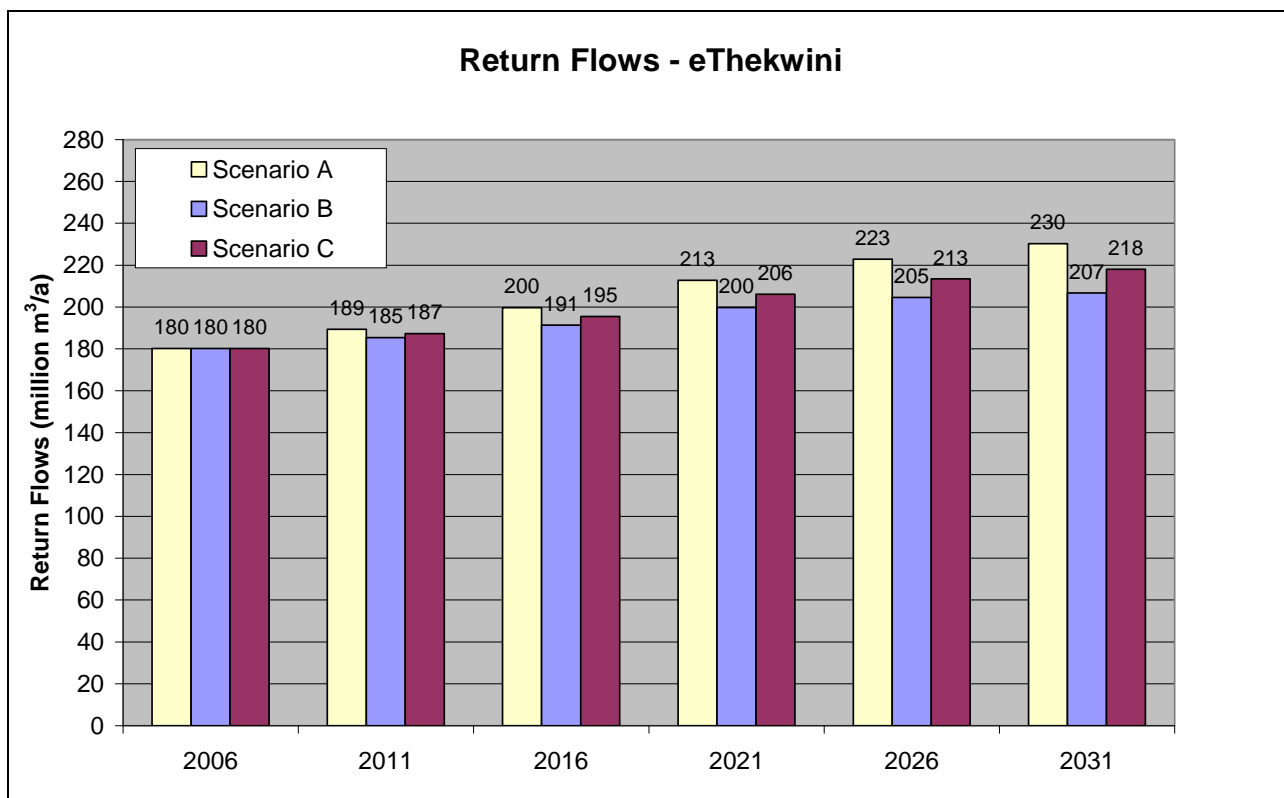


Figure 4.5: Return flow projections for the eThekweni municipal area

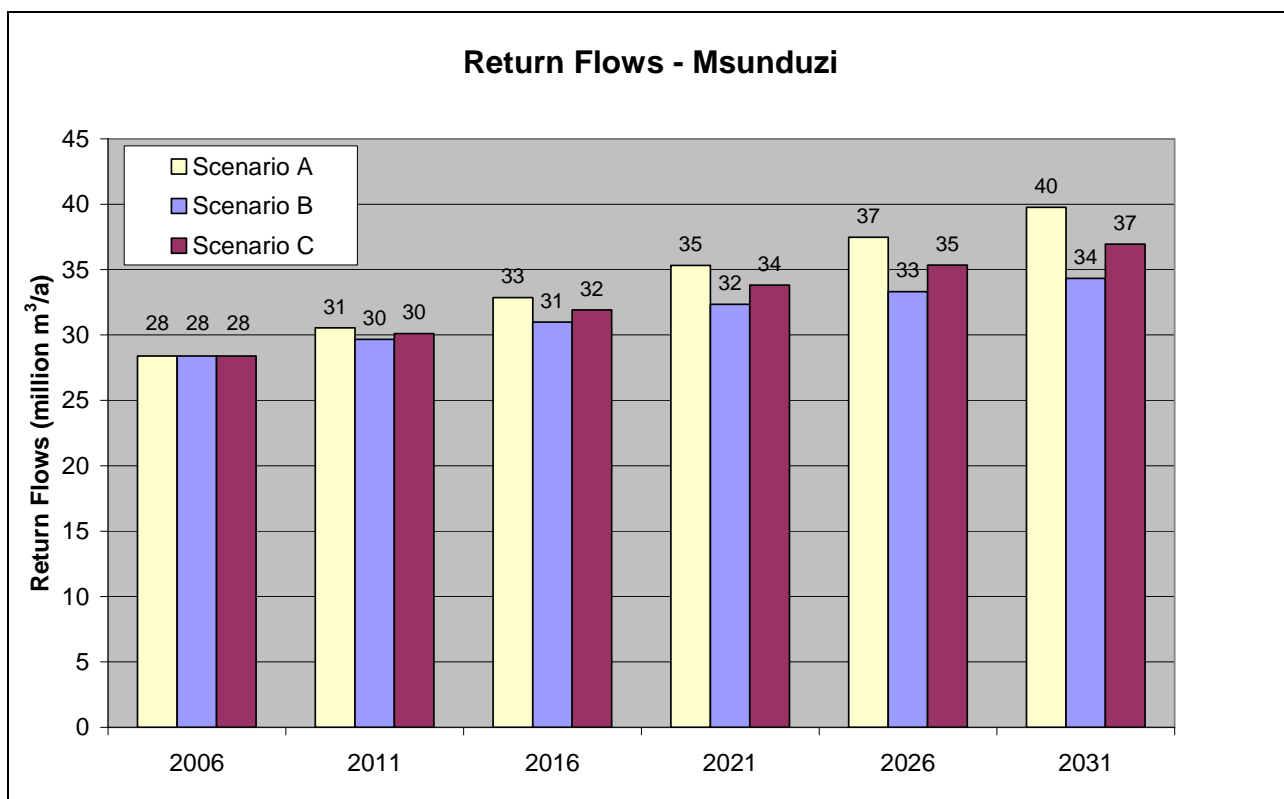


Figure 4.6: Return flow projections for the Msunduzi municipal area

The total gross water requirement projection for the Mgeni River System was developed by combining the water requirement projections of both the Msunduzi and eThekwini municipal areas with the projections derived by Umgeni Water for the portions of uMgungundlovu DM and Ugu DM that are supplied from the Mgeni River. The percentage of the total urban water requirement projection for 2011 (**Scenario A**) supplied to the three main demand centres is illustrated in **Figure 4.7**.

A portion of certain SDA demands in the northern part of eThekwini are also supplied from the Mdloti and Tongaat River System, which were removed from the demand imposed on the Mgeni System. The results for the three water requirement scenarios are illustrated graphically in **Figure 4.8**. The 2008 Umgeni Water projection is also illustrated and is very similar to **Scenario A** up to 2013, after which it drops off and is positioned between **Scenario C** and **A** for the remainder of the planning period. The 2009 Umgeni Water projection became available during the Second Stage Strategy and it is slightly higher than the 2008 Umgeni Water Projection as illustrated. It is very similar to the **Scenario A** projection up to 2022, after which it increases above **Scenario A** for the remainder of the planning period (approximately 30 million m³/annum higher in 2030).

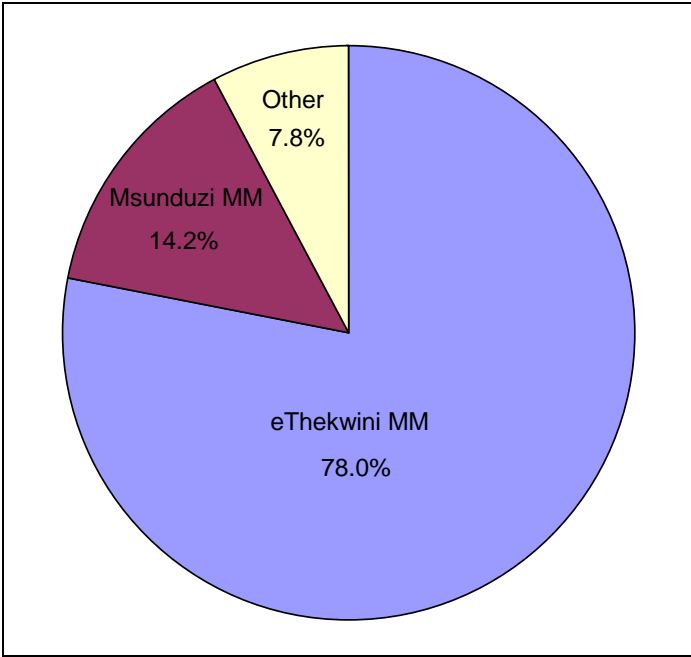


Figure 4.7: Mgeni River System Water requirements

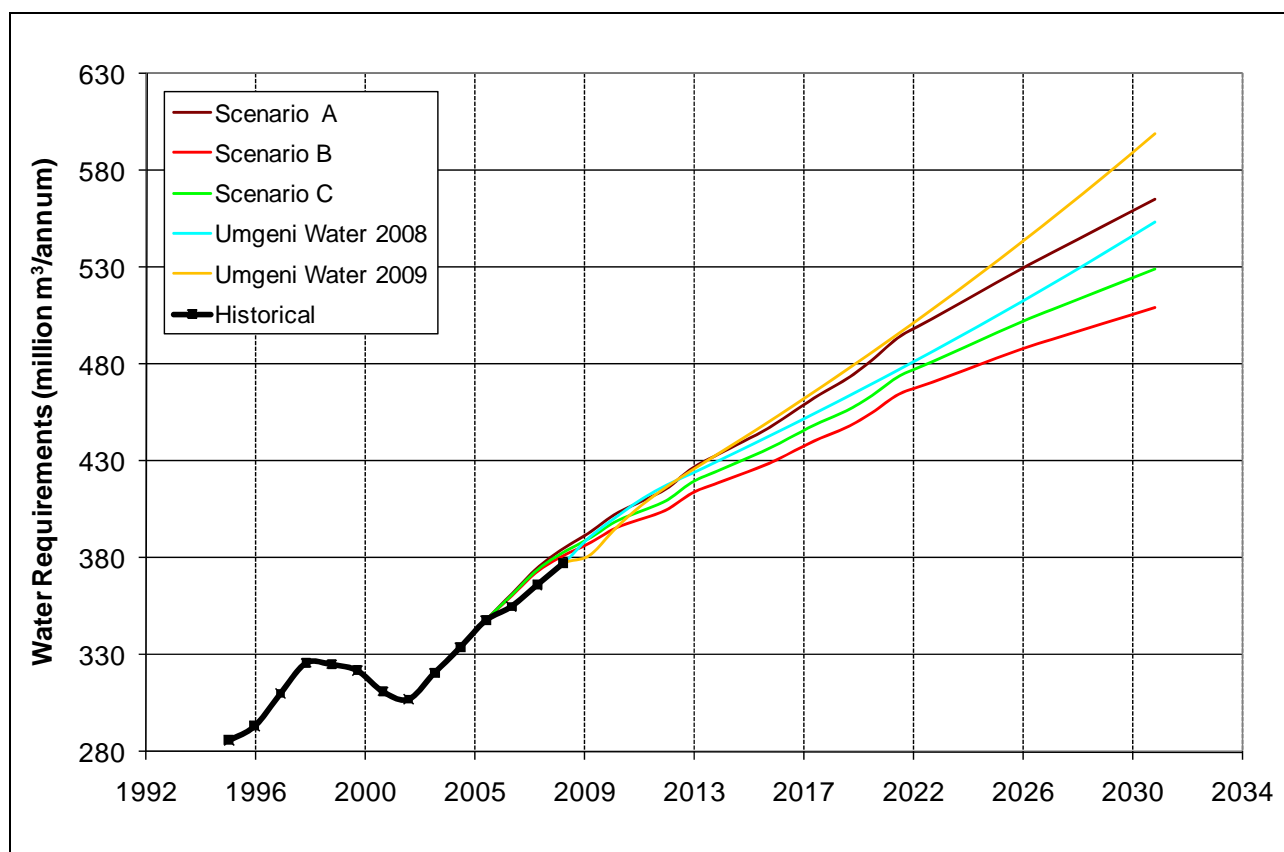


Figure 4.8: Summary of the Mgeni River System urban water requirement scenarios

4.2.3 Mdloti River System water requirement scenarios

The Mdloti River System consists of Hazelmere Dam on the Mdloti River, which is the source of water to the surrounding urban areas and also irrigation downstream of the dam (see **Figure A-3** in **Appendix A**). Umgeni Water is the WSA responsible for the operation of the dam as well as the treatment and bulk distribution of the water for urban supply. The areas supplied are northern eThekweni, Siza Water (WSA), surrounding rural areas (Ndwedwe and Groutville) and limited supply to Kwadukuza. In 2006 the total water use from the system was 12.0 million m³/annum, of which 52.2% was supplied to northern eThekweni, 27.0% to Siza Water, 18.5% to Ndwedwe and Groutville and 2.3% to Kwadukuza. Umgeni Water and ILembe DM had compiled recent up to date water requirement scenarios which were adapted for the study.

Two water requirement scenarios were considered in the study for the Mdloti River System. The first scenario was derived from the Water and Sanitation Master Plan for the iLembe District Municipality (**DWA, 2007b**). The projection however excluded the component supplied to the northern parts of eThekweni. The projection for this area was developed using the water

requirements and return flow model (**Section 4.2.2**) and the two projections were combined to develop a total water requirement projection (**Scenario M-A**).

The second scenario was compiled from the Umgeni Water 2007 Projection data, which consisted of a combination of projections for the northern parts of eThekweni, Siza Water and additional areas in the iLembe DM supplied from the Mdloti System. The Siza Water and iLembe DM components were disaggregated into projections for “approved”, “approval pending” and “conceptual” projects. It was indicated by both Umgeni Water and Siza Water that several of the approved development projects were taking longer to be developed than expected and that the Umgeni Water Projection is optimistic. The actual consumption in 2007 was also lower than the volume projected by Umgeni Water. Based on these evidence, the “approval pending” and “conceptual” categories were removed in order to derive a more realistic water requirement projection (**Scenario M-B**).

A summarised description of the two water requirement projection scenarios are shown in **Table 4.5** and are illustrated graphically in **Figure 4.9**.

Table 4.5: Mdloti River System water requirement scenarios

Scenario	Description
Scenario M-A	iLembe Master Plan projection with the eThekweni component supplied from the Mdloti System included (Scenario A – Section 4.2.2).
Scenario M-B	Umgeni Water 2007 projection excluding pending and conceptual developments.

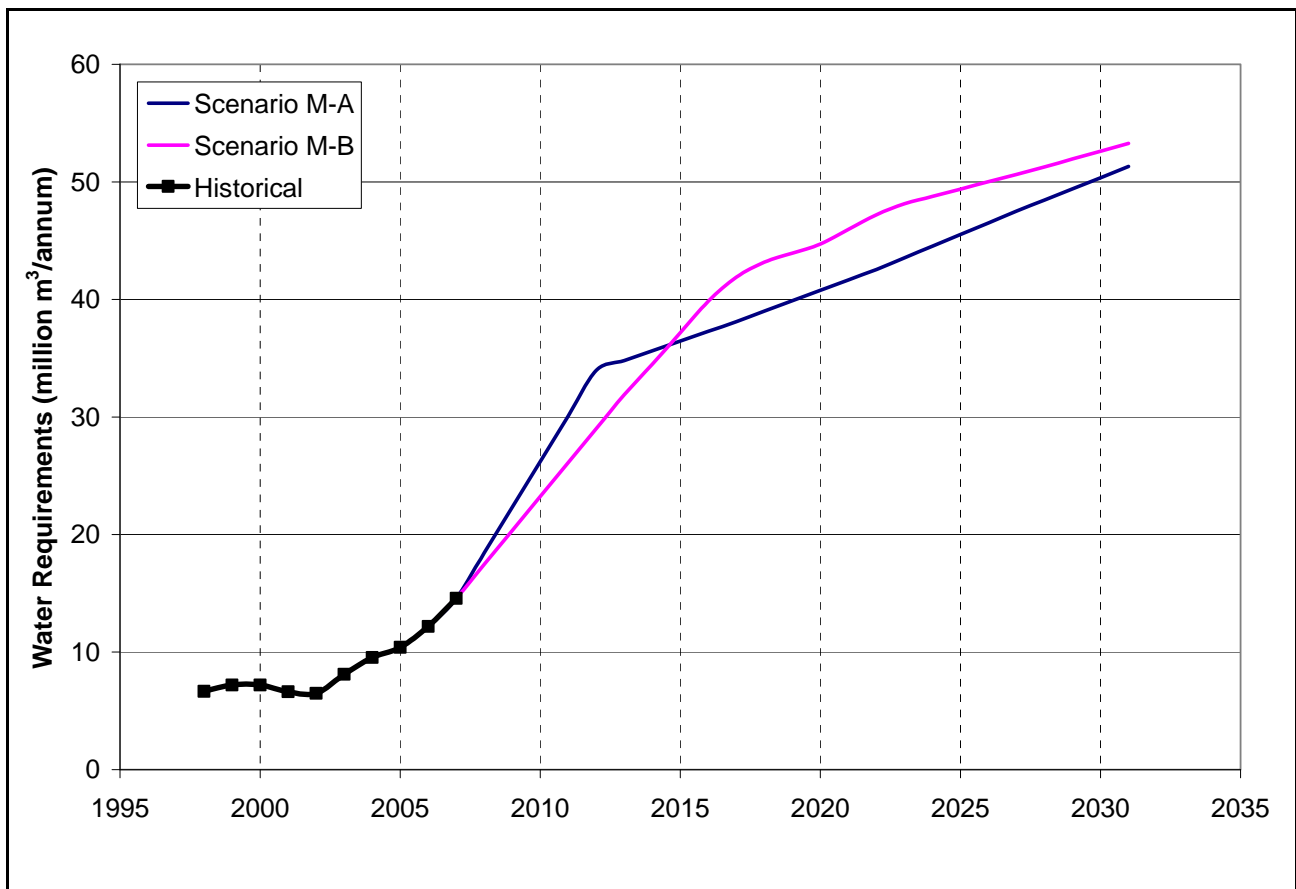


Figure 4.9: Summary of the Mdloti River System water requirement scenarios

4.2.4 Mvoti River System water requirement scenarios

Water is currently supplied from the river abstraction on the Mvoti River for supply to KwaDukuza via the Mvoti Water Treatment Works. The treatment works have a capacity of 12 Ml/day (4.38 million m³/annum) which is fully utilised. Additionally, there are two industrial water users also abstracting water directly from the river. These include (DWA, 1996b):

- Sappi fine paper mill (3.6 million m³/annum).
- Gledhow sugar mill (2.5 million m³/annum).

According to the Mvoti Dam Feasibility Study: Water Demands report (DWA, 1996b) Glendale sugar mill, distillery and village located upstream of KwaDukuza consumed a total volume of 0.3 million m³/annum from the Mvoti system. The sugar mill was closed in the late 1990's, while the distillery is still functioning. The water requirement of the distillery is minimal and was regarded as negligible.

Water requirement projections for KwaDukuza and the surrounding towns were sourced from the Water and Sanitation Master Plan for the iLembe District Municipality (**DWA, 2007b**). These were combined with the industrial demand requirements to produce total water requirement projection for the Mvoti System (**Scenario K-A**) as illustrated in **Figure 4.10**.

The purpose of the I Lembe Master Plan was to plan bulk supply schemes to all areas in the I Lembe DM area. Water requirement projections were therefore compiled based on the total water requirements that would ultimately be required in the area. It was assumed that the bulk supply scheme will take time to implement. The assumption made was that the total current water use of 10.5 million m³/annum will increase to what was projected in the I Lembe Master Plan by 2012, after which the growth from the I Lembe Master Plan was assumed.

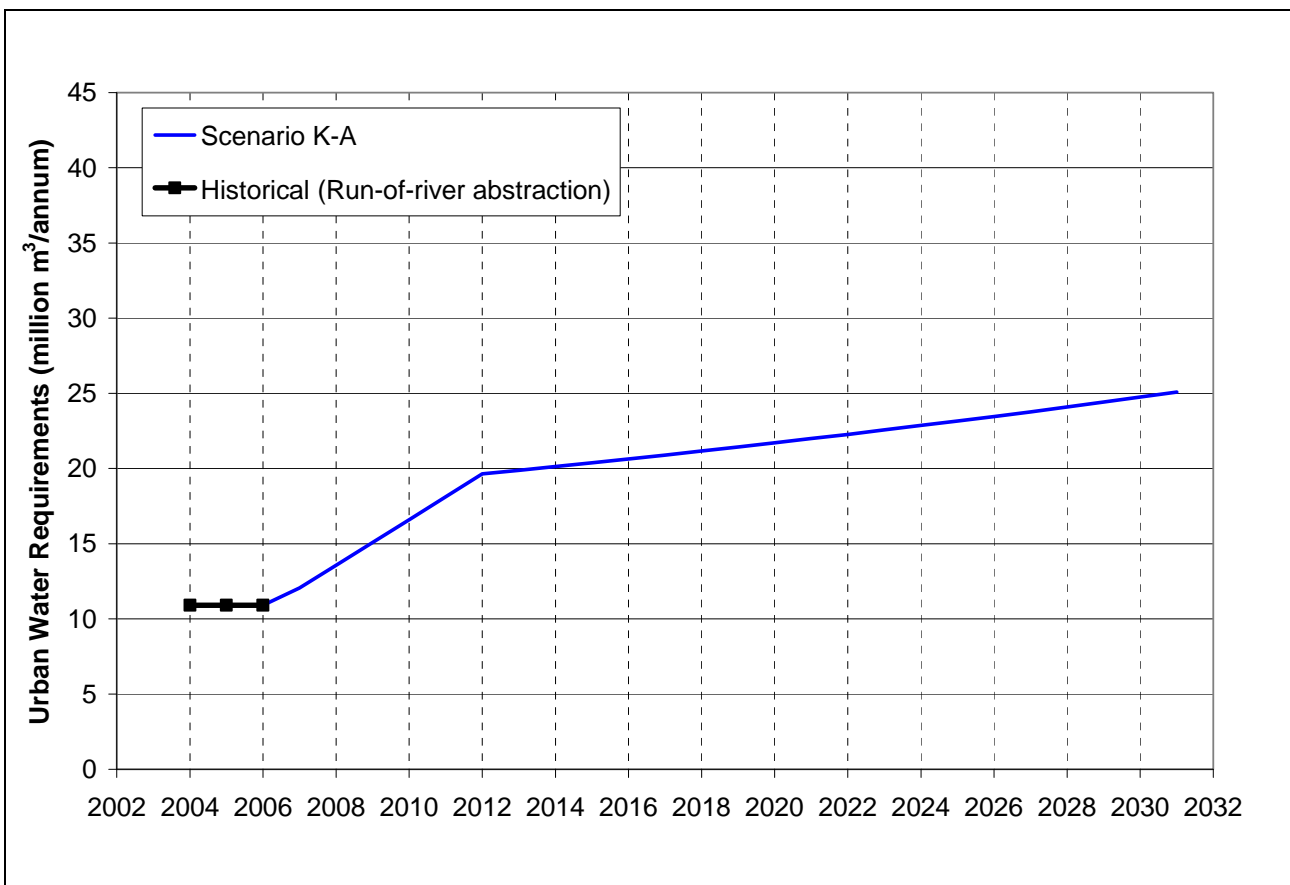


Figure 4.10: Mvoti River System water requirement projection

4.2.5 Lower Thukela River System water requirement scenarios

The Lower Thukela River System is defined as the river section between Kranskop and the Thukela Mouth in this report. The three largest abstractions in this part of the river are (see **Figure A-3 in Appendix A**):

- The Middeldrift abstraction, from where water can be conveyed to the Ngcebo settlement south of the Thukela and also north over the watershed into the Mhlathuze River catchment and thereby serve the needs of greater Richards Bay.
- The Sundumbili abstraction upstream of Mandeni and serves as source for a water treatment works that serves Sundumbili and surrounds.
- The SAPPI abstraction that provides water for the Thukela paper mill of SAPPI, as well as potable water to the town of Mandeni.

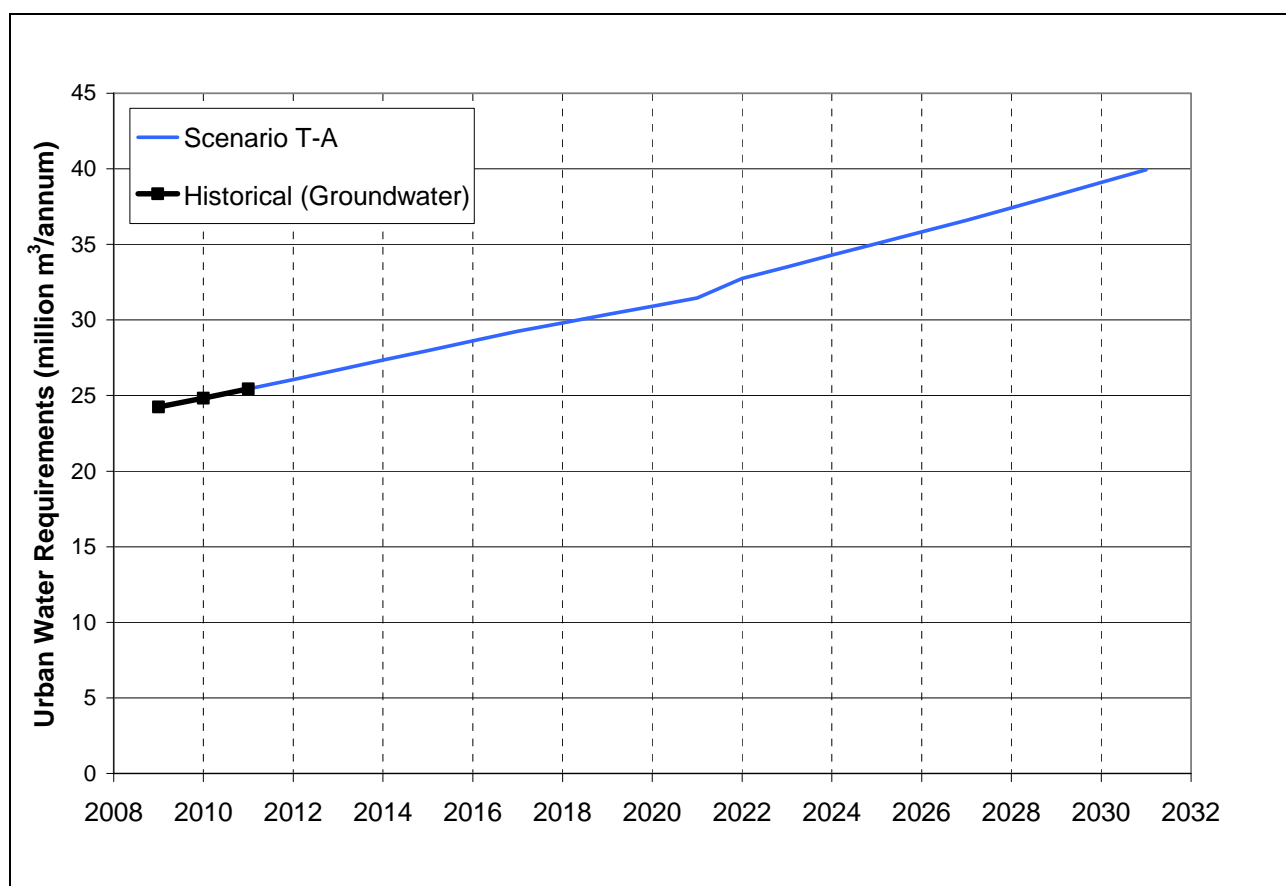


Figure 4.11: Lower Thukela River System water requirement projection

A water requirement projection for the Lower Thukela supply area (**Scenario T-A**) was adopted from the ILembe Master Plan (**DWA, 2007b**) and included the Ngcebo Scheme supplied from the proposed Middeldrift abstraction and the towns north of the Thukela River supplied from the Sundumbili abstraction (see **Figure A-3** in **Appendix A**). The water requirement projection excludes the existing demands and only includes the projected growth in demands in order to compare the projection to the existing available yield in the Lower Thukela System discussed in **Section 7.4**. The water requirement projection is illustrated in **Figure 4.11**.

5 WATER CONSERVATION AND WATER DEMAND MANAGEMENT SCENARIOS

The focus of the assessment was on the large city centres and key demand centres as they hold the greatest potential for savings including the following municipalities:

- eThekweni Metropolitan Municipality (Durban).
- Msunduzi Municipality (Pietermaritzburg).
- Ilembe District Municipality which focused on Siza Water Company and KwaDukuza (Stanger).

eThekweni MM has an advanced WC/WDM programme and should be commended for their efforts. It has however been established through the study (in consultation with eThekweni MM) that there is scope for further WC/WDM initiatives in eThekweni. Msunduzi on the other hand has major water loss problems with a very high average consumption. This municipality should embark on a major WC/WDM programme in order to reduce their losses and decrease their consumption.

The water balance for the Siza Water supply area (iLembe DM) showed that there is limited scope for reducing real losses in the area. The objective in this area should be to enforce efficiency measures to reduce customer demand. This could be achieved through tariff increases and consumer awareness. It was established that the water losses in Stanger were not excessive but are to a large extent controlled by the capacity of the Stanger WTW. It is expected that should the capacity increase, the losses will increase and it is proposed that the municipality should also embark on a more extensive WC/WDM programme.

eThekweni and Msunduzi municipalities account for approximately 91% of Umgeni Water's total supply and are the main focus of this chapter.

Three saving scenarios were developed from the assessment of the potential for water conservation and water demand management (WC/WDM) in the urban sector of the eThekweni and Msunduzi Municipalities. The savings were applied to the water requirements of **Scenario A** and were labelled **Scenarios A.1, A.2** and **A.3** respectively. The description and saving results from the scenarios are presented in the following section.

5.1 SCENARIO DESCRIPTIONS

5.1.1 Scenario A.1: 5 Years water loss programme

Water losses can be controlled within the next 5 years and maintained afterwards.

Limited water use efficiency is introduced.

This scenario assumes that certain actions can be implemented over a period of 5 years. These include capital expenditure to improve the distribution systems followed by maintenance activities to prevent water losses to increase. This scenario addresses only reduction in wastage of water with limited implementation of water use efficiency measures.

5.1.2 **Scenario A.2:** 5 Years water loss programme and efficiency

Water losses can be controlled within the next 5 years and maintained afterwards (same as for **Scenario A.1**).

Water use efficiency is implemented by targeting the billed consumption. It was assumed that a 1% per annum efficiency can be gained from 2015 increasing to approximately 25% in the year 2025.

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

The savings from the non-revenue water concentrate on issues such as leakage detection and repair in areas where consumers have high levels of payment and any losses after the customer meter are basically considered to be part of the customer demand – normally these losses are relatively small since the customer will identify any household leakage and repair the leaks quickly. In the case of areas where the level of payment is very low or is based on a “lump-sum” tariff, the losses tend to be greatest inside the properties after the consumer meter. In many cases, no accounts are sent to the consumers or the accounts are so high that they are generally ignored and payment will never be received by the Municipality. In such areas, the general monthly water demand per property (assuming that there is full 24-hour supply) is usually between 35 m³/month and 55 m³/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 m³/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 m³/month, which is often sufficient to justify major investment.

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 water wastage inside the properties tends to be relatively small and is not the serious problem. Although the physical leakage is considered to be the main problem 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.

This scenario is potentially problematic for the water utilities since their capital costs and much of their operational costs are fixed while the income is dependent on the water sales. To reduce the overall demand can cause problems to the financial viability of a water utility.

In **Scenario A.2**, 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. .

5.1.3 **Scenario A.3:** 10 Years water loss programme

Water losses can be controlled within the next 10 years and maintained afterwards.

No water use efficiency is introduced.

Scenario A.3 is basically the same as **Scenario A.1** 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 A.1**, based on practical experience gained by the project team from numerous WC/WDM projects.

5.1.4 Potential savings and net system water requirements

Table 5.1, **Table 5.2** and **Table 5.3** present the savings that can be achieved for each of the scenarios described above (savings are shown in **Row b** of each tables). It was assumed that the WC/WDM measures will also impact on the return flows. The return flows from the Msunduzi Municipality contribute to the resources utilised by eThekweni and hence the reduction needed to be accounted for as reflected in **Row c**. The overall impact on the net system water requirement is determined in **Row d**, and **Row e** provides the total system net water requirement. The gross system water requirement (including treatment works losses of 4%) is reflected in **Row f**. The results of the three scenarios are illustrated graphically in **Figure 5.1**.

Table 5.1: Savings and system net water requirements for Scenario A.1

Row	Component Description	Planning Years					
		2007	2011	2016	2021	2026	2031
a	Nett System Demand	360.7	393.3	430.0	474.5	510.1	543.2
b	Reduction in Water Requirements	5.4	33.8	42.7	44.9	47.2	49.6
c	Reduction in Msunduzi LM Return Flows	0.2	4.6	5.9	6.2	6.5	6.9
d	Net Reduction	5.2	29.2	36.8	38.7	40.7	42.7
e	System Nett Demand	355.5	364.1	393.2	435.8	469.4	500.5
f	System Gross Demand	369.7	378.6	408.9	453.3	488.2	520.5

Notes: (1) All volumetric values are given in million m³/annum.

Table 5.2: Savings and system net water requirements for Scenario A.2

Row	Component Description	Planning Years					
		2007	2011	2016	2021	2026	2031
a	Nett System Demand	360.7	393.3	430.0	474.5	510.1	543.2
b	Reduction in Water Requirements	5.4	33.8	61.4	91.9	113.0	121.7
c	Reduction in Msunduzi LM Return Flows	0.2	4.6	6.9	8.8	10.1	10.8
d	Net Reduction	5.2	29.2	54.5	83.1	102.9	110.9
e	System Nett Demand	355.5	364.1	375.5	391.4	407.2	432.4
f	System Gross Demand	369.7	378.6	390.6	407.1	423.5	449.7

Notes: (1) All volumetric values are given in million m³/annum.

Table 5.3: Savings and system net water requirements for Scenario A.3

Row	Component Description	Planning Years					
		2007	2011	2016	2021	2026	2031
a	Nett System Demand	360.7	393.3	430.0	474.5	510.1	543.2
b	Reduction in Water Requirements	5.4	20.1	39.2	44.9	47.2	49.6
c	Reduction in Msunduzi LM Return Flows	0.2	2.4	5.4	6.2	6.5	6.9
d	Net Reduction	5.2	17.7	33.8	38.7	40.7	42.7
e	System Nett Demand	355.5	375.7	396.1	435.8	469.4	500.5
f	System Gross Demand	369.7	390.7	412.0	453.3	488.2	520.5

Notes: (1) All volumetric values are given in million m³/annum.

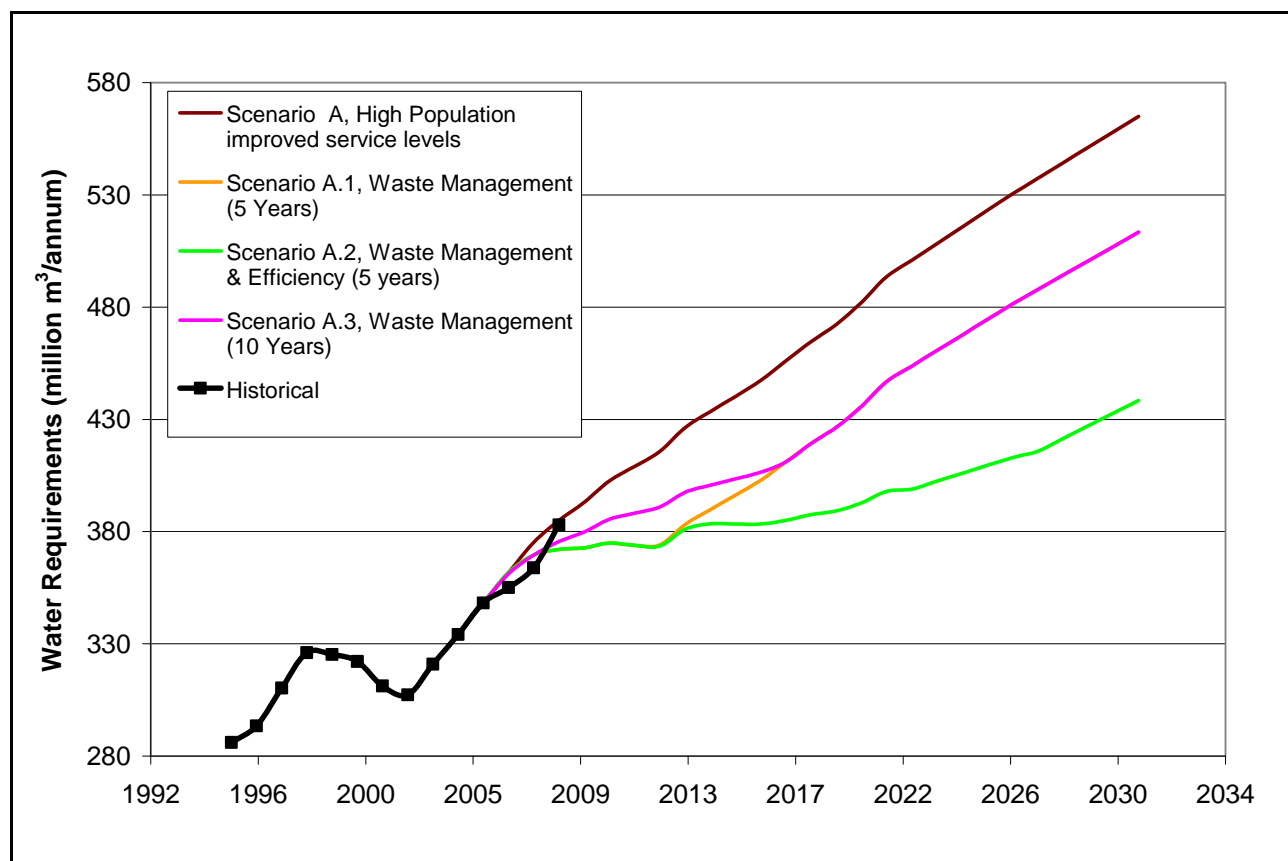


Figure 5.1: Summary of the Mgeni River System water requirement scenarios (WC/WDM)

These water requirements and return flows were used to compile the reconciliation scenarios, which are presented in **Section 8.8**.

5.2 WC/WDM RELATED CONCLUSIONS AND RECOMMENDATIONS

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

WC/WDM can provide a significant reduction in the water demands in the area if the measures are implemented properly and maintained indefinitely. The cost of implementing WC/WDM measures is often less than the maintenance costs, however, without continuous maintenance WC/WDM interventions fail within a year or two of being implemented.

The potential savings that can be achieved in the study area range from a maximum optimistic estimate of approximately 86 million m³/annum (**Scenario 2**) in the year 2024 to a more conservative and possibly realistic estimate of 40 million m³/annum (**Scenario 1 and 3**).

Garden irrigation using potable water is a huge problem 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 on efficiency grounds.

Government Departments must co-ordinate their efforts with regard to WC/WDM. The efforts of DWA where the Department is spending large budgets to educate consumers on the evils of hosepipe irrigation is being undermined by the efforts of the Department of Agriculture, where it is providing free hosepipes to the same consumers to grow vegetables. Those wishing to grow vegetables in such areas should be provided with buckets or watering cans, which can still be used with good effect without causing the system problems mentioned previously. Alternatively, roof tanks should be provided to capture rainwater, which is ideal for such irrigation.

DWA should encourage WDM activities – e.g. fund projects like, 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 urban systems where maintenance has been neglected for many 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.

6 INFRASTRUCTURE INTERVENTION OPTIONS

Due to the orientation and layout of the individual rivers flowing to the ocean and the stretched-out urban development along the coast, several detached development options (each supplying a portion of the area) were identified as potential solutions to augment the study area's water needs.

Numerous previous studies investigated these development options at varying levels of detail with the result that the implementation readiness of the developments vary. Given the current (year 2009) situation, where the water demands exceed the sustainable resource availability (See **Section 7** for details), some of the developments require immediate implementation and planning of others that need a long lead time to implement should commence immediately.

The different augmentation options considered in the study are summarised below. The reader is referred to the Infrastructure report of the same study for more details on the different water resources development options (**DWA, 2008c**).

6.1 MOOI-MGENI TRANSFER SCHEME PHASE 2 (SPRING GROVE DAM)

The Mooi-Mgeni Transfer Scheme currently consists of the Mearns Weir on the Mooi River, from where water is abstracted and pumped over the catchment divide as an inter basin transfer into Midmar Dam.

The Mgeni River System Analysis Study (**DWA, 1994**), the Mooi-Mgeni Transfer Scheme Pre-feasibility Study (**DWA, 1999**) and the Mooi-Mgeni River Transfer Scheme Phase 2 (MMTS-2) Feasibility Study (**DWA, 2007c**) conducted by UW and DWA have identified that further water resource developments on the Mooi River to transfer adequate water to the Mgeni system are feasible and it was confirmed that Phase 2 of the scheme should be implemented. The proposed scheme consists of a large storage dam on the Mooi River at Spring Grove and a pump station and transfer infrastructure to transfer the water to Mgeni system. Further flexibility of Spring Grove Dam is that it could also be used to support the Lower Thukela supply area via the Mooi River, which enters the Thukela River. The yield of the Spring Grove Dam has been determined as 60 million m³/a (**DWA, 2007c**).

DWA recently approved the scheme and directed the Trans-Caledon Tunnel Authority (TCTA) to implement Phase 2 of the Mooi-Mgeni Transfer Scheme. According to the implementation programme the scheme should be completed by 2013.

6.2 MKOMAZI-MGENI TRANSFER SCHEME PHASE 1 (SMITHFIELD DAM)

In 1997, DWA initiated the Mkomazi-Mgeni Transfer Scheme Pre-Feasibility Study, which investigated transfer water from the upper Mkomazi River to the Mgeni System (**DWA, 1999b**). Phase 1 of the scheme consists of a dam on the Mkomazi River near Smithfield, with a pump station and transfer tunnel to the Mlazi River near Baynesfield and conveyance and treatment and infrastructure supplying potable water to a proposed reservoir at Umlaas Road.

Only Phase 1 of the scheme was considered in this study. The yield for Smithfield Dam has been determined as 147 million m³/a (**DWA, 1999b**). According to the implementation programme, 10 years are required for the implementation of the scheme.

6.3 MVOTI RIVER DEVELOPMENT (ISITHUNDU DAM)

The Mvoti River Dam Feasibility Study was initiated in 1995 by DWA and UW (**DWA, 1996a**). The objective of the study was to find an acceptable proposal to provide storage for users supplied from the Mvoti River. The study concluded that a 51 million m³ gross storage capacity dam at IsiThundu should be constructed, which could be raised by 15m (102 million m³ gross storage) as a second phase of the development.

The proposed option consists of the IsiThundu Dam on the Mvoti River, upgraded abstraction works and transfer infrastructure to a new off-channel storage dam, a pump station and treatment infrastructure. The updated yield for IsiThundu Dam was calculated as 33.6 million m³/a and 46.3 million m³/a for a storage capacity of 51 million m³ and 102 million m³ respectively, as part of the study. According to the implementation programme 10 years are required for implementing the scheme.

6.4 LOWER THUKELA SCHEME

The lower Thukela River was defined as the river section between Kranskop and the Thukela Mouth for the purpose of this study. The maximum yield available in the Lower Thukela was estimated as 77 million m³/a. The yield included the available yield in the lower Thukela of 45 million m³/annum and the unused allocation to Mhlathuze Water of 32 million m³/annum (see **Section 7.4** for more detail).

The proposed scheme consists of constructing abstraction works, a pump station at the existing gauging weir at Mandini and transfer and water treatment infrastructure to supply the KwaDukuza

and surrounding areas. According to the implementation programme, 5 years are required for the implementation of the scheme.

6.5 WASTE WATER RE-USE OPTIONS

There are currently significant volumes of treated wastewater processed by municipalities that are either discharged directly or indirectly through the coastal rivers into the ocean. eThekweni has already successfully implemented re-use for industrial purposes and reconnaissance investigations show that by applying sophisticated filtration and treatment processes (addition to current wastewater treatment plants) further reuse seems plausible and economically comparable to other alternatives.

A further advantage of wastewater reuse is that it can be implemented over a shorter timeframe compared to the large dam development and could augment the water needs over the medium term.

The total return flow volumes generated from the eThekweni and Msunduzi municipal areas in 2006 are 57% of the total water use (195.0 million m³/annum). Of the total return flows, certain wastewater treatment works (WWTW) were identified to be suitable for domestic re-use purposes based on their location, return flow volumes and the industrial component of the effluent. Effluent with an industrial component of 10% or less was regarded as suitable for domestic re-use purposes and effluent with an industrial component of more than 10% as only suitable for industrial purposes. The return flow and potential re-use volumes are shown in **Table 6.1**.

Table 6.1: Effluent volumes categorised according to reusability

Description	Return Flow Volumes (million m ³ /annum)					
	2006	2011	2016	2021	2026	2031
Total Effluent	195.0	206.4	219.0	234.5	246.8	256.6
Unsuitable Due to Location and Size (including Darvil)	40.2	43.0	46.0	49.5	52.9	55.7
Total Volume Remaining	154.8	163.4	173.0	185.1	193.9	200.8
Suitable for Industrial Re-use Only	89.4	92.5	95.7	100.3	102.5	104.4
Remaining Suitable for Urban Re-use	65.4	70.9	77.3	84.7	91.3	96.4
Total Re-use applied in Scenarios I-IV	48.0	48.0	48.0	48.0	48.0	48.0
Total Re-use applied in Scenarios V	65.4	70.8	77.2	84.6	91.2	96.2

Preliminary assessments of possible re-use options were carried out as part of the study (**DWA, 2008c**) and three types of re-use options were investigated:

- Direct Re-use (potable water)
- Indirect Re-use (into dam)
- Indirect Re-use (irrigation)

Based on the economic analysis results, indirect re-use was established as the most feasible option. **Figure 6.1** presents the geographical location of the Waste Water Treatment Works that were identified as possible sources for re-use for domestic purposes. These include:

- Tongaat Central (Mdloti supply area)
- Verulam (Mdloti supply area)
- Phoenix (Mdloti supply area)
- Kwamashu (Mdloti or Mgeni supply area)
- Northern (Mgeni supply area)

Umhlanga and Amanzimtoti were also identified, but are not as favourable due to their small return flow volumes and unfavourable locations. At the time of the study, the implementation of infrastructure for the diversion of the Phoenix WWTW to the Mgeni System was in the process of being finalised. Phoenix WWTW was however considered as a potential source due to its proximity to augment the water supply of the areas currently supported from the Mdloti River System and was included in **Scenario V** of the reconciliation scenarios (see **Section 8.5** for details).

The development time frame for a re-use option was estimated to be approximately 6 years.

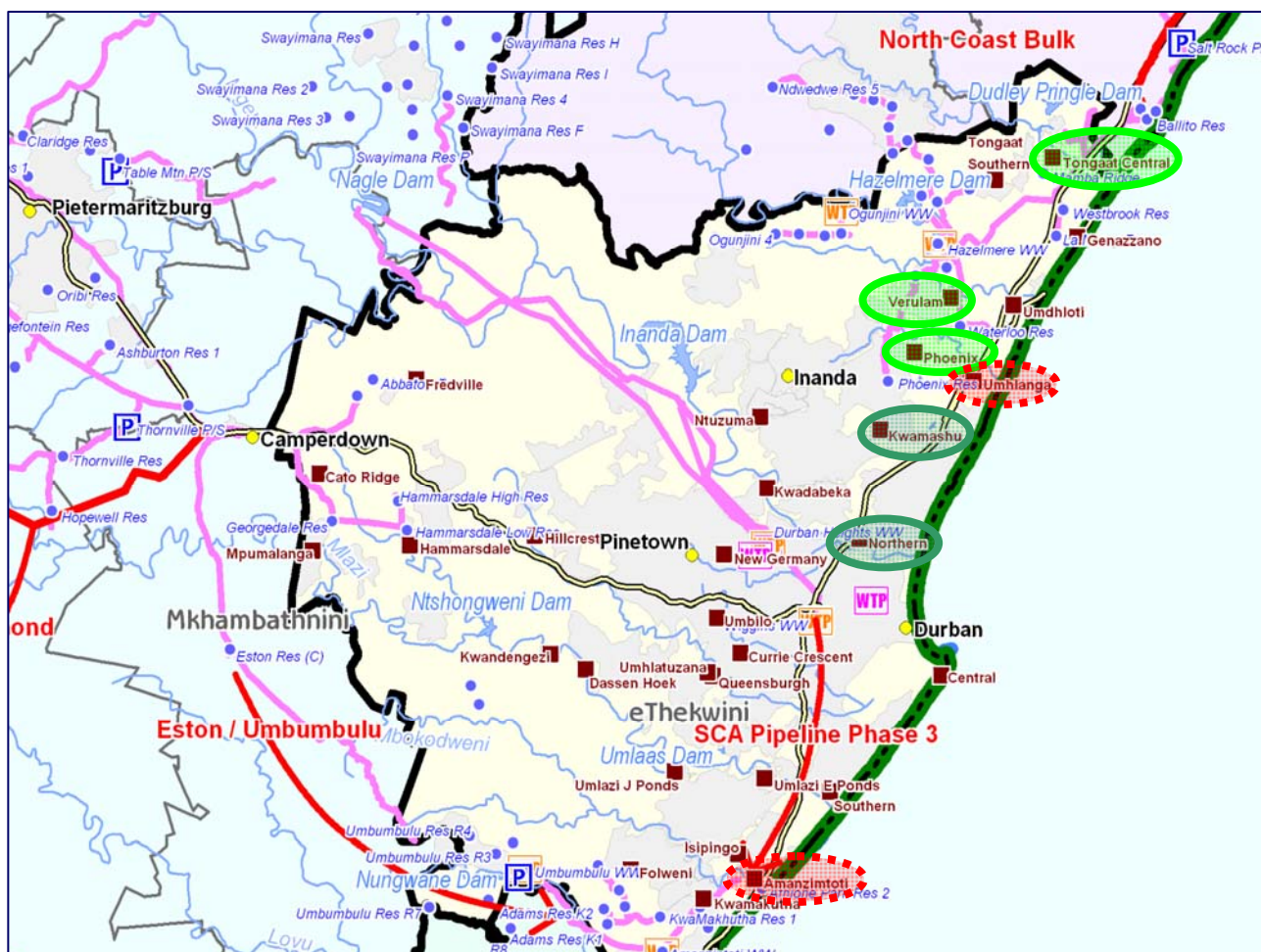


Figure 6.1: Location of identified re-use options

6.6 DESALINATION

Desalination of sea water is a further intervention option that could be implemented to augment water supply in the study area. A study to investigate the feasibility of desalination of sea water as an option to provide additional domestic water is being undertaken by Umgeni Water (“Augmentation of Mgeni System from Large Scale Desalination”, **Umgeni Water, 2009**). A technical review of the “Augmentation of Mgeni System from Large Scale Desalination” study report was undertaken by members of this study team and initial results suggest that desalination of sea water is becoming more economically competitive when compared to other alternative options. This finding indicated that there is not a clear economic differentiation and therefore further higher level investigations are required for desalination options.

7 SUPPLY SITUATION WITH RESPECT TO EXISTING RESOURCE

The projected water balances based on the water available from the existing water resources (excluding interventions) within the various river systems are presented in this chapter.

The projected water balance graphs for the Mgeni, Mdloti, Mvoti and Lower Thukela systems are shown in **Figure 7.1** to **Figure 7.5**, and described below.

7.1 MGENI RIVER SYSTEM

The Total Mgeni System and the Upper Mgeni System balances are provided in **Figure 7.1** and **Figure 7.2** respectively based on the water requirement for **Scenario A** (no WC/WDM initiatives). The Upper Mgeni System balance is provided separately since there are water users that can only be supplied from the upper part of the system (from Midmar Dam) and their supply situation has to be compared against the available water (yield) from the upper system.

Revised water requirement information for the Upper Mgeni System was made available by Umgeni Water during the development of the Second Stage Strategy and has been incorporated in **Figure 7.2**.

The results of the water balances show that the water requirements exceeds the yield of the Total Mgeni System by 40 million m³/annum in the year 2008 and this shortfall increases to 201 million m³/annum by the year 2030. This situation indicates that there is an immediate need for the implementation of interventions to reduce the risk of supply shortages. The increase in yield illustrated in **Figure 7.1** is as a result of the growth in return flows at the Darvill treatment works that enter the Mgeni System which contributes to the yield of the system.

The Upper Mgeni System is in balance up to the year 2015 and a deficit of 31 million m³/annum is estimated for the year 2030. This indicate that augmentation is specifically required to augment the water resource of the Upper Mgeni System.

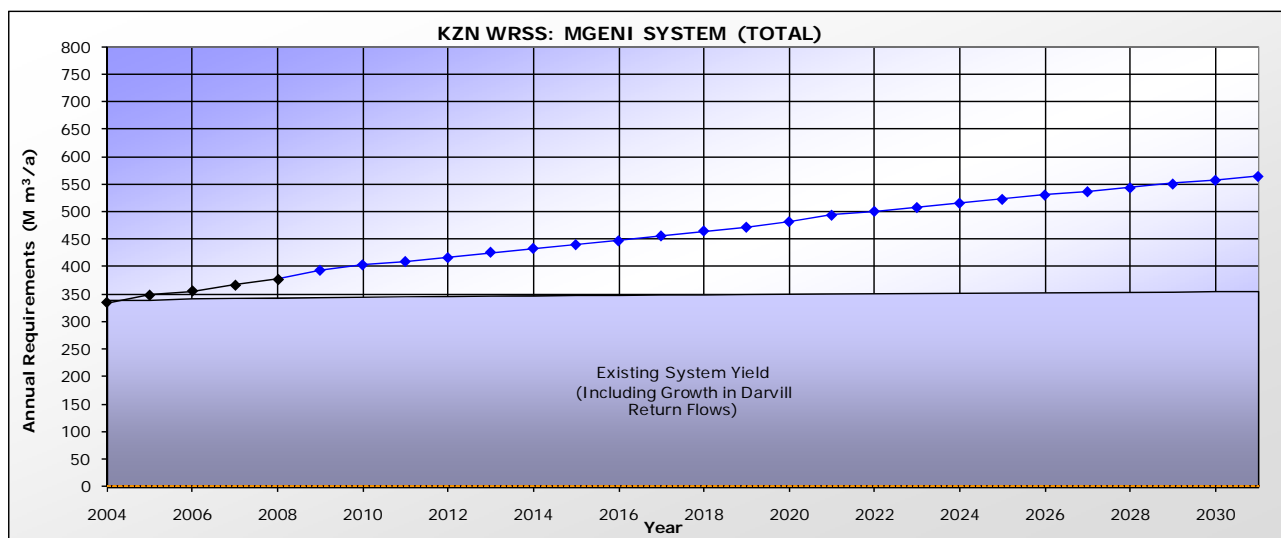


Figure 7.1: Water balance diagram of the existing total Mgeni River System

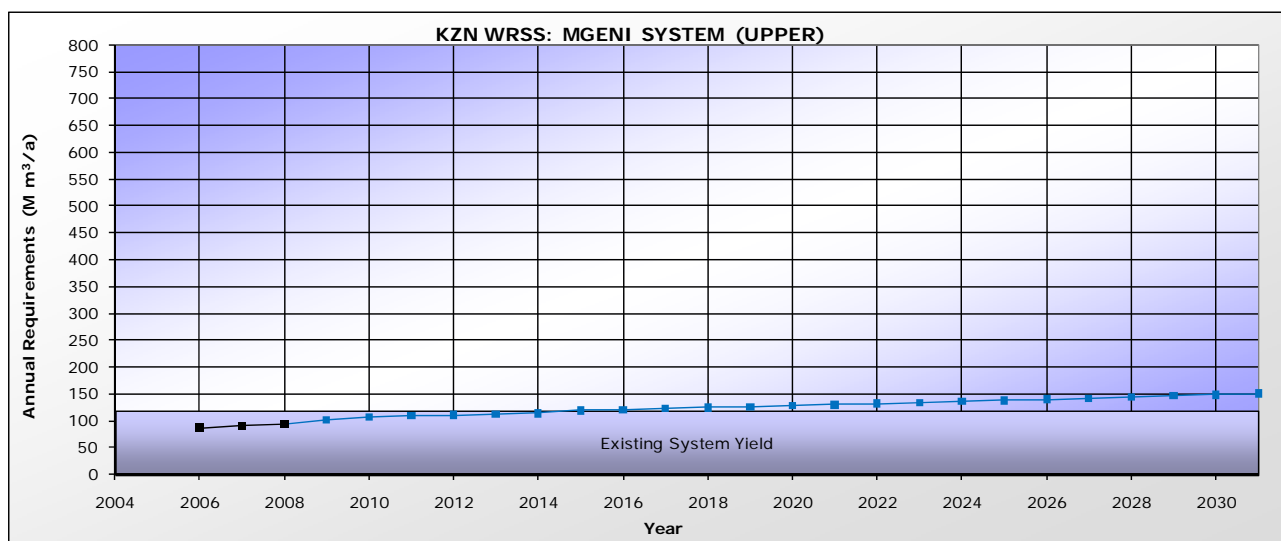


Figure 7.2: Water balance diagram of the existing Upper Mgeni River System

7.2 MDLOTI RIVER SYSTEM

The water balance for the Mdloti System is illustrated in **Figure 7.3** and the two water requirement scenarios, **Scenario M-A** and **Scenario M-B** are illustrated (see **Section 4.2.3** for a description of these scenarios). The two water requirement scenarios are similar, with **Scenario M-B** being the more conservative projection. The Mdloti System has a deficit of 2 million m³/annum in the year 2008, which increases to 47 million m³/annum by the year 2030. Interventions are therefore immediately required to prevent unacceptable shortages in supply. The decrease in yield illustrated in the **Figure 7.3** is as a result of gradual siltation that reduces the storage capacity of Hazelmere

Dam. These assumptions were obtained from the Raising of Hazelmere Dam Feasibility Study: Hydrology Report (DWA, 2003).

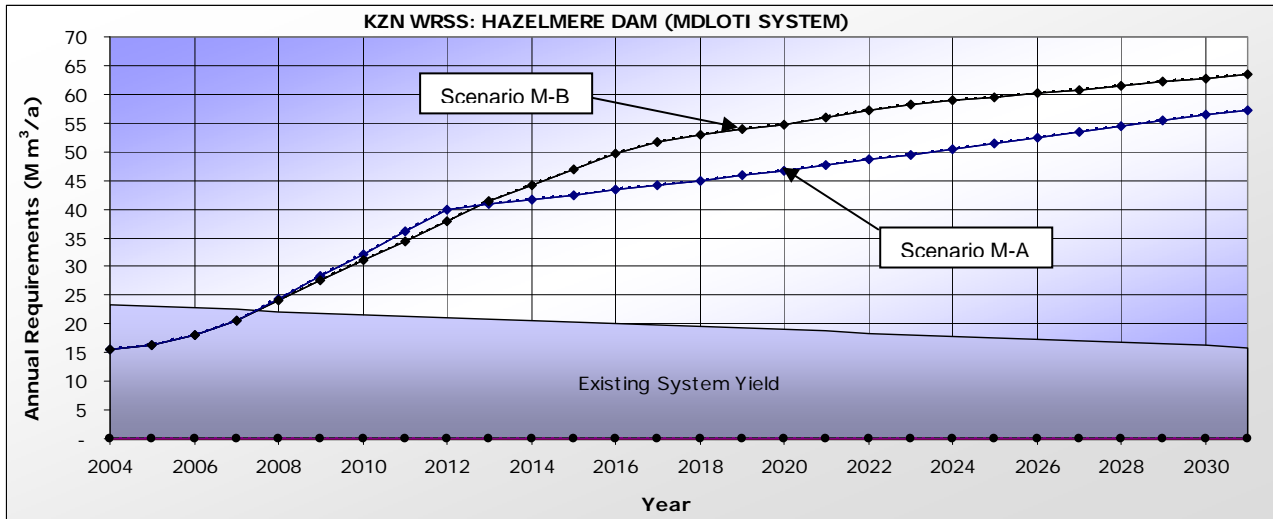


Figure 7.3: Water balance diagram of the existing Mdloti River System

7.3 MVOTI RIVER SYSTEM

The Mvoti System water balance is shown in **Figure 7.4** based on the water requirement scenario that was derived from the ILembe Master Plan (DWA, 2007b). The indicated system yield represents the existing run-of-river abstraction from the Mvoti River which is currently the source of water for KwaDukuza. The water requirement scenario projection includes water requirements for towns and villages in the surrounding area to be connected to the bulk water supply system as defined in the recommendations of the ILembe Master Plan. It was assumed the supply to these areas will be connected over a period of time and therefore the graph show a steep increasing slope for the period between the years 2006 and 2012. The system is currently in deficit and the shortages increases over time with the addition of areas being linked to the bulk supply system as well as the natural growth. The projected shortage is estimated to be 20 million m³/annum in the year 2030. The water balance situation indicate that water resource augmentation is immediately required.

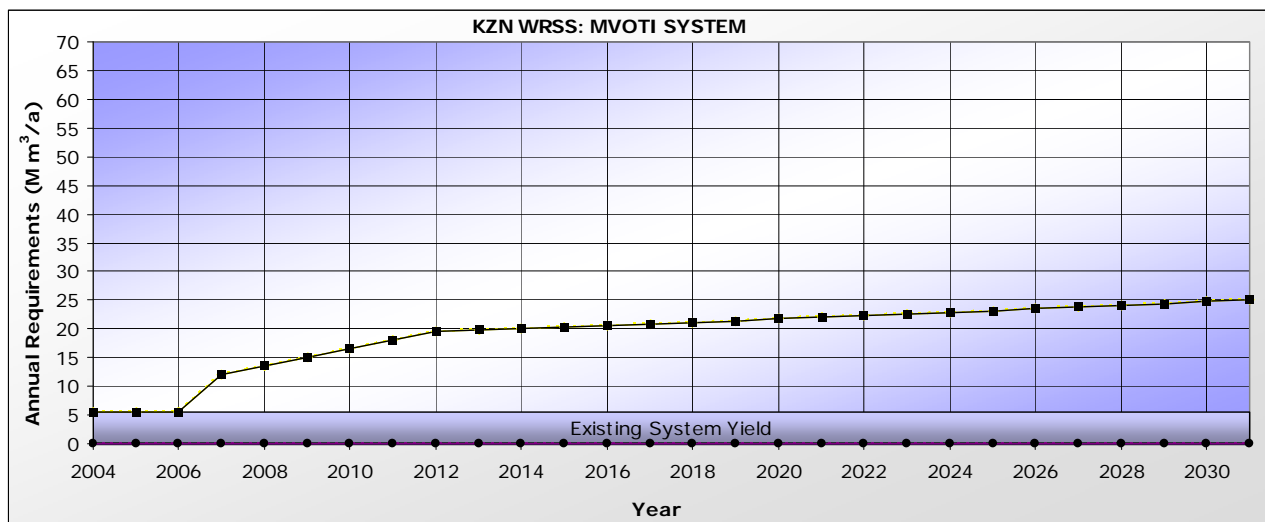


Figure 7.4: Water balance diagram of the existing Mvoti River System

7.4 LOWER THUKELA RIVER SYSTEM

The available yield from the Lower Thukela River System was derived from information obtained in the report describing the Internal Strategic Perspective (ISP) for the Thukela Water Management Area (DWA, 2004c)

A summary of the calculations of the available water in the Lower Thukela River System is given in **Table 7.1**, which shows 45 million m³/annum is available for supply to the urban areas in the Illembe District Municipality as defined in the Illembe Master Plan. There is a potential further additional volume of 32 million m³/annum that could be made available if the unused allocation given to Mhlathuze Water for the proposed Fairbreeze Mine option is not taken up. The total volume of water that is currently not utilised is thus 77 million m³/annum.

Table 7.1: Water balance in Lower Thukela Area (year 2005 development level)

Description	Volume (million m ³ /annum)
Excess/Available Yield	190
Water Requirements (2005)	145
Balance	45
Currently unused allocation of Mhlathuze Water for Fairbreeze Mine (1:50 assurance)	32
Excess/Available Yield in the Lower Thukela	77

Based on these yield results, the water balance provided in **Figure 7.5** for the Lower Thukela River System indicates the availability for two cases, with and without Mhlathuze Water’s unused allocations. The water requirement scenario presented in **Figure 7.5** includes the water need for the villages north of the Thukela River and all the areas that were identified in the Illembe Master Plan.

The water balance for the Lower Thukela River System shows that there are sufficient water resources available to supply the water need up to the year 2030. It should be noted that bulk water supply infrastructure has to be developed to utilise the available water (recommendations in this regard are provided in **Section 14.3.2**).

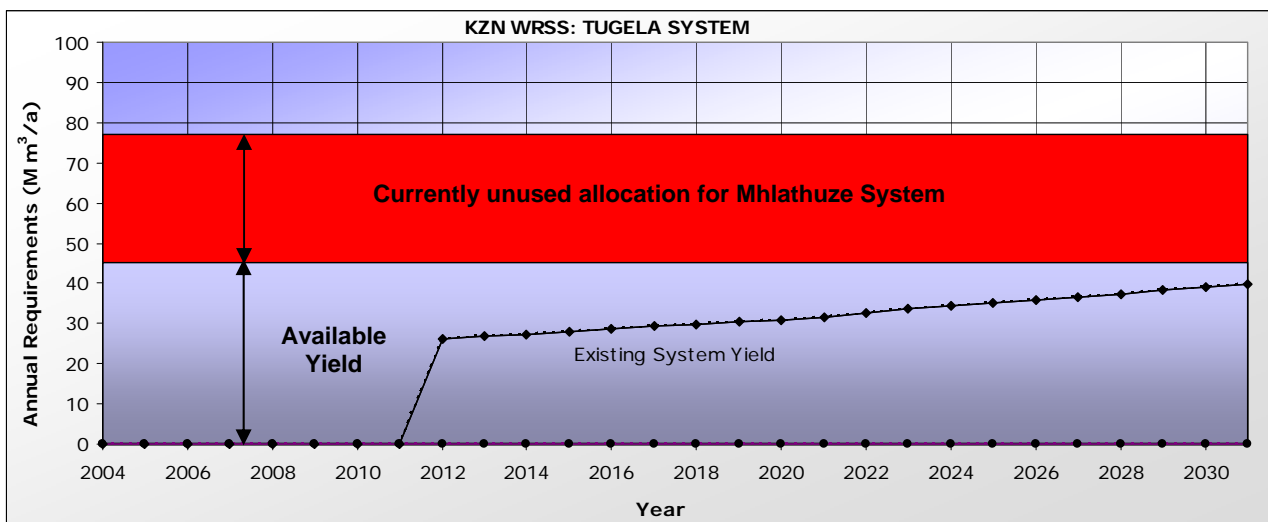


Figure 7.5: Water balance diagram of the existing Lower Thukela System

8 RECONCILIATION SCENARIO DESCRIPTIONS

Based on the results of the existing supply situation (see **Chapter 7**), seven scenarios were formulated to reconcile the future water requirements with the water availability of current and future developments. The scenarios are labelled (**Scenario I** to **Scenario VII**) and described in **Section 8.1** to **Section 8.7**.

8.1 SCENARIO I

Scenario I investigated the option of utilising the Lower Thukela Scheme for supplying and supporting the Mvoti and Mdloti supply areas respectively. The various interventions for the Mgeni System were also investigated. **Scenario I** included the following water requirement scenario and interventions:

- **Scenario A.1** water requirement projection (Mgeni System) i.e. Waste management over 5 years
- Implementation of the Lower Thukela Transfer Scheme to support KwaDukuza and the Mdloti System (Historic Firm Yield (HFY) = 77 million m³/annum)
- Raising of Hazelmere Dam (1:100 Stochastic Yield = 8.90 million m³/annum)
- Incorporation of indirect water re-use (KwaMashu WWTW= 23.00 million m³/annum, North Coast WWTW's = 5.25 million m³/annum, Northern WWTW = 19.70 million m³/annum)
- Implementation of the Mooi-Mgeni Transfer Scheme (MMTS) Phase 2 (Spring Grove Dam: 1:100 Stochastic Yield = 60.00 million m³/annum)
- Implementation of the Mkomazi-Mgeni Transfer Scheme (Smithfield Dam: 1:100 Stochastic Yield = 147.00 million m³/annum)

8.2 SCENARIO II

Scenario II investigated the option of utilising only the existing available yield in the Lower Thukela Scheme for supplying and supporting the Mvoti supply area i.e. excluding the unused allocation to Mhlathuze Water. Due to the reduced available yield from the Lower Thukela, the development of the Mvoti River is also required for supporting both the Mvoti and the Mdloti Supply Area. The following assumptions were made:

- **Scenario A.1** water requirement projection (Mgeni System) i.e. Waste management over 5 years
- Implementation of the Lower Thukela Transfer Scheme to support the Mvoti supply area (excluding the unused allocation to mhlathuze water i.e. Available Historic Firm Yield (HFY) = 45 million m³/annum)
- Implementation of the IsiThundu Dam on the Mvoti River to support KwaDukuza and the Mdloti System (1:100 Stochastic Yield = 40.85 million m³/annum – 102 million m³ Dam Capacity)
- Raising of Hazelmere Dam (1:100 Stochastic Yield = 8.90 million m³/annum)
- Incorporation of indirect water re-use (KwaMashu WWTW= 23.00 million m³/annum, North Coast WWTW's = 5.25 million m³/annum, Northern WWTW = 19.70 million m³/annum)
- Implementation of the Mooi-Mgeni Transfer Scheme (MMTS) Phase 2 (Spring Grove Dam: 1:100 Stochastic Yield = 60 million m³/annum)
- Implementation of the Mkomazi-Mgeni Transfer Scheme (Smithfield Dam: 1:100 Stochastic Yield = 146 million m³/annum)

8.3 SCENARIO III

The purpose of **Scenario III** was to investigate the impacts of increased water savings (implementation of efficiency measures) through WC/WDM. The following assumptions were made:

- Similar to **Scenario I**
- **Scenario A.2** water requirement projection i.e. Waste management over 5 years and improvement of efficiency.

8.4 SCENARIO IV

Scenario IV assumed that the treated wastewater from some of the WWTW's supply the estuarine water requirements for the Mdloti and Tongati Rivers. The scenario was conducted for investigative purposes and was not taken further. The following assumptions were made:

- Similar to **Scenario I**

- Treated wastewater from Verulam and Tongaat WWTW assumed to supply the estuarine water requirements for the Mdloti and Tongati Rivers (Further investigations will be necessary to confirm EWR and the water balance)

8.5 SCENARIO V

Scenario V was included to determine the impact on the water resources if the projected return flow growths of the re-use options and additional identified re-use options are included. The following assumptions were made:

- Similar to **Scenario I**
- Inclusion of return flow growth for water re-use options
- Incorporation of additional water re-use (Phoenix, Umhlanga & Amamzintoti WWTW)

8.6 SCENARIO VI

The purpose of **Scenario VI** was to determine the impact on the water resources systems if the re-use options were excluded as interventions in order to illustrate the importance of re-use. The following assumptions were made:

- Similar to **Scenario I** without any water re-use option.

8.7 SCENARIO VII

During the development of the Second Stage Strategy the “Ngcebo 3: Bulk Water Services: Planning Report” (Ilembe, 2008) became available, which included updated water requirement projections for the area. The water requirement projections included a Theme Park Development, which according to the report was being planned for the coastal area north of the uThukela Mouth. The proposed development will have a major impact on the areas water use. The developers have indicated that the potable water requirements could be 14.6 million m³/annum by 2010 with an ultimate demand of 76.7 million m³/annum by 2024.

This development was not accounted for in the First Stage Strategy reconciliation scenarios and the study team was requested to formulate an additional scenario (including the additional demand for the Theme Park Development) to reconcile the future demands with supply.

8.8 SUMMARISED DESCRIPTION OF RECONCILIATION SCENARIOS

The salient features of the seven reconciliation scenarios are summarised in **Table 8.1**, illustrating the rationale for each scenario.

Table 8.1: Summarised description of reconciliation scenarios

Scenario Label	Description of reconciliation options	
	North Coast Systems	Mgeni River System
I	<ul style="list-style-type: none"> Development of the Lower Thukela Option. Assumed Mhlathuze Water's unused allocation is available as resource for the northern areas. No development on Mvoti River. 	Schedule of interventions to maintain positive balance, including re-use options.
II	<ul style="list-style-type: none"> Development of the Lower Thukela Option. Assumed Mhlathuze Water's unused allocation is NOT available as resource for the northern areas. Schedule the development of the Mvoti River Options as required - to maintain a positive water balance. 	Schedule of interventions to maintain positive balance, including re-use options.
III	Similar to Scenario I.	Assume both loss management and improved efficiency measures are implemented – water requirement Scenario A.2.
IV	Similar to Scenario I with the option where Verulam and Tongaat WWTW supply the estuary water requirements in the Mdloti and Tongati rivers.	Schedule of interventions to maintain positive balance, including re-use options.
V	Similar to Scenario I.	Similar to Scenario I , and allowing the re-use volumes to increase over time and incorporate reuse from less favourable WWTW.
VI	Similar to Scenario I.	Exclusion of any re-use option.
VII	Inclusion of the water requirements for the proposed Theme Park Development north of the Thukela River (additional water requirement of 78 million m ³ /annum).	Schedule of interventions to maintain positive balance, including re-use options.

9 RECONCILIATION SCENARIO RESULTS

The results of the reconciliation scenarios are described with reference to the water balance graphs for the appropriate water resource systems.

9.1 SCENARIO I

Scenario I included the utilisation of the Lower Thukela Scheme to supply and support the Mvoti and Mdloti supply areas respectively. Other interventions as presented in Section 8.1 were introduced for both the Mdloti and Mgeni Systems.

Mgeni River System

The water balance diagram of the Total Mgeni System for **Scenario I** is shown in **Figure 9.1**. The **Scenario A.1** water requirement projection i.e. waste management over 5 years was adapted to schedule the developments for this scenario. The **Scenario A** water requirement projection is also illustrated and it can be seen that the water use savings represented by **Scenario A.1** has a significant benefit by reducing the shortages over the short term and medium term.

Even with the water use savings of **Scenario A.1**, the system remains to experience shortages in with the deficit reaching 28 million m³/annum in the year 2012 period. In the year 2013 additional yield of 60 million m³/annum is made available through the implementation of the second phase of the Mooi-Mgeni Transfer Scheme (Spring Grove Dam and transfer infrastructure). This additional yield is available to both the Upper and the Lower Mgeni systems. The implementation of Phase 2 of the Mooi-Mgeni Transfer Scheme (MMTS) is in an advanced stage of planning and will provide sufficient water for the **Scenario A.1** water requirement until the year 2017. (Note that the yield contribution from Phase 2 of the MMTS scheme includes the dam as well as additional transfer infrastructure).

In order to avoid any further deficits after the implementation of Spring Grove Dam, the KwaMashu re-use option, Northern re-use option and the Smithfield Dam were phased to deliver water in 2017, 2018 and 2020 respectively. The re-use options were required to avoid deficits prior to the implementation of Smithfield Dam – the earliest date for water delivery is in the year 2019. The KwaMashu and Northern re-use options contribute 4.0 and 19.7 million m³/annum respectively. The remaining re-use volume from KwaMashu (19 million m³/annum) is used to support the Mdloti System. Smithfield Dam has a yield of 147 million m³/annum and is only available to the Lower Mgeni System.

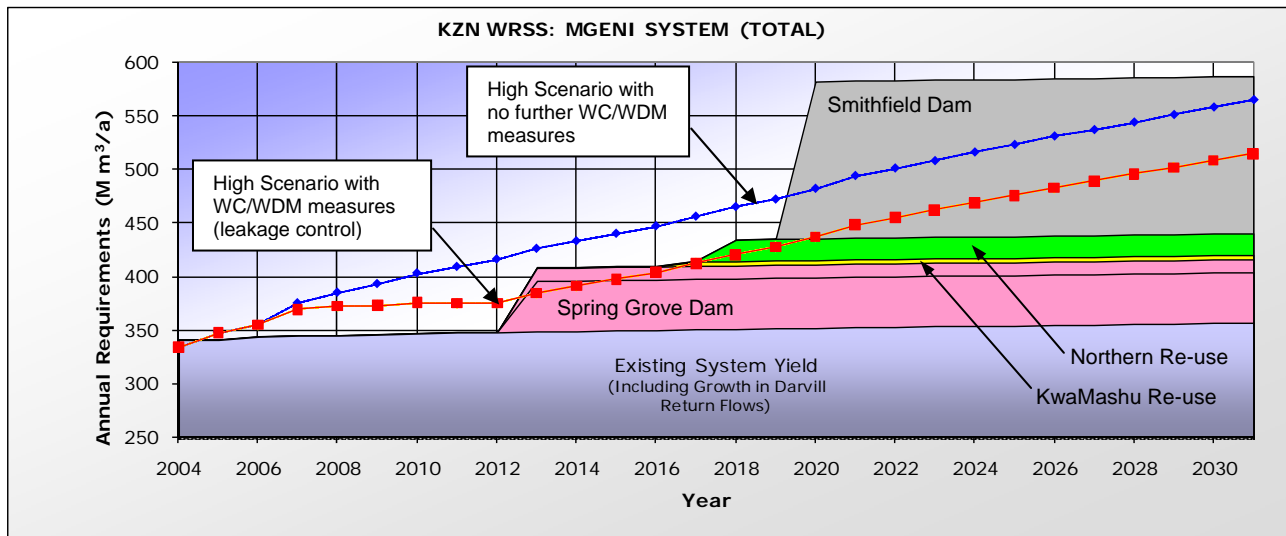


Figure 9.1: Scenario I: Water balance diagram of the Total Mgeni System

Together with the implementation of Spring Grove Dam, additional infrastructure is in the process of being implemented by eThekweni MM and Umgeni Water that will make it possible to shift more of the water requirements onto the Upper Mgeni in the future. The additional infrastructure includes an upgrade of the Midmar Water Works, 53 Pipeline, 61 Pipeline, Richmond Pipeline and the Western Aqueduct (see **Figure A-3** in **Appendix A**). The Upper Mgeni System water balance diagram is illustrated in **Figure 9.2** and shows two cases. The first is where the full capacity of the proposed infrastructure is used to shift maximum demand onto the Upper Mgeni River System (implementation date assumed to be the year 2014) and the second scenario is where no load shift takes place.

With the implementation of Spring Grove Dam, the Upper Mgeni System has surplus water throughout the planning horizon if no load shift in the water requirement takes place. If one considers the water requirement projection where the full load shift takes place, the Upper Mgeni is in deficit from 2019 onwards, with a projected deficit of 29 million m³/annum for 2030. The implementation of Smithfield Dam will provide sufficient water for the case where load shift takes place. This balance result indicates that the operation with respect to the water abstraction from the Upper Mgeni River System will have to be carefully managed in the period prior to be implementation of Smithfield Dam. This is to ensure over abstraction from the Upper Mgeni River System is prevented.

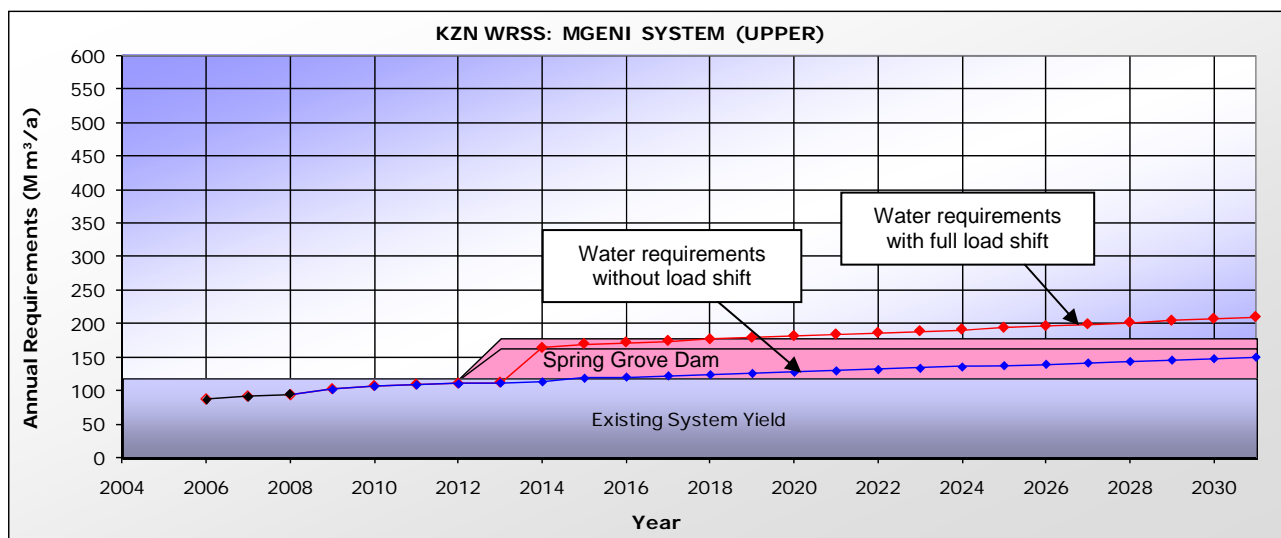


Figure 9.2: Scenario I: Water balance diagram of the Upper Mgeni System

Note that the water balance for the Upper Mgeni System remains the same for all the scenarios and are therefore not repeated for the other scenarios.

Mdloti River System

The water balance diagram of the Mdloti System (Hazelmere Dam) is shown in **Figure 9.3**. From the figure it can be seen that various interventions are necessary to ensure adequate water is available over the planning horizon.

The first intervention that can be implemented is the raising of Hazelmere Dam wall which is scheduled to be completed in 2010 and will increase the yield by 8.9 million m³/annum. The expected growth in the water requirements is such that the system is in deficit for approximately three years (maximum 8 million m³/annum) from after the dam is raised. In the year 2014 additional support is provided from the surplus yield from the proposed Lower Thukela Scheme. (This surplus is over and above support provided to Mvoti River System).

In order to meet the projected water requirements, additional support is required and in this scenario indirect waste water re-use from the KwaMashu WWTW (KwaMashu Re-use), the Verulam and Tongaat Central WWTW's (North Coast Re-use) is implemented. The KwaMashu re-use option was scheduled to deliver water by 2014, which is the earliest implementation date for the re-use options. The supply volume assumed for support to the Mdloti River System was 19 million m³/annum (4 million m³/annum was assigned to the Mgeni System) and is sufficient to supply the water requirements until 2025. The North Coast re-use option was therefore scheduled to supply water by 2026 at a volume of 5.25 million m³/annum, which achieves a positive water balance until the year 2030.

It is proposed that the Ecological Water Requirements (EWR) be introduced once sufficient water is available for meeting the projected water requirements. As a result the EWR releases were only imposed from the year 2014 onwards, which is illustrated by a sudden drop in yield in the year 2014.

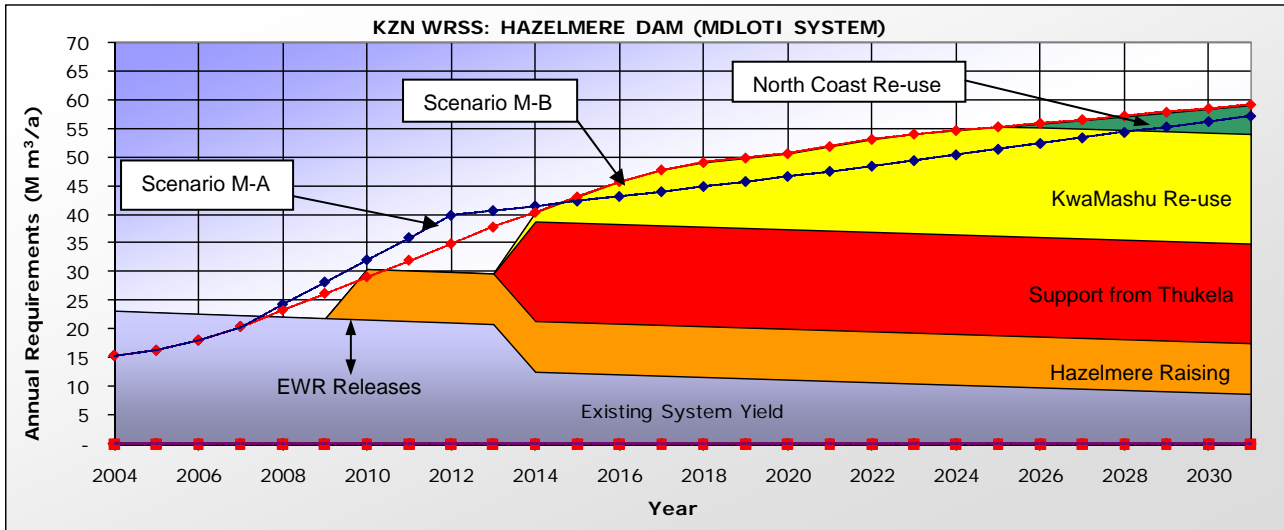


Figure 9.3: Scenario I: Water balance diagram of the Mdloti System

Mvoti System

The water balance diagram for the Mvoti System is shown in **Figure 9.4** and indicates the system is in a deficit situation up to 2014, after which the system is supported from the available yield in the Lower Thukela. A maximum deficit of 14 million m³/annum occurs in this period.

The reason for the decrease in yield shown on **Figure 9.4** is due to the increasing demand that is being supplied to the villages north of the Thukela River i.e. the surplus yield after supplying the demand centres north of the Thukela is reflected as the yield available for the Mvoti River System.

A significant portion of the unused allocation to Mhlathuze Water is required for the Mvoti System and to also support the Mdloti River System (see previous description of the Mdloti River System).

These findings show that a balance can only be achieved for **Scenario I** if the unused allocation to Mhlathuze Water is available to supply water to the northern part of the study area.

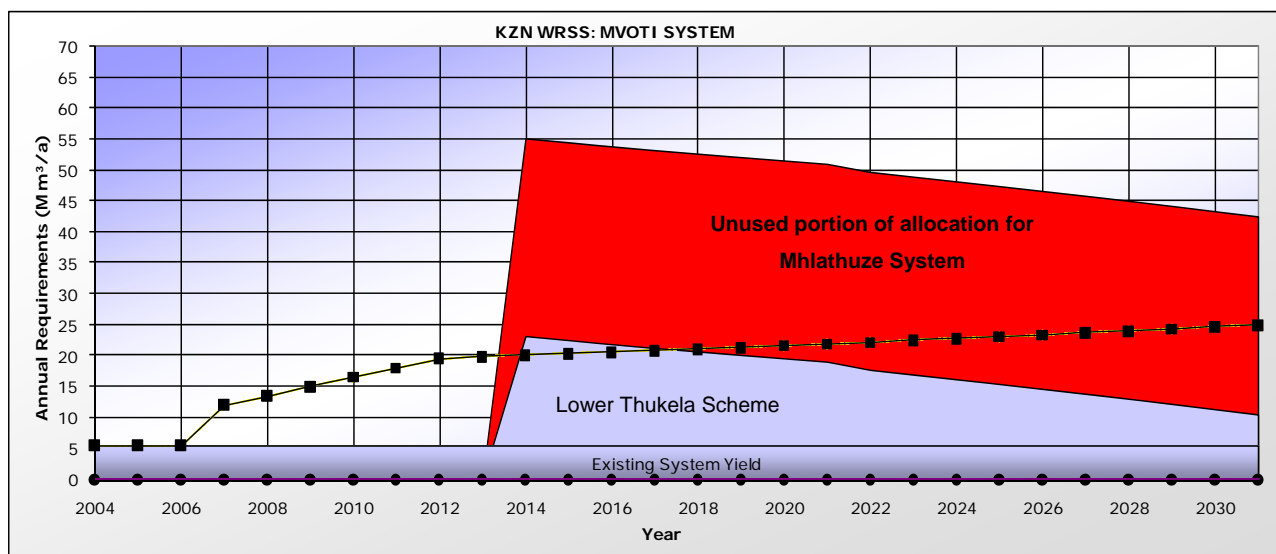


Figure 9.4: Scenario I: Water balance diagram of the Mvoti System

9.2 SCENARIO II

The objective with Scenario II was to formulate a reconciliation scenario where it is assumed the unused allocation to Mhlathuze Water is not available to supply users in the northern areas. The proposed Mvoti River Scheme (IsiThundu Dam) was introduced as an additional resource for this scenario.

Mgeni System

The water balance diagram for the Mgeni System is shown in **Figure 9.5** and it can be seen that the balance for **Scenario II** are very similar to **Scenario I**. In Scenario II the full reuse volume from KwaMashu is required to achieve reconciliation in the Mdloti River System with the result that the Northern re-use option had to be scheduled to deliver water by the year 2017 to avoid a shortage for the period prior to implementation of the Mkomazi River Scheme (Smithfield Dam) by the year 2019.

Mdloti System

The water balance diagram for the Mdloti System is shown in **Figure 9.6**. The deficits that occur are very similar to **Scenario I**. The main difference (compared to **Scenario I**) is that the IsiThundu Dam is scheduled to deliver water in the year 2019 (for **Scenario I** the Lower Thukela Scheme could provide support from the year 2014). Due to the longer lead time required for the implementation of the IsiThundu Dam, it is only possible to implement the EWR releases in 2019, which is five years later than in **Scenario I**. The yield for the IsiThundu Dam has been shown for two development phases (the first phase is for a dam capacity of 51 which is increased to 102

million m³ in the second phase). The reason for the projected decrease in the yield of Phase 1 is because a portion of the yield is also required to supply the Mvoti demand centre (see **Figure 9.7**) i.e. the surplus yield after supplying the Mvoti demand centre is reflected as the yield available for the Mdloti River System. Both phases are required to achieve reconciliation until the year 2030.

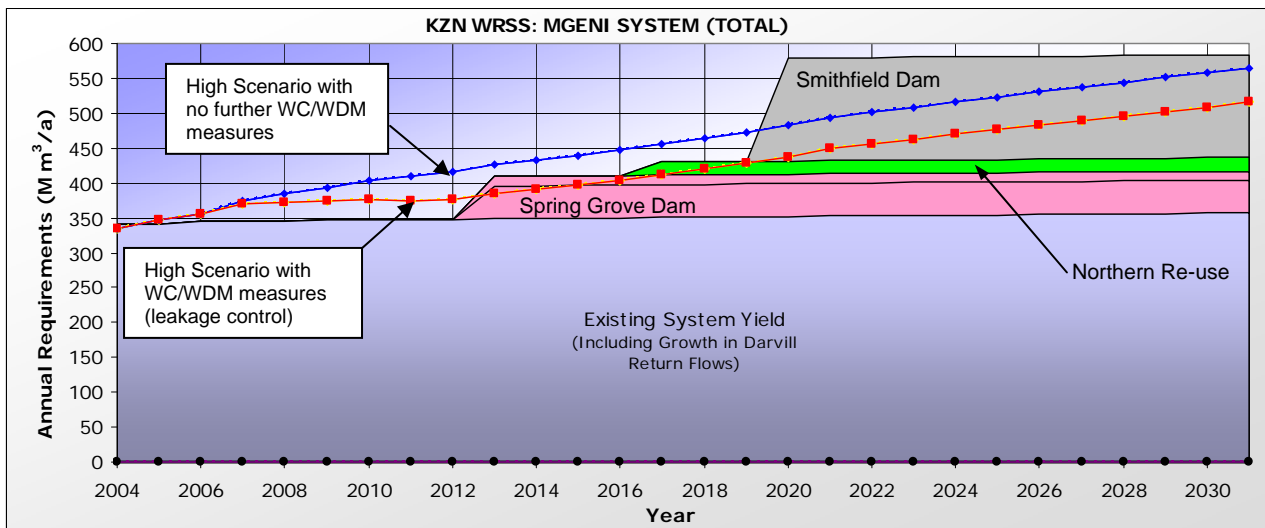


Figure 9.5: Scenario II: Water balance diagram of the Total Mgeni System

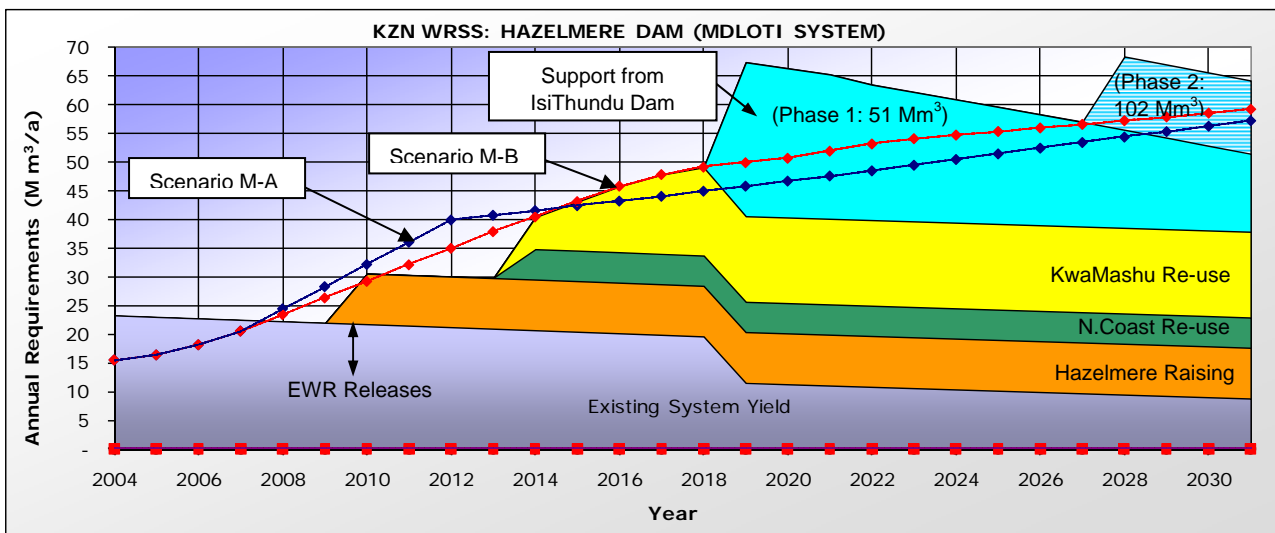


Figure 9.6: Scenario II: Water balance diagram of the Mdloti System

Mvoti System

The water balance diagram for the Mvoti System is shown in **Figure 9.7** and indicates the system is in a deficit until the year 2014 when the Lower Thukela Scheme can deliver water. Further

support is provided by the Mvoti River Development (IsiThundu Dam) from the year 2019 onwards. The surplus yield from the IsiThundu Dam is used to support the Mdloti System.

The illustrated existing system yield for the Mvoti River represents the existing run-of-river abstraction from the river (5.5 million m³/a). The total yield of IsiThundu Dam is 33.6 million m³/a and 46.3 million m³/a for Phase 1 and 2 respectively, which includes the currently assumed existing yield of 5.5 million m³/a. As a result, only the incremental increase in yield due to the IsiThundu Dam development is illustrated in the water balance diagrams i.e. 28.1 million m³/a and 40.8 million m³/a for Phase 1 and Phase 2 respectively. The total Mvoti System yield with IsiThundu Dam (Phase 2) included is thus 46.3 million m³/a.

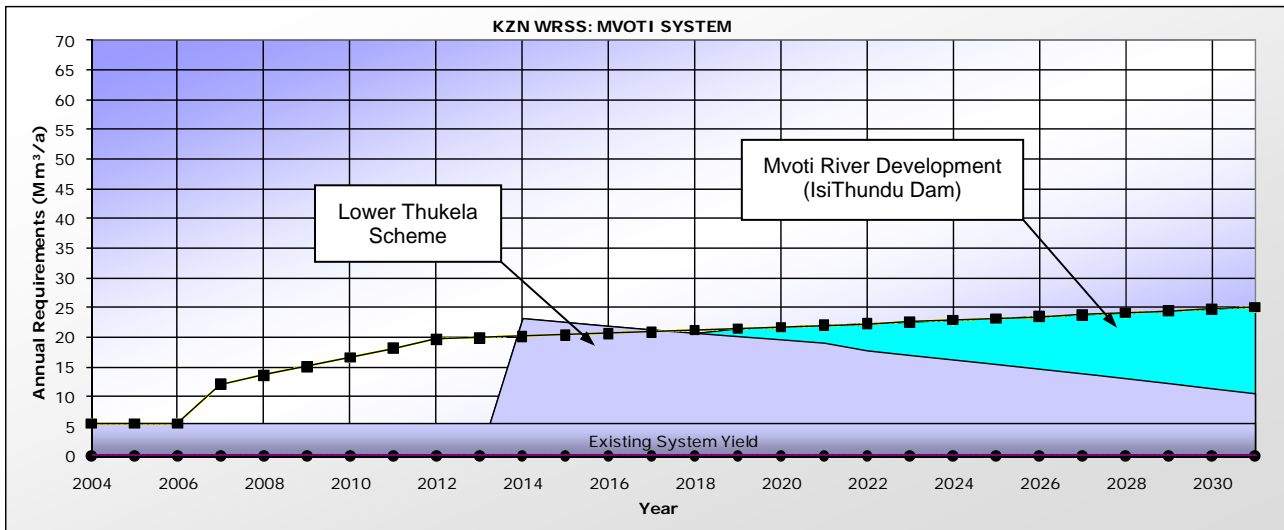


Figure 9.7: Scenario II: Water balance diagram of the Mvoti System

An additional scenario was investigated where it was assumed that no water is available from the Lower Thukela for supporting the Mvoti River System. The water balance diagram for the Mvoti System for this scenario is illustrated in **Figure 9.8**. The yield of the IsiThundu Dam has been shown for the two development phases. The long initial period of shortages makes this scenario unacceptable and it was not taken further in the evaluations.

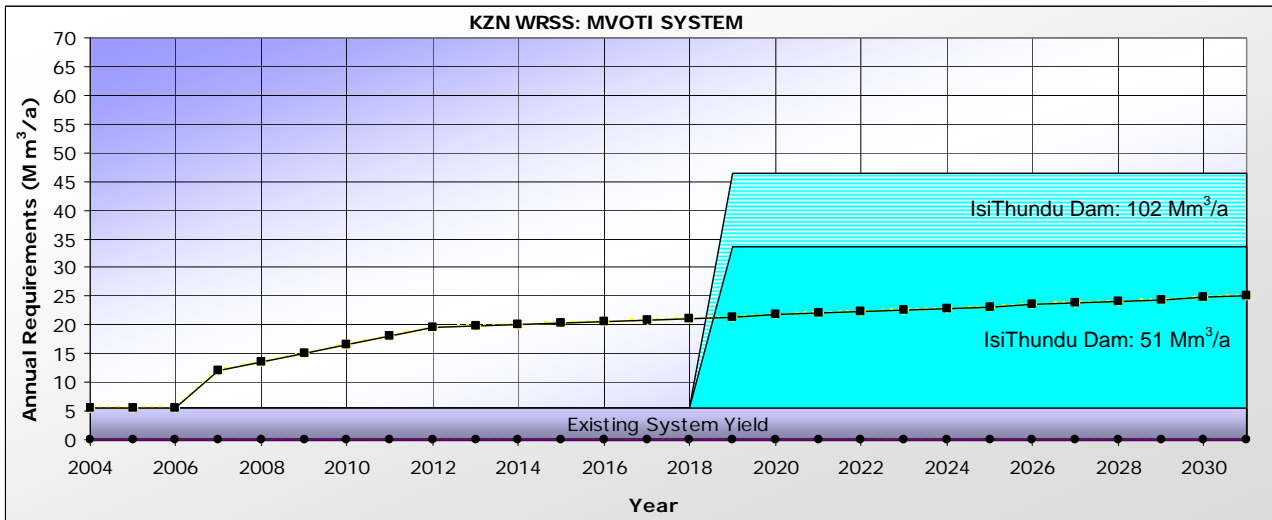


Figure 9.8. Water balance diagram of the Movti System (no support provided from the Lower Thukela)

9.3 SCENARIO III

Scenario III evaluates the reconciliation option for the situation where both waste management and efficiency improvements are implemented as Water Conservation and Water Demand Management measures in the eThekweni and Msunduzi municipalities. The saving **Scenario A.2** was applied for this reconciliation scenario - see **Section 5.1.2** for details.

Mgeni System

The water balance diagram is provided in **Figure 9.9** and shows that the initial shortages for the period up to the year 2014 were identical to those for **Scenario I** and **II**. This is because the water requirements were the same for all three scenarios over the initial period and reflect the same saving by implementing measures to reduce the wastage of water over the first five years. After the year 2014 measures are implemented to improve the efficiency of water use in **Scenario III**.

The impact of the improved efficiency is substantial and the implementation of the Smithfield Dam Scheme is not required in the illustrated planning horizon. Spring Grove Dam, KwaMashu re-use and Northern re-use are the only infrastructural interventions required. The implementation of the KwaMashu and Northern re-use options have been scheduled to deliver water by the years 2026 and 2028 respectively.

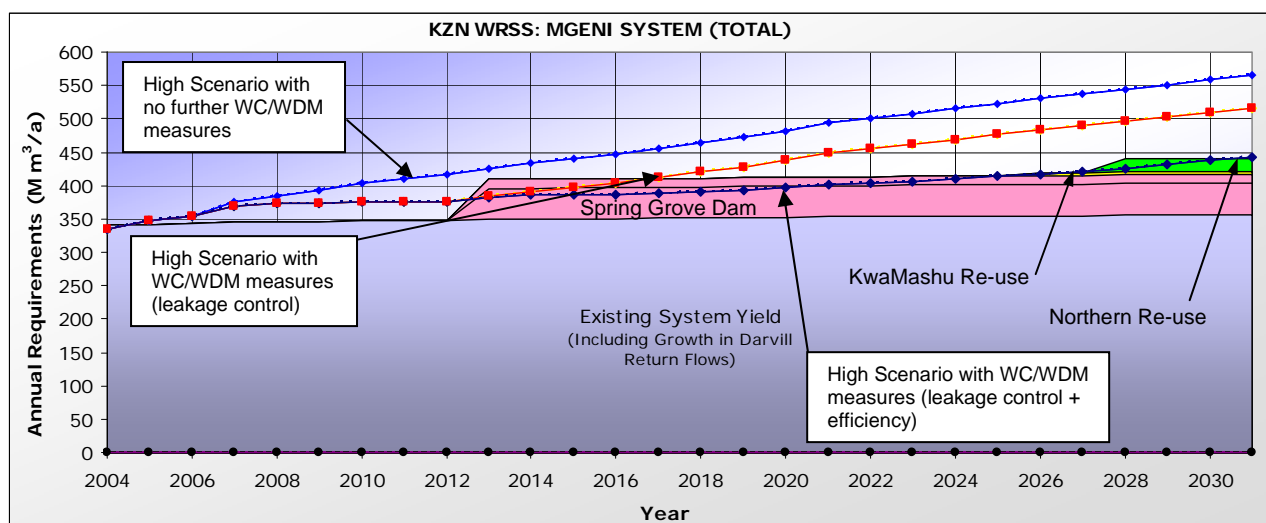


Figure 9.9: Scenario III: Water balance diagram of the Total Mgeni System

The water balance diagrams for the Mdloti and Mvoti systems are identical to **Scenario I** and were therefore not repeated in this section.

9.4 SCENARIO IV

Scenario IV assumed that the treated wastewater from some of the WWTW's supply the estuarine water requirements for the Mdloti and Tongati Rivers. The scenario was conducted for investigative purposes only and was not taken further due to the refinements that are required to integrate the estuary flow requirements with the water resource availability assessments.

9.5 SCENARIO V

The purpose of **Scenario V** was to investigate the situation where all the identified re-use options including the future expected growth in return flows were treated and re-used.

Mgeni System

The water balance diagram is provided in **Figure 9.10** and shows that by treating and re-using the growth in return flows as well as water from the Umhlanga, Phoenix (North Coast reuse options) and from Amanzimtot WWTW, postpones the need for Smithfield Dam until the year 2026.

It should be noted that the Amanzimtoti re-use option is not ideally located and would require long pipelines to convey the water for re-use.

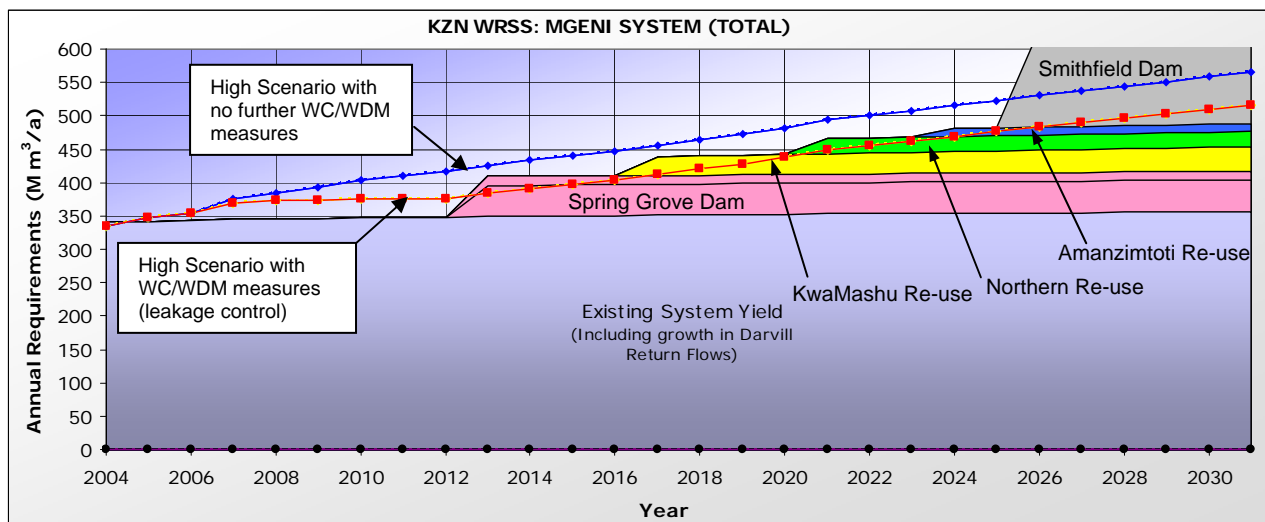


Figure 9.10: Scenario V: Water balance diagram of the Total Mgeni System

Mdloti System

The water balance diagram is provided in **Figure 9.11** and indicates the supply contribution from the Northern Re-use option (re-using from the Umhlanga and Phoenix WWTWs). This scheme contributes a total volume of 9.6 million m³/annum and will be delivering water by the year 2014. Due to the inclusion of the return flow growths, only 2 million m³/annum is required from the KwaMashu Re-use option in order to maintain a positive water balance. The optimisation of the re-use schemes will need to be investigated in a subsequent feasibility study.

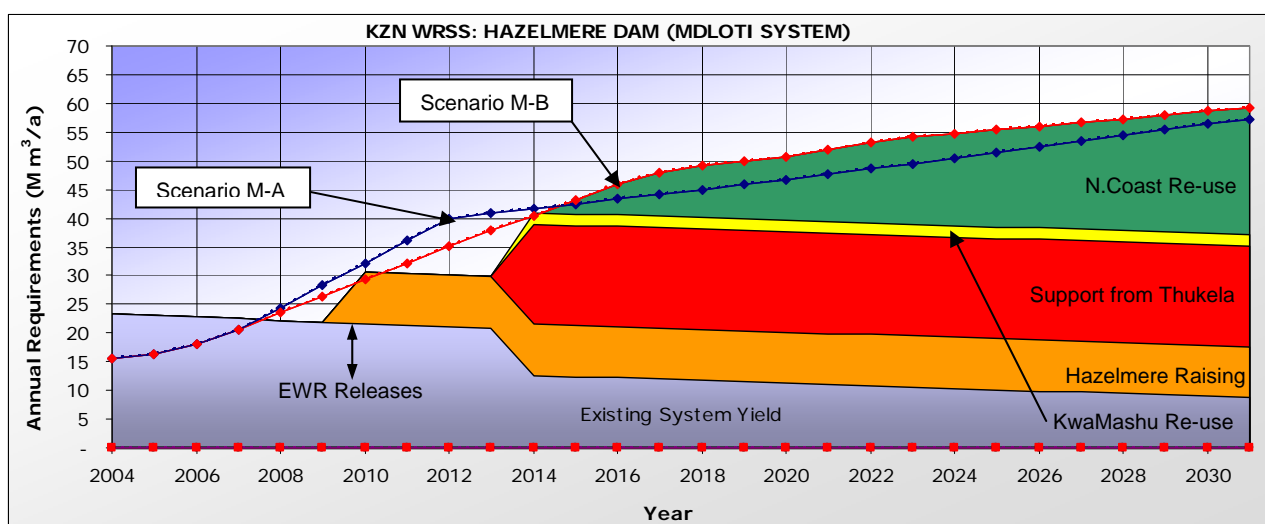


Figure 9.11: Scenario V: Water balance diagram of the Mdloti System

A further alternative reconciliation scenario was investigated where the total available return flows are treated and re-used. The water balance diagram of the Mgeni River System for this scenario is presented in **Figure 9.12** and it can be seen that there is sufficient re-use water available to delay

Smithfield Dam beyond the current planning horizon. The total volume of water re-used in this scenario is about 200 million m³/annum by the year 2030 (see **Table 6.1** for details)

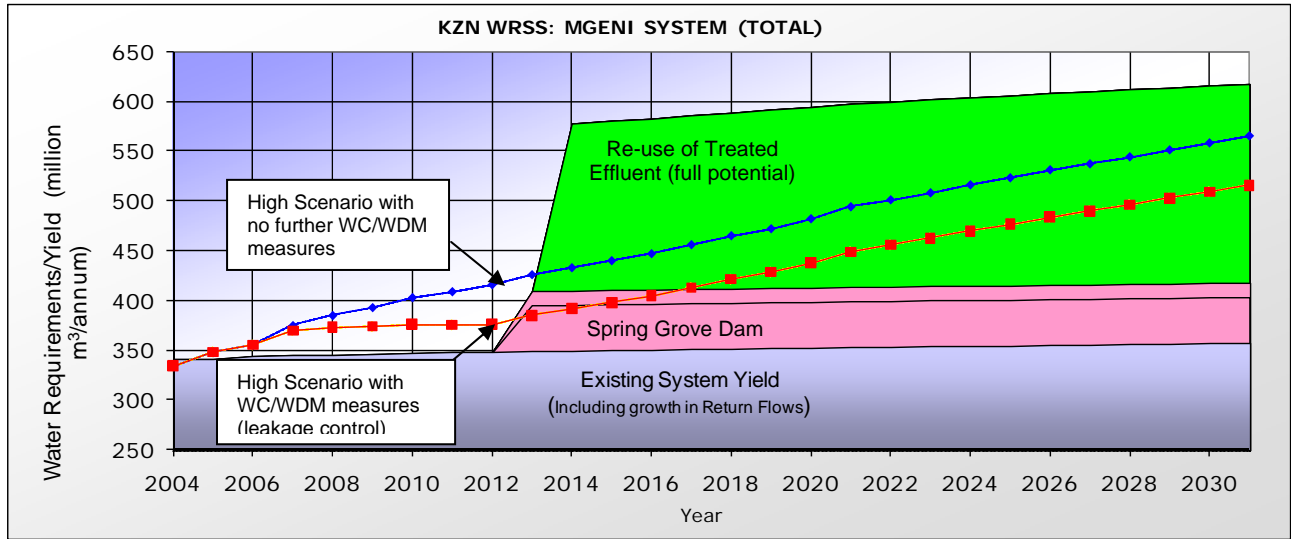


Figure 9.12: Water balance diagram for the Mgeni River System (full potential re-use)

9.6 SCENARIO VI

Scenario VI represents the reconciliation scenario where no re-use takes place and was formulated to show the importance of re-use, which is required to maintain a positive water balance for the systems over the planning period.

Mgeni System

The water balance diagram is illustrated in **Figure 9.13** and shows that the system will experience a shortfall prior to the implementation of the Mkomazi Scheme (Smithfield Dam) in the year 2019 (the earliest possible implementation date). Re-use will therefore be required to achieve reconciliation before the Mkomazi Scheme can deliver water.

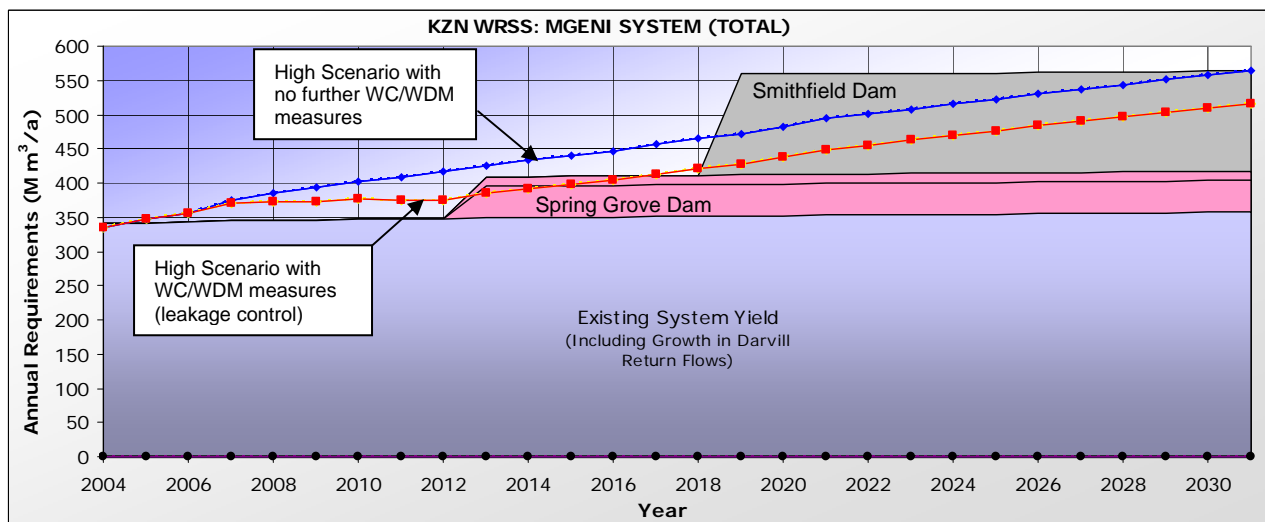


Figure 9.13: Scenario VI: Water balance diagram of the Total Mgeni System

Mdloti System

Figure 9.14 presents the water balance diagram and shows that support from both the Lower Thukela Scheme and the IsiThundu Dam on the Mvoti System are required due to the exclusion of the re-use options. The initial shortages up to the year 2014 are similar to those of **Scenario I**, however shortages also occur for a three year period in 2016 to 2019 (maximum deficit of 10 million m³/annum) which was not evident for **Scenario I**. The yield for the IsiThundu Dam has been shown for two development phases (the first phase is for a dam capacity of 51 which is increased to 102 million m³ in the second phase). The yield for the IsiThundu Dam illustrated in **Figure 9.14** is again the surplus yield after the Mvoti demand centre has been supplied. Both phases are required to achieve reconciliation until the year 2030.

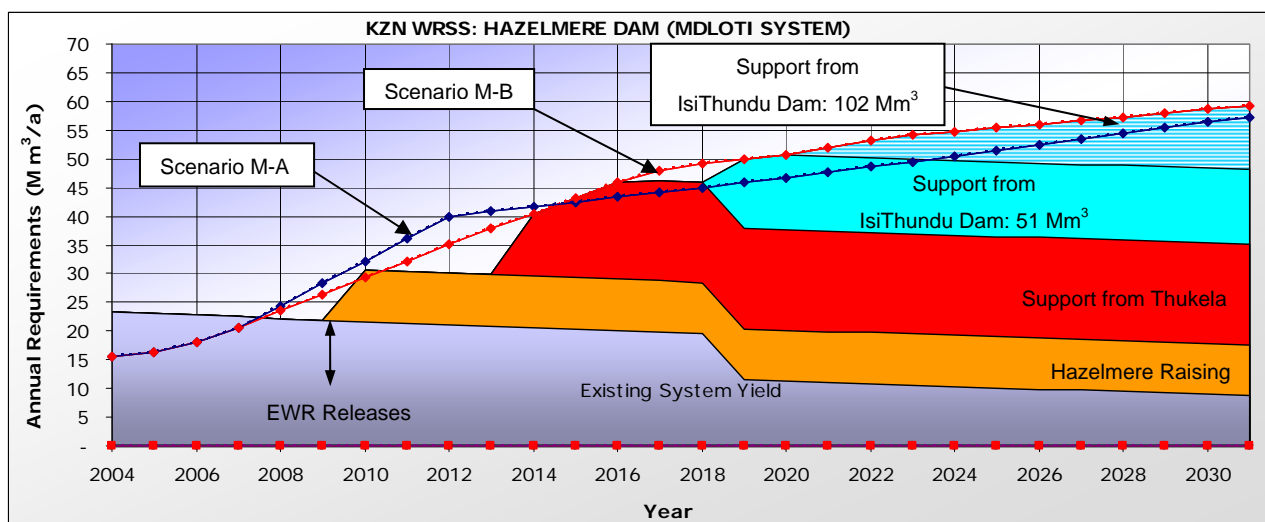


Figure 9.14: Scenario VI: Water balance diagram of the Mdloti System

From the results of **Scenario VI** it can be concluded that the re-use options will need to be implemented to achieve a reconciliation balance for the periods where shortages are indicated in the previous discussions.

9.7 SCENARIO VII

The purpose of this scenario was to establish the interventions required to supply the water needs of a large proposed theme park development north of the Thukela River. The information for this proposed development was obtained from the report “Ngcebo 3: Bulk Water Services: Planning Report” (Ilembe, 2008). The scenario was evaluated at a cursory level of detail and the results are summarised below. It was possible to achieve a balance for the systems through the following interventions:

- Implementation of the Lower Thukela Transfer Scheme to support the Lower Thukela Supply Area (with the increased demand) as well as KwaDukuza, including the utilisation of the Mhlathuze Water’s unused allocation (Total volume available for the Lower Thukela River System was 77 million m³/annum).
- Incorporation of water re-use (KwaMashu WWTW= 23.00 million m³/annum, North Coast WWTW’s = 5.25 million m³/annum, Northern WWTW = 19.70 million m³/annum) for supporting the Mgeni and Mdloti Systems.
- Raising of Hazelmere Dam on the Mdloti River (1:100 Stochastic Yield = 8.90 million m³/annum).
- Implementation of the IsiThundu Dam on the Mvoti River to support KwaDukuza and the Mdloti System (1:100 Stochastic Yield = 40.85 million m³/annum – 102 million m³ Dam Capacity).
- Implementation of the Mkomazi-Mgeni Transfer Scheme (Smithfield Dam: 1:100 Stochastic Yield = 146 million m³/annum) for supporting the Mgeni System.
- Implementation of the Mooi-Mgeni Transfer Scheme (MMTS) Phase 2 (Spring Grove Dam: 1:100 Stochastic Yield = 60 million m³/annum) for supporting the Mgeni System. Once the the Mkomazi-Mgeni Transfer Scheme has been implemented and surplus yield exists in the Mgeni system, Spring Grove Dam is used to support the Lower Thukela Supply area via the Mooi River.

10 OTHER CONSIDERATIONS

10.1 ECONOMIC COMPARISON OF DEVELOPMENT OPTIONS

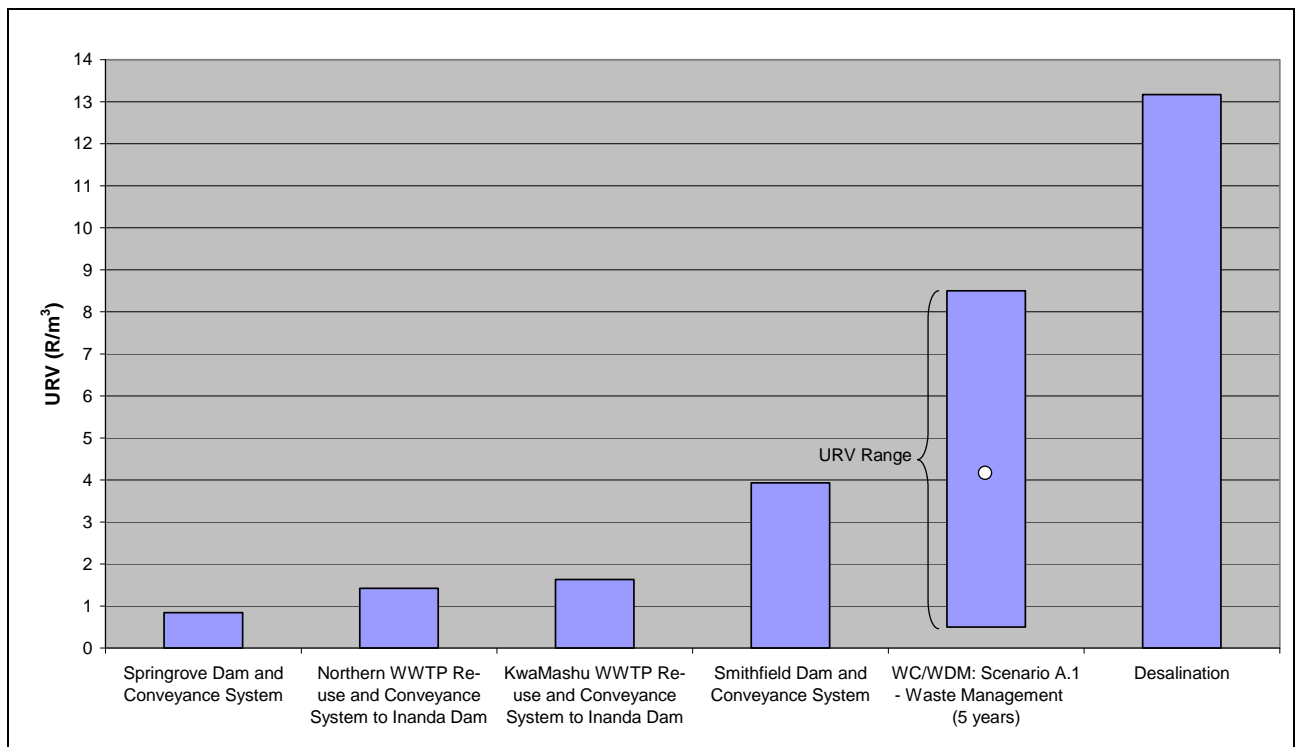
Preliminary cursory comparative economic analyses were carried out for the proposed interventions based on the Unit Reference Values (URV). URV is an economic indicator that is expressed in Rand per cubic meter of water supplied by a scheme (R/m³). It is a standard indicator applied by DWA for economic comparisons between alternative proposed water resource schemes. The salient results of the evaluation are presented in this section and the reader is referred to the Infrastructure Report for more details (**DWA, 2008c**).

The results for the options that can augment the Mgeni System and Northern supply areas are illustrated respectively in **Figure 10.1** and **Figure 10.2**. For reference purposes the URV was also calculated for a sea water desalination option (rudimentary assessment) as illustrated. The initial results from the Umgeni Water desalination feasibility study (**Umgeni Water, 2009**), which became available subsequent to the publication of these results, indicated that a large desalination project becomes economically competitive when compared to conventional development options such as the Smithfield Dam option. This finding indicated that there is not a clear economic differentiation and therefore further higher level investigations are required for desalination options – see the recommendation presented in **Section 14.3.4.**)

The WC/WDM scenario consists of several interventions and a range of URVs have therefore been indicated in the figure. The combined URV of all the WC/WDM interventions is indicated by the circle symbol.

The URV results for the options supplying the Northern areas shows that the Lower Thukela Scheme is significantly cheaper than the development of the IsiThundu Dam options. A further advantage of the Lower Thukela Scheme is the shorter lead time required for implementation.

The URV's for the re-use of waste water from the various WWTW's were calculated for the indirect re-use options. With the exception of the Mooi-Mgeni Transfer Scheme (Spring Grove Dam), the costs of the re-use options are in general lower when compared to the other development options. A further advantage of the re-use options is that they have a shorter lead time than the options requiring the development of dams.



Note: Initial results from the subsequent Umgeni Water desalination study indicate lower costs for desalination, making desalination more economically competitive.

Figure 10.1: URV's for augmentation options of the Mgeni System supply area (8% discount rate)

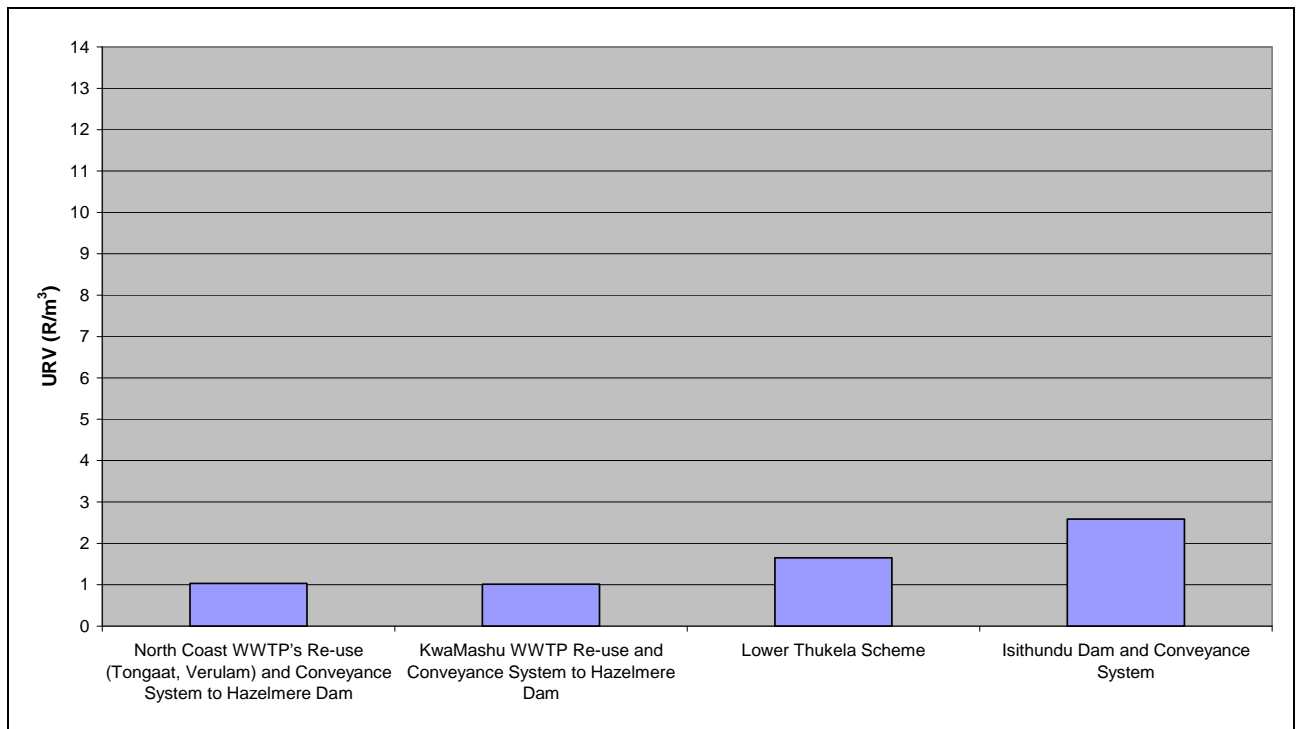


Figure 10.2: URV's for augmentation options of the Northern supply area (8% discount rate)

10.2 PERSPECTIVE ON ECOLOGICAL WATER REQUIREMENTS FOR THE MGENI RIVER

A high level cursory evaluation was carried out to assess the implications of implementing the Ecological Water Requirements (EWR) in the Mgeni River System. Low confidence EWR's data was obtained from the DWAF Directorate: Resource Directed Measures for inclusion in the Water Resources Yield Model (WRYM) of the Mgeni River System for analysis. It was found that the average annual volumes of water for the EWR's were much larger than the compensation flows that were used in previous water resource analysis studies – this is shown in **Table 10.1**. Historical Firm Yield analyses were carried out with the WRYM for the three dams in the Mgeni River System for both the cases where either the compensation releases or the low confidence EWR were imposed on the system. **Table 10.2** presents the results of the analysis and it is shown that the yields for the case where the EWR's are implemented are significantly lower compared to the case where the compensation flows are implemented.

Table 10.1: Mgeni System release scenarios

Location	Natural Flow (MAR)	Compensation Flows	EWR Scenario (Class C)
Midmar Dam	201.7	28.4	47 (23.4%)
Nagle Dam	472.8	22.4	153 (32.3%)
Inanda Dam	629.7	47.3	216 (34.2%)

*Values are given in million m³/annum

Table 10.2: Mgeni System yields

Subsystem	Historical Firm Yields (million m ³ /annum)		Differences
	Compensation Release Scenario	EWR Scenario	
Midmar Dam	177	149	28
Nagle Dam	284	162	122
Inanda Dam	384	210	174

These results together with the current shortage illustrated in systems water balance (see description in **Section 7**) indicates that the immediate implementation of the EWR (based on the scenario analysed) will cause significant further shortages, which will be very disruptive to the socio-economic stability of the water users in the KZN Metropolitan Area. It is therefore necessary to follow a different approach to the conventional reserve determination methods and it is proposed that a remedial flow management plan be developed with the objective to seek pragmatic solutions that will improve the current situation.

Consideration on the Perspective on the Ecological Water Requirements (Reserve)

In compliance the National Water Act, the strategy and the reconciliation scenarios were developed by incorporating available Ecological Water Requirement (EWR) information in the estimates of the utilisable yield of the water resource systems. The EWR determinations differ for each system and the following summary is provided to present the approach that was adopted in the study:

- Comprehensive Reserve Determination studies were carried out for both the Thukela River and Mooi River systems. The utilisable yields for the Mooi-Mgeni Transfer Scheme Phase 2 and the proposed Lower Thukela River Scheme were determined with the EWR supplied as a priority water use.
- High confidence reserve determination information was available for the Mdloti River and estuary. The strategy incorporated releases from Hazelmere Dam as reflected in the reconciliation scenarios discussed in **Section 9**. The D:RDM will carry out further technical refinements to make the river and estuary flow requirements compatible.
- Low confidence reserve determination information was available for the Mvoti River and Mkomazi River systems. This information was incorporated in the determination of the usable yield for the proposed Mvoti River Development (Isithundu Dam and conveyance infrastructure) as well as the option where water is transferred from Smithfield Dam on the Mkomazi River to augment the Mgeni River System. The D:RDM is initiating further studies to undertake high confidence reserve determinations for these river systems. This information is needed for the proposed feasibility studies (see **Section 14** for the recommendations).
- The Mgeni River requires special consideration due to the highly modified state of the system. The water resources of the Mgeni River are extensively utilised for storage, abstraction and discharge of water without which the current socio-economic developments in the KZN Metropolitan Area would not be possible. It will therefore be necessary to follow a slightly

different approach to the conventional reserve determination methods and it is proposed that a remedial flow management plan be developed with the objective to seek pragmatic solutions that will improve the current situation.

10.3 RAINWATER HARVESTING

A preliminary analysis was conducted to evaluate the potential yield that could be achieved through rainwater harvesting in the eThekweni Municipal Area as part of the First Stage Strategy. A yield analysis was conducted using conventional methods of yield determination (Historic Firm Yield analysis) and URV's were calculated, which could then be compared directly to the proposed bulk water supply augmentation schemes. These conventional analysis results showed that on a comparative basis rainwater harvesting is economically unattractive compared to the other options.

At the Study Steering Committee and Public Meetings it was requested that further investigations be carried out on rainwater harvesting and hence a detailed study was undertaken to:

- Analyse rainwater harvesting as conjunctive use with alternative sources such as normal municipal reticulation (lower assurance).
- Conduct an economic analysis to assess the benefits of rainwater harvesting from a users perspective and also from the municipalities perspective.
- Obtain an overview of different rainwater harvesting technologies and uses.

A locally developed computer programme, the "Rainfall Harvesting Calculator" was used to perform daily water balances, using 50 years of daily rainfall data obtained from the University of KwaZulu-Natal's School for Bioresources Engineering and Environmental Hydrology. Two types of rainwater harvesting as conjunctive use were investigated:

- Maximum drawdown (where reliable alternative water supply is in place)
- Conservative drawdown (where alternative water supply is unavailable or not reliable)

The average rainwater harvesting yield was calculated, as well as the number of 'dry tank days' or failures. An economic analysis from the household perspective (payback period and Net Present Value (NPV)) and from the municipalities perspective (payback period and URV) was also conducted.

The findings from the study indicated that rainwater harvesting is not suitable for the replacement of conventional bulk water schemes, but is indeed effective when used as conjunctive use with a reliable alternative source such as normal municipal reticulation and the economic indicators are favourable from both household and municipal perspective. The reader is referred to the “Rainwater Harvesting” report in **Appendix B** for a detailed description of the various scenarios analysed as well as the results.

10.4 IMPACTS OF CLIMATE CHANGE

Climate change could have an influence on the reconciliation scenarios presented in the document. Umgeni Water is in the process of conducting research on the impacts climate change could have on the water resources in the future. It is recommended that the implication of this study and other related research be evaluated in subsequent reviews of the reconciliation strategy.

11 PERSPECTIVE ON WATER QUALITY MANAGEMENT

11.1 OVERVIEW

A water quality review was conducted in the study area and the main purpose was to use the available water quality data and water quality reports from previous studies to develop an understanding of the water quality profiles of the major rivers in the study area. The understanding achieved was used to provide qualitative input of the impact that the reconciliation options could have on water quality.

The review was conducted for the various stages of the Mgeni System and its major tributaries and for the Mdloti, Mvoti and Mkomazi River Systems and is summarised below. Further details are available in the Water Quality Review report of the same study (**DWA, 2008d**)

11.2 MGENI RIVER RESOURCE UNIT

The Mgeni River serves the Pietermaritzburg-Durban region, which is controlled by the four dams. The water quality of the Mgeni River has been good over the past few years. However, over the past 10 years a slight deterioration in water quality has been observed at a number of monitoring points, especially in the Lower Mgeni System.

The water at Midmar Dam in the upper Mgeni is of good quality and meets the water user requirements of all the water users. The available data however did show deterioration in water quality due to the significant increase in nutrient concentrations, in particular phosphorus. This could be ascribed to agriculture, in particular dairies, piggeries and maize production, impacting moderately on the river health through excessive nutrient input into the rivers. An increase in pollution from the growing Mphophomeni settlement could also have an effect.

The water quality in the upper Mgeni deteriorates on its passage from Midmar Dam through Howick to Albert Falls Dam and an increase in nitrate, phosphate and metal concentrations occurs. The Bacteriological contamination also exceeds the water quality guideline for full contact recreation with a relatively high turbidity. Effluent discharges from the towns Howick and Hilton and runoff and return flows from agriculture are assumed to be the cause of the deteriorating water quality.

The conductivity in Albert Falls Dam has increased about 28 % during the past 10 years. The average *E.coli* count is low and the dissolved inorganic nitrogen is the lowest in the Mgeni System.

The SRP concentration has however increased significantly over the past 10 years and the trophic status of the dam could trend towards a mesotrophic status, if it increases further.

Increasing trends in the conductivity and the SRP concentrations occur in the Mgeni system on its passage from Albert Falls Dam to Nagle Dam. The water quality data of Nagle Dam showed that the average phosphate concentration was low but on a slight increasing trend. The nitrate concentrations were relatively low and showed a decreasing trend.

A distance below Nagle Dam, the Mgeni River is joined by the Msunduzi tributary and continues in an easterly direction towards Inanda Dam. The water quality in the middle and lower Msunduzi is very poor, with high faecal coliform content and nutrient over-enrichment. There is a significant risk of possible health effects if the water is used for drinking or contact recreation. The high nutrient concentrations in the lower Msunduzi River contribute significantly to the eutrophication process in the lower Mgeni River.

The water quality in the Mgeni River after the Msunduzi confluence is poor. High conductivity, very high faecal contamination indicating sewage pollution, very high nitrate concentrations, high ammonium, high phosphorus and high turbidity occur.

The water quality data in the Inanda Dam (300m from the dam wall) showed an increasing trend in salinity over the past 10 years. The ammonium, phosphates and SRP concentrations also showed an increasing trend and the dam is well within the mesotrophic range.

11.3 MOOI RIVER RESOURCE UNIT

The Mgeni River System is augmented by an inter-basin transfer from the Mooi River in the Tugela Basin. The water is currently transferred from the Mearns Weir to the Midmar Dam. An additional development option necessary for supporting the Mgeni System by increasing the volumes transferred to Midmar Dam is the construction of the Spring Grove Dam on the Mooi River.

The data from the Mooi River indicate generally good water quality, with no significant changes during the past years for most of the parameters. However, high *E.coli* counts upstream in the river (at Spring Grove and Mearns) and the significant increase in the ammonium concentration in Mearns Weir is a matter of concern. Umgeni Water has also reported that the water quality assessment of Mearns Weir showed increased trends in nutrient levels. Analysis indicated that highly intensive agriculture is the cause of the eutrophication.

The additional transfer from Spring Grove Dam could have an impact on the microbiological status of the receiving stream.

11.4 MDLOTI RIVER RESOURCE UNIT

The average conductivity in the Mdloti River at the inflow into Hazelmere Dam is higher than in the upper reaches of the Mgeni River System but have been fairly stable over the past 10 years. The turbidity is very high, which indicates a high silt load that could contribute to a high siltation rate. The turbidity has however decreased over the past few years.

The water quality at the outflow of the Hazelmere Dam is very similar to the quality in the dam. It is only the ammonium concentration that is slightly higher indicating that the water was released from the lower layers of the water column where higher ammonium concentration accumulated due to decomposition.

11.5 MVOTI RIVER RESOURCE UNIT

The available data showed a deterioration in water quality further downstream on the Mvoti River due to runoff and return flows from agriculture, return flows from urban areas and industrial discharges. The water quality is overall good when compared to the fitness for water use quality requirements.

11.6 MKOMAZI RIVER RESOURCE UNIT

The available data for the upper Mkomazi River showed that the TDS and SRP concentrations are low. The TDS concentration is higher in the lower reaches. The water quality data showed a relatively stable water quality profile over time.

12 CONCLUSIONS

Given the current water balance situation, the reconciliation scenarios as well as the economic, water quality and other considerations presented in the previous sections the following conclusions can be made:

- The short-term shortages in the water balance of all the systems in the study area need to be managed and the only measure that can alleviate the problem is through the implementation of WC/WDM measures as well as early drought restrictions in the water use.
- The implementation of interventions to reduce water losses in the urban areas will reduce the shortages in the Mgeni River and Mdloti River systems, however, the water balance remains negative even if the waste management measures for **Scenario A.1** are implemented. It is therefore essential to augment the system as a priority action.
- To this end, the Mooi-Mgeni Transfer Scheme Phase 2 (Spring Grove Dam) and the raising of Hazelmere Dam should be implemented immediately to provide additional resources and will prevent unacceptable high risks of water restrictions during drought periods.
- The water balance of the Mvoti River System shows there are currently shortages and the implementation of the North Coast Pipeline for short-term support to Kwadukuza (from the Mdloti System) and support over the long term to the Mdloti System (bi-directional pipeline) should be implemented. (The North Coast Pipeline will link the Mdloti and Mvoti systems.)
- The available water in the Lower Thukela River System can be utilised to alleviate the shortages in the Mdloti and Mvoti River systems over the medium term and has the benefit of a significant shorter implementation period compared to the Mvoti River Development Option (IsiThundu Dam).
- Large volumes of treated wastewater are available for re-use through further treatment and direct and indirect supply options have been identified to augment the Mgeni and Mdloti River systems. Re-use options have significant shorter implementation periods compared to the large dams and the preliminary economic evaluations indicate that the re-use options are comparable to the dam schemes.
- The Mkomazi River Transfer Scheme (Smithfield Dam) and the Mvoti River Development (IsiThundu Dam) are necessary developments to reconcile the water balance over the long term. Due to the long lead times for implementing these schemes it is advisable to proceed

with detailed feasibility studies of both options and have the flexibility to expedite or delay the decision to implement based on the water supply status in future.

- Implement mechanisms for the monitoring and management of the poor water quality in the Msunduzi and lower Mgeni River System. This should also be implemented in the Mooi River System, where the water quality is deteriorating.
- Rainwater harvesting is a viable alternative supplementary source if used in conjunction with the normal municipal supply and is economic beneficial to both the municipality and the end user.
- Desalination of sea water appears to be approaching viability and should be further investigated.

13 STAKEHOLDER ENGAGEMENT PROCESS DURING THE STUDY

From the onset of the study, partnerships were formed with key stakeholders representing the various sectors of society and in particular, close cooperation was achieved between eThekweni Metropolitan Municipality, Umgeni Water, DWA and other organisation through the functioning of the Study Technical Committee (STC). Eight STC meetings were held where the technical progress of the study was presented and discussed

Broader stakeholder participation was achieved through two Public Meetings where representatives were selected to serve on the Study Steering Committee (SSC) at the start of the study. The First Stage Reconciliation Strategy was presented to the SSC where the recommendations and respective responsibilities for the actions were formulated.

The following meetings were held:

- Public Meeting No.1 - 20 June 2007.
- SSC Meeting No. 1 - 18 October 2007.
- SSC Meeting No. 2 - 28 February 2008.
- Public Meeting No. 2 - 31 March 2008.
- SSC Meeting No. 3 - 11 August 2008.
- Final SSC Meeting - 3 December 2009.

The Study Steering Committee will be converted to a Strategy Steering Committee to oversee and guide the implementation of the Strategy. The primary function of the Strategy Steering Committee will be to ensure the implementation of the Strategy and to make recommendations on an annual basis, on long-term planning activities required to ensure ongoing reconciliation of water requirement from and available supply to the KZN Metropolitan Areas covered in this study.

The objectives of the Strategy Steering Committee are:

- Ensure the implementation of the recommendations of the Reconciliation Strategy.
- To update the Strategy to ensure that it remains relevant.

- Ensure that the Strategy and its recommendations are appropriately communicated to all relevant organisations, institutions and the public.

14 STRATEGY RECOMMENDATIONS

14.1 OVERVIEW

The findings from the water reconciliation scenario results, and the conclusion presented in the previous sections, point to specific strategies that are required for the sustainable management of the water resources in the KZN study area.

These strategies are presented in the subsequent sections, and the intention is that projects and programmes need to be developed and the human and financial resources also need to be made available to achieve the underlying objectives.

14.2 PRIORITY INFRASTRUCTURE IMPLEMENTATION PROJECTS

14.2.1 Implement the Mooi-Mgeni Transfer Scheme.

Urgently implement the Mooi-Mgeni Transfer Scheme Phase 2A, consisting of the construction of Spring Grove Dam in the Mooi River Catchment. Current indications are that the dam could deliver water by 2012. The additional yield available from the option is 46.8 million m³/annum (Total yield of Mooi-Mgeni System of 380.8 million m³/annum).

Implement the Mooi-Mgeni Transfer Scheme Phase 2B, consisting of a pump station and pipeline transferring water directly from Spring Grove Dam to the Mgeni River System. Delivery by 2013 with an additional yield of 13.2 million m³/annum (Total yield of the Mooi-Mgeni System of 394.0 million m³/annum).

The scheme has the shortest lead time of all the development options proposed for the Mgeni System. It is thus important that the scheme is implemented as soon as possible to minimise the deficits illustrated in the water balance diagrams. DWA has recently directed the Trans-Caledon Tunnel Authority (TCTA) to implement Phase-2 of the Mooi-Mgeni Transfer Scheme (MMTS-2 - Spring Grove Dam and associated transfer infrastructure).

Action: DWA: National Water Resource Infrastructure Branch / TCTA

Timing: Immediate

14.2.2 Implement the Raising of Hazelmere Dam.

Raise Hazelmere Dam to provide an additional yield of approximately 9 million m³/annum (assumed 2015 sediment projection and excluding the implementation of the Ecological Water Requirements). The total yield of the Mdloti System after raising of Hazelmere Dam is approximately 30 million m³/annum. It is proposed that the EWR releases from Hazelmere Dam in the Mdloti River System are implemented when sufficient resources are available for meeting the requirements of the system.

Umgeni Water is planning to extend the water treatment capacity and construct additional pipelines to convey the additional yield from the proposed raising of Hazelmere Dam to the water users. This includes the proposed North Coast Augmentation Pipeline to convey water to KwaDukuza and adjacent areas.

Action: DWA: National Water Resource Infrastructure Branch.

Timing: Immediate.

14.2.3 Implement the North Coast Augmentation Pipeline

Implement the bi-directional North Coast Augmentation Pipeline for short-term support to Kwadukuza and long-term support to the Mdloti System from either the Lower Thukela or Mvoti system.

Action: Umgeni Water

Timing: To start immediately

14.3 PRIORITY FEASIBILITY STUDIES

14.3.1 Proceed with the Feasibility Study of the Mkomazi River Transfer Scheme

The Phase 1 of the Mkomazi-Mgeni Transfer Scheme consists of the Smithfield Dam with gravity conveyance infrastructure transferring water to Umlaas Road. The yield for delivery to the Mgeni River System for the scheme is estimated to be 136 million m³/annum. The earliest time for delivery is estimated to be December 2018. (Total yield of the Mooi-Mkomazi-Mgeni System is 530 million m³/annum).

According to the water balance diagram for the Mgeni System (**Scenario I**), the scheme is required in 2019 and hence the feasibility study of the Mkomazi River Transfer Scheme should be implemented.

Action: DWA Directorate: Options Analysis.

Timing: Begin study immediately

14.3.2 Commission a Feasibility Study of the Thukela and Mvoti systems

Although the primary purpose of the Lower Thukela Scheme or the proposed water resource development options in the Mvoti River would be to support the far northern areas (KwaDukuza and surrounding developments), the scheme would also be required to augment the water resources of the North Coast Metropolitan Area (support the Mdloti System) as discussed in **Section 8.8**. This could be achieved by reversing the flow in the proposed North Coast Augmentation Pipeline currently being planned.

A feasibility study needs to be commissioned to assess the two alternative augmentation options.

Alternative Augmentation Option 1: Lower Thukela Augmentation Option

The existing surplus yield in the Lower Thukela River System is 45 million m³/annum, given that support is provided from Spioenkop and Wagendrift dams to the Lower Thukela River. The above excess yield is over an above the currently unused allocation of 32 million m³/annum that has been granted to Mhlathuze Water for supply to the proposed Fairbreeze Mine option. (Total available surplus yield currently not taken up by users, 77 million m³/annum).

The total yield of 77 million m³/annum will be required to supply both the Kwadukuza and surrounding developments and the North Coast Metropolitan Area (Mdloti System). It has been indicated that the Mhlathuze River System will not require the Thukela allocation for the planning period up to 2030, should the Medium Demand Scenario for the system realise. If the High Demand Scenario realises, augmentation to the Mhlathuze River System is required in 2014 (The High Demand Scenario excludes the impact of major additional WC/DM measures.)

Alternative Augmentation Option 2: Mvoti River Augmentation Scheme

The proposed components of the Mvoti River Augmentation Scheme consist of IsiThundu Dam and conveyance infrastructure.

The proposed IsiThundu Dam has a yield of 33.6 million m³/annum and 46.3 million m³/annum for a storage capacity of 51 million m³ and 102 million m³ respectively. The IsiThundu dam with a capacity on 102 million m³ will be required as illustrated in **Section 8.8**.

A flow gauge needs to be constructed on the Mvoti River in order to improve the unacceptably low level of confidence in the hydrological modelling of the system.

Action: DWA Directorate: Options Analysis to coordinate

Timing: Begin study immediately

14.3.3 Commission a Feasibility Study for Water Re-use Options

The feasibility study should investigate the option to reuse treated wastewater from the Northern and Kwamashu Waste Water Treatment Works for transfer to Inanda Dam. This will involve secondary treatment processes, collection systems and transfer infrastructure to convey the water into Inanda Dam. KwaMashu is positioned in such a way that the treated wastewater could be transferred to either Inanda or Hazelmere Dam and both options should be investigated. The total volume available in 2006 is 43 million m³/ annum.

The feasibility study should also investigate the option to reuse treated wastewater from the Verulam, Phoenix as well as the Tongaat Central Waste Water Treatment Works for transfer to Hazelmere Dam. This will involve secondary treatment processes, collection systems and transfer infrastructure to convey the water into Hazelmere Dam. The total volume available in 2006 is 9.8 million m³/ annum.

Action: eThekweni Metro with support from DWA and Umgeni Water

Timing: Study already underway

14.3.4 Commission a Feasibility Study for the Desalination of Sea Water

Commission a feasibility study for the desalination of sea water for supply to the Mgeni River System and the North Coast.

Action: DWA, eThekweni Metro and Umgeni Water

Timing: Begin study immediately

14.4 WATER USE EFFICIENCY

14.4.1 Implement WC/WDM Waste Management Measures.

The continuation of current, and the initiation of further WC/WDM projects, is essential to minimise the deficits in water balance of the Mgeni River System.

The responsibility for the implementation of WC/WDM measures reside primarily with the municipalities and their water service providers. DWA and provincial government should provide an active supporting role in the form of appropriate legislation and regulations, as well as making dedicated financing available in areas where resources are limited or lacking at municipalities.

Action: Ethekwini, Ilembe, Ugu and Umgungundlovu municipalities as well as DWA Directorate Water Use Efficiency.

Timing: Immediately

14.4.2 Encourage Rain Water Harvesting

Rain water harvesting should be encouraged in the study area, as it is a further method of extending the water resource investigated in the study area. Although it does not have a major impact on reducing the municipal water demands when analyzed with conventional methods of yield determination, rainwater harvesting has a number of other benefits.

Action: DWA Directorate Water Use Efficiency Timing: Ongoing

14.5 INSTITUTIONAL ARRANGEMENTS

14.5.1 System Operation Management Forum

At the Study Technical Committee Meeting held on 30. May 2008, it was recommended that an System Operation Management Forum be established. The function of the Operational Forum would be to monitor and manage the short-term deficit in the Mgeni System. The forum would consist of high level individuals from the DWA and the various stakeholders in the study area.

Action: DWA KZN Regional Office

Timing: Immediately

14.5.2 Strategy Steering Committee

At the Steering Committee Meeting held on 29 March 2006, it was recommended that the current Study Steering Committee should be converted into a Strategy Steering Committee. The committee will be responsible for the implementation of the strategy once the study has been completed.

Action: DWA Directorate: National Water Resource Planning and Study Steering Committee

Timing: At the end of the study

14.5.3 Information Forum

Establish a forum where information on projects and measures to save water are discussed and experiences are exchanged.

Action: Umgeni Water to coordinate

14.6 COMMUNICATION

14.6.1 Media Campaign

Embark on a well structured media campaign to support all the short term actions.

Action: DWA KZN Regional Office and municipalities

Timing: Immediate.

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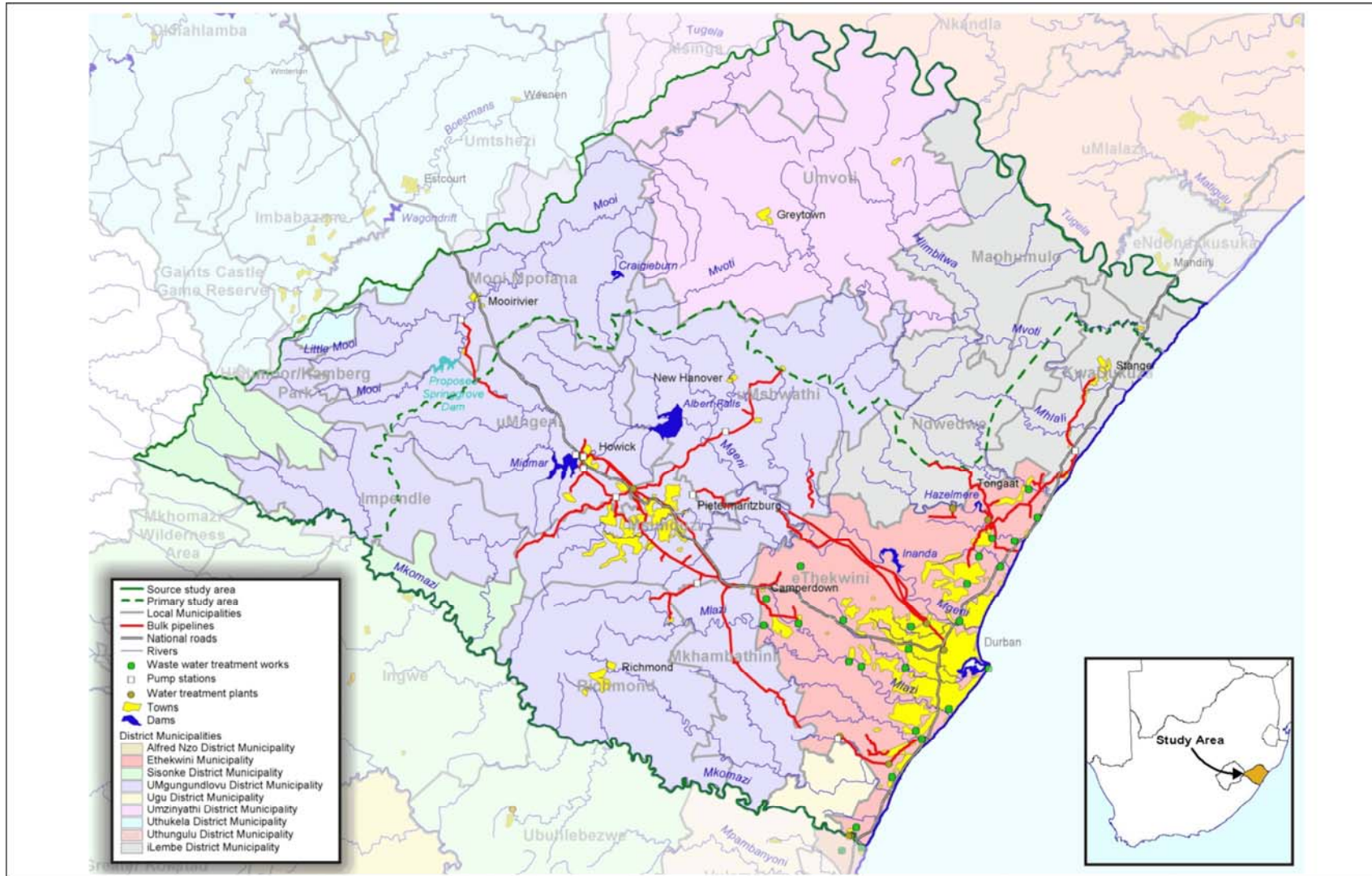
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Appendix A

<u>No:</u>	<u>Description</u>
A-1	Study area
A-2	Irrigation development within study area
A-3	Water resource systems and demand centres



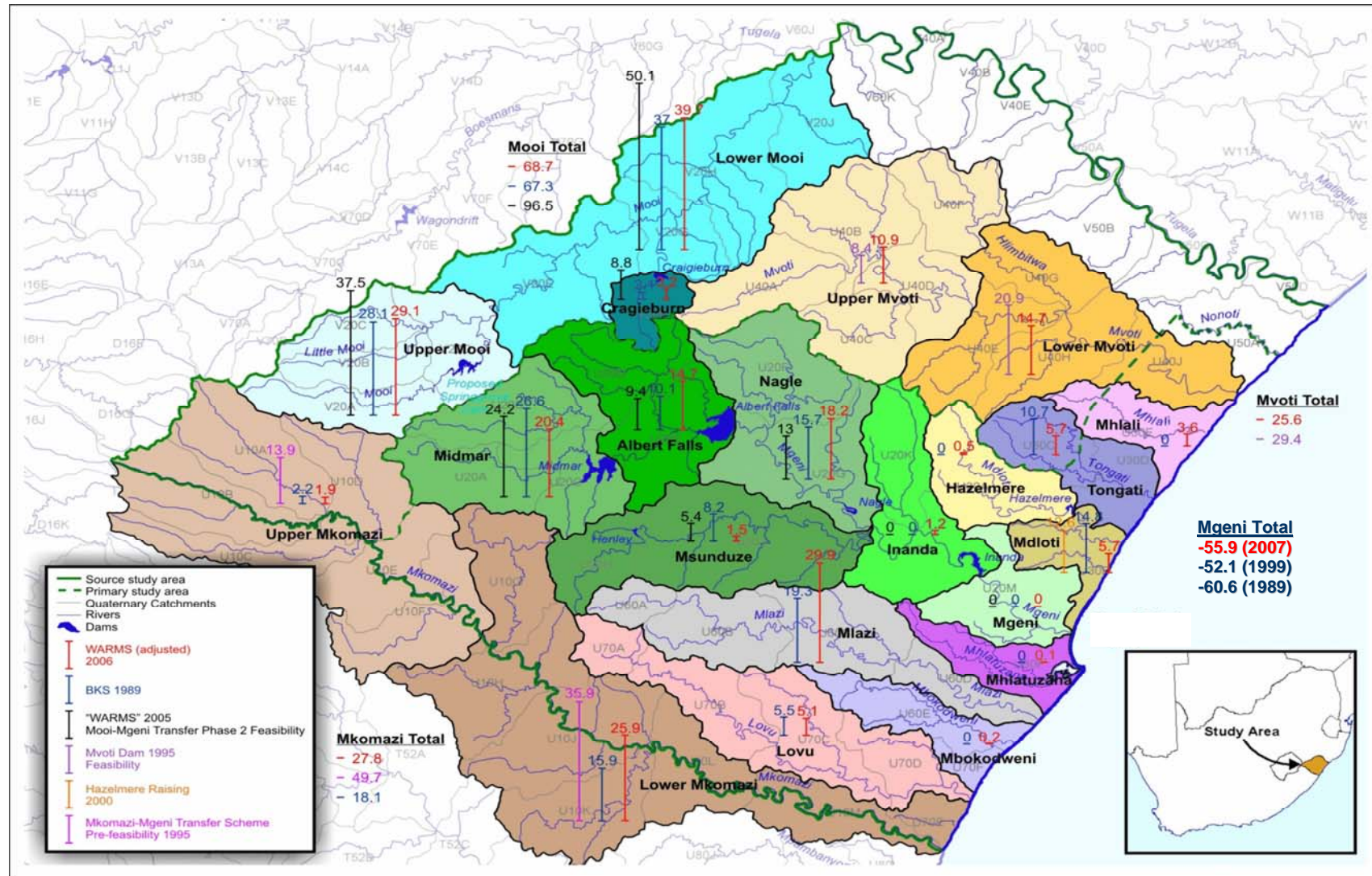
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WATER RECONCILIATION STRATEGY STUDY FOR THE
KWAZULU-NATAL COASTAL METROPOLITAN AREAS

Study Area

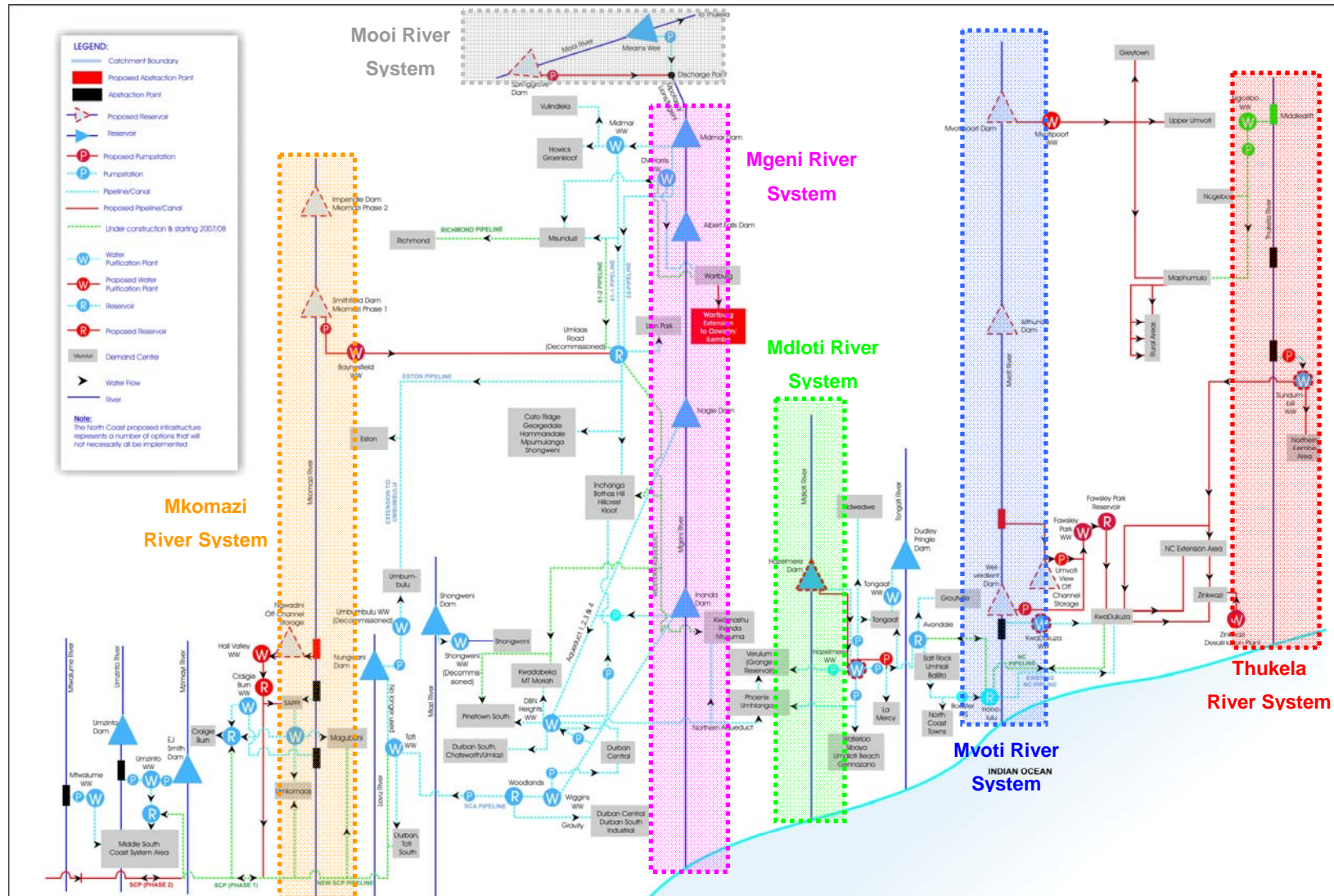
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WATER RECONCILIATION STRATEGY STUDY FOR THE
KWAZULU-NATAL COASTAL METROPOLITAN AREAS



WATER RECONCILIATION STRATEGY STUDY FOR THE
KWAZULU-NATAL COASTAL METROPOLITAN AREAS

Water resource systems and demand centre

A-3

Appendix B

<u>No:</u>	<u>Description</u>
B-1	Rainwater Harvesting Report

Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas

Rainwater Harvesting

December 2009

Synopsis

The rainwater harvesting investigation for the Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas was a limited additional study initiated at the request of stakeholder forums for the study. The study focused mainly on 'urban rainwater harvesting', and particularly the potential of rooftop rainwater harvesting for household use in different user categories across the study area. It also touched on possibilities for stormwater storage and utilisation on business premises and for home food production.

It was found that the contribution of rooftop rainwater harvesting is most significant in 'conjunctive use' scenarios, and shows favourable economic indicators from both household and municipal perspectives, for both poor and non-poor households. Rainwater harvesting yields are lower and economically less favourable when it is used as a 'sole supply' option, where a higher assurance of supply is required. It is however meaningful as an interim strategy for underserved areas (e.g. by reducing the annual volume of water trucked to households), and then has lasting relevance for 'conjunctive use' as and when the reach of mains supplies expands to these underserved areas.

Since rainwater yields vary spatially and according to management and physical criteria, refined analyses should underpin implementation planning for the various municipal areas. However, for all households in the study area with firm roofing, a 5 kl rainwater tank would be an asset with generally positive economic indicators.

Further work is also necessary to understand the scope for surface runoff collection for a variety of uses, including but not limited to food gardening, private and municipal landscaping and beautification, and restoration of natural capital, while helping to mitigate flash floods.

The effect of uptake of the range of rainwater harvesting applications on municipal bulk supply demand has not been analysed, and therefore readers should note that the potential contribution of rainwater harvesting does not reflect in the water reconciliation strategy scenarios in the main report.

Background and overview of the rainwater harvesting investigation

Initial investigations on rainwater harvesting in the Water Reconciliation Strategy Study used Firm Yield as a basis for comparison with other water supply options, which resulted in a high Unit Reference Value (URV) of R19.95 (at a discounting rate of 8%).

At Study Steering Committee meetings and Public Meetings, representatives requested a fresh look at rainwater harvesting as an option to help reconcile water supply and demand. At the request of DWA and WRP (Pty) Ltd. a team lead by Socio-Technical Interfacing CC (STI) investigated further options, and proposed to broaden the investigation in several ways. The intention was not to assess the wholesale installation of household roofwater harvesting systems as an alternative to bulk water supply for household uses. Instead, the proposed methodology aimed to assess:

- The application of a range of water harvesting technologies (e.g. roofwater harvesting and landscape water harvesting and storage);
- for either full supply or conjunctive use with other supplies as appropriate;
- in a few typical household settings within the municipal area. Urban landscape, commercial and industrial applications of water harvesting would also be touched on, but not assessed in detail.

A locally developed computer programme, the 'Rainfall Harvesting Calculator' was used to run a daily water balance on fifty years of daily rainfall data. The average rainwater harvesting yield (kl/annum) is

A key research outcome:

The findings of this study were more favourable than those of the initial rainwater harvesting investigation. This is mainly because the initial investigation calculated Historic Firm Yield of rainwater systems (i.e. abstraction is limited to avoid the tank running dry at all times), while the new study also assessed possibilities for conjunctive use (i.e. making maximum use of rainwater at all times and switching to municipal supply only when unavoidable).

The differences found were significant: with a Firm Yield approach, only 30 kl/a could be harvested from a 150m² roof using a 10 kl tank (URV R19.95); while with conjunctive use, 117 kl/a could be harvested from a 200m² roof using a 5 kl tank (URV R1.93) (please refer to Table 8). There were also differences in discount rates, tank sizes, and both capital and maintenance costs which account for the differences between the initial and current investigations.

calculated, as well as 'dry tank days' per year as a measure of assurance of supply. Economic analysis from the household perspective (payback period and NPV), and from the municipal view (URV and payback period) was carried out with a spreadsheet solution.

The accurate determination of rainwater tank sizes depends on daily rainfall data, rainwater demand, and roof area. Counter-intuitively, an increase in the roof area does not always result in the need for a larger rainwater tank capacity. Therefore, it is recommended that rainwater tank capacity be determined for each dwelling and location (Ghisi *et al*, 2006). Such detailed analysis was not within the scope of this study, but

nonetheless, a much closer approximation was achieved through assumptions and calculations of several variables, as shown below.

Rainfall data

Daily rainfall data for the period 1950 to 1999 were obtained from University of KwaZulu-Natal School for Bio-resources Engineering. This is a recently completed improved dataset, containing daily rainfall data for all quaternary catchments in South Africa. The study area for the KZN Coastal Metropolitan Areas covers 20 quaternaries. The rainwater harvesting analysis was based on data for quaternary U60F.

Total roof area

There are 438 563 housing units on separate stands, and 39 754 housing units in town clusters in the eThekweni municipal area. Table 1 shows the assumed distribution of roof sizes as used in the rainwater harvesting calculations. This distribution resulted in an average roof size of 127 m², compared to an average roof size of 150 m² assumed in the initial URV calculation. Note that this excludes informal housing.

Table 1: Assumed distribution of roof sizes of formal dwellings in eThekweni municipal area

Housing units on separate stands				
Roof area: m ²	% properties	No properties	Total roof area m ²	Average roof area per dwelling m ²
40	20%	87 713	3 508 504	
60	20%	87 713	5 262 756	
100	20%	87 713	8 771 260	
150	20%	87 713	13 156 890	
200	10%	43 856	8 771 260	
350	8%	35 085	12 279 764	
500	2%	8 771	4 385 630	
Sub-total	100%	438 563	56 136 064	128
Town clusters				
75	40%	15 902	1 192 620	
100	30%	11 926	1 192 620	
150	20%	7 951	1 192 620	
200	10%	3 975	795 080	
Sub-total	100%	39 754	4 372 940	110
Total		478 317	60 509 004	127

Current water use and tariff structures

Domestic use constitutes 96% of all connections and 56% of total water use in eThekweni Municipality. The average usage per domestic connection is 22.7 kl per month.

Table 2: Current water use in eThekweni

Usage type	% of connections	Total daily usage (million kl/d)		Average usage per connection (kl/month)	Average usage per connection (kl/annum)
Domestic	96%	0.314	56%	22.7	276.6
Non-domestic	4%	0.244	44%	417.2	5075.8
		<u>0.558</u>			

Source: Adapted from COINS analysis, June 2009.

eThekweni Municipality uses a rising block tariff system, shown in Table 3. In Table 4, an assumption is shown of how average water usage could be approximated in accordance with the size of dwelling.

Table 3: eThekweni rising block water tariff structure

Block	kl/m	R/kl
1	0 - 9	0
2	9 - 25	5.99
3	25 - 30	8.19
4	30 - 45	18.06
5	>45	19.86

Source: DWA, October 2009.

Table 4: Assumed distribution of domestic water use according to dwelling sizes

Housing units on separate stands									
Tariff block	Roof area (m ²)	Household usage (kl/a) (kl/m)		Usage per tariff block				Number of properties	Total usage (kl/m)
		B1	B2	B3	B4				
1	40	108	9	9	-	-	-	87 713	789 413
1	60	108	9	9	-	-	-	87 713	789 413
2	100	264	22	9	13	-	-	87 713	1 929 677
2	150	300	25	9	16	-	-	87 713	2 192 815
3	200	360	30	9	16	5	-	43 856	1 315 689
4	350	420	35	9	16	5	5	35 085	1 227 976
4	500	528	44	9	16	5	14	8 771	385 935
Sub-total								438 563	8 630 920
Town clusters									
2	75	240	20	9	11	-	-	15901.6	318 032
2	100	240	20	9	11	-	-	11926.2	238 524
2	150	240	20	9	11	-	-	7950.8	159 016
2	200	240	20	9	11	-	-	3975.4	79 508
Sub-total								39754	795 080
Total								478317	9 426 000

Municipal perspective: Potential roof rainwater yield

Rainwater yield depends on daily rainfall, roof area and tank size, but also substantively on rainwater demand (how much water is drawn from the tank, or drawdown). The objective was to determine the upper limit of potential, and the following assumptions were used in the scenarios depicted in Tables 5: Scenario M1 and Table 6: Scenario M2:

- Rainfall data for quaternary U60F was used, and roof areas and tank sizes were assumed as shown in Table 5: Scenario M1 and M2.
- To determine the absolute upper limit of potential, full conjunctive use was assumed, with drawdown assumed close to full monthly municipal use as shown in Table 5: Scenario M1. This assumes household point-of-use treatment for drinking water uses.
- Table 6: Scenario M2 shows a second scenario with reduced drawdown where rainwater is still used conjunctively with municipal supplies, but only for so-called 'outdoor uses', which includes running the washing machine, flushing toilets, and garden and swimming pool uses. This option is more expensive to implement than full conjunctive use as shown in Scenario M1, as it may require retrofitting to separate water reticulation for outdoor uses.

The full conjunctive use scenario shown in Table 5: Scenario M1 resulted in an upper limit of potential rainwater yield for formal housing units in eThekweni of 42.98 million kl/annum. The conjunctive use of harvested rainwater for 'outdoor water uses' only (shown in Table 6: Scenario M2), resulted in a total annual rainwater yield for formal housing units in eThekweni of 32.86 million kl/annum. Current domestic water demand for this municipality is approximately 115 million kl/annum (from COINS analysis, June 2009).

Notes on the upper limit of potential:

Readers should note that scenario M1 presents the upper limit of potential for rooftop rainwater harvesting by formal housing units.

- The *realistic yield* will depend on how many formal housing structures actually choose to implement rainwater harvesting, as it is highly unlikely that all will do so.
- The upper limit will increase when the potential yield of rooftop rainwater harvesting from *non-residential roofs* is added (e.g. city buildings, factories, etc). These constitute only 4% of water users, but account for 44% of daily water use in eThekweni.
- The upper limit of potential will further increase when practical ways could be found to harvest rainwater in *informal housing areas*, where it is arguably most dearly needed.

Readers should further note that the upper limit of potential for surface runoff collection and use has not been quantified in this report, for instance:

- The volume of water available through surface runoff collection for *home food production* and *gardening* purposes; and
- The overall volume of stormwater that could be utilised to save on the use of potable water supplies, e.g. for *municipal, industrial and commercial non-potable uses* such as industrial processes, cleaning, landscaping, and firefighting.

Finally, it should be noted that more complex analysis would be required to understand how rainwater utilisation may change the patterns of demand and supply on existing components of the municipal water supply system.

Table 5: Scenario M1: Total potential rainwater yield for full conjunctive rainwater harvesting use in formal housing units in eThekweni Municipality

Roof area: m ²	Tank size: kl	Target drawdown: kl/m	RWH/unit: kl/a	Total RWH yield kl/a
40	5	9	31	2 754 176
60	5	9	44	3 850 583
100	9	22	76	6 666 158
150	9	25	106	9 288 764
200	15	30	144	6 328 464
350	22	35	229	8 034 474
500	44	44	333	2 918 198
Sub-total				39 840 817
75	5	10	56	887 309
100	9	20	76	901 621
150	9	20	103	818 932
200	15	30	135	535 486
Sub-total				3 143 349
Total				42 984 166

Table 6: Scenario M2: Total potential rainwater yield for conjunctive use of harvested rainwater for ‘outdoor uses’ in formal housing units in eThekweni Municipality

Roof area: m ²	Tank size: kl	Target drawdown: kl/m	RWH/unit: kl/a	Total RWH yield kl/a
40	5	6	31	2 684 006
60	5	6	41	3 604 988
100	5	20	65	5 718 862
150	5	20	87	7 613 454
200	5	30	104	4 543 513
350	5	30	136	4 757 531
500	5	50	163	1 425 330
Sub-total				30 347 682
75	5	10	52	833 244
100	5	20	63	750 158
150	5	20	76	603 466
200	5	30	83	327 971
Sub-total				2 514 838
Total				32 862 521

Economic analyses from household and municipal perspectives

The following economic indicators were calculated:

The Unit Reference Value (URV), which is an indicator of the discounted present value of the cost of delivering one unit of water (1kl) over the entire project period. URVs can be calculated for different project designs (and hence project costs and yields), as well as different project periods and at various discount rates. Generally one would prefer a project with a low URV above one with a high URV. The two important variables for URVs are (i) implementation cost and (ii) yield; the lower the cost of a rainwater system, and the higher the annual rainwater yield it can achieve, the lower (better) the URV.

Payback period, Net Present Value (NPV) of cost savings, and benefit/cost ratio. These are standard financial and economic indicators used to assess a project’s viability and are calculated from the perspective of ‘the one who pays’.

From the household’s perspective: If a household pays for installation, then such household would want to know if the expense will be offset by the savings on what they would otherwise have paid for water over the lifespan of the rainwater system (e.g. at the relevant municipal tariff, or to a water vendor, or compared to the cost of pumping from their own borehole or other source). Rainwater installations typically have a relatively high capital cost upfront, but thereafter provides essentially free

water. The household would like to know: Would there be a net saving for me, how much would it be, and how long will it take before such saving would occur.

From the municipality’s perspective: If the municipality pays for the installation it would want to compare the cost of installing rainwater harvesting systems to other water augmentation schemes and what the potential municipal savings would be by implementing a system of conjunctive use. Finding a reasonable figure for comparison is not easy, as situations differ dramatically across different municipal areas, and can also be expected to change significantly over the lifespan of the rainwater system (which is taken here at 20 years). Immediate municipal savings on supply would relate mainly to a reduction in recurrent operational costs – which could be dramatic where water is trucked at R170/kl, but less significant where it would involve mainly a reduction in pumping and water treatment before and after use. Further, rainwater installations cannot redeem past expenditures on infrastructure development, but could help reduce the demand on current and planned new infrastructure.

Should the municipality decide to subsidise household rainwater installation by an amount equal to the NPV of their cost savings on supply, the household’s cost of installation reduces, which impacts very favourably on the payback period and NPV of cost savings from the household’s point of view.

The assumptions and results for the economy-wide impact of rainwater harvesting for Scenarios M1 and M2 in eThekweni are shown in Tables 7 below. More specific results from the household perspective are shown in Tables 8, 9 and 10.

Table 7: Inputs, assumptions and results for economy-wide impact of rainwater harvesting in eThekweni Municipal area

Scenario M1 and M2: Economy-wide impact of RWH in eThekweni	
Inputs:	
- Total no of houses on separate stands	438 563
- Total number of cluster homes (formal)	39 754
- Quaternary catchment no	U60F
- Rainfall: mm/a	963
Assumptions:	
- % of total no of dwellings in scheme	100%
- Unit cost of a tank installed	R 3 500
- Project implementation period: years	5
- O&M as % of CapEx	0.5%
- % state subsidy in alternative scenario	50%
- Discount rate	2.0%
- Price of a ton of carbon	R 120
- Energy requirement to pump m ³ in kWh	0.0711
- Carbon grid factor (tCO ₂ /MWh)	1.2

Scenario M1:			
Results for full conjunctive use		Proportionate subsidy= 50%	
Unit cost at R3 500/5kl; price of water R8.00/kl	10% roll-out	15% roll-out	100% roll-out
Rainwater harvesting yield (kl/a)	4 298 417	6 447 625	42 984 166
Cost: Full subsidy (Rmil)	321	482	3 213
Cost: proportionate subsidy (Rmil)	161	241	1 606
Discount rate= 2%	URV	Payback: Years	B/C ratio
Full subsidy & full O&M	5.23	7.10	1.62
Proportionate subsidy & no O&M	2.44	4.10	3.48
Discount rate= 8%	URV	Payback: Years	B/C ratio
Full subsidy & full O&M	7.71	7.10	1.10
Proportionate subsidy & no O&M	3.68	4.10	2.31

Scenario M2:			
Results for conjunctive 'outdoor' uses		Proportionate subsidy= 50%	
Unit cost at R10 000/5kl; price of water R15.00/kl	10% roll-out	15% roll-out	100% roll-out
Rainwater harvesting yield (kl/a)	3 286 252	4 929 378	32 862 521
Cost: Full subsidy (Rmil)	478	717	4 783
Cost: proportionate subsidy (Rmil)	239	359	2 392
Discount rate= 2%	URV	Payback: Years	B/C ratio
Full subsidy & full O&M	10.19	8.08	1.47
Proportionate subsidy & no O&M	4.75	4.21	3.15
Discount rate= 8%	URV	Payback: Years	B/C ratio
Full subsidy & full O&M	15.01	8.08	1.00
Proportionate subsidy & no O&M	7.18	4.21	2.09

Should eThekweni decide to provide a full subsidy and operation and maintenance for the implementation of rainwater harvesting for full conjunctive use (Scenario M1) on all formal dwellings in a five year implementation period, the Unit Reference Value is a R5.23 per m³ water delivered. With the price of water taken at R8.50/kl, the payback period would be seven years, and the benefit/cost ratio 1.62. Total cost of implementation over five years would be R3.21bn and the average volume of rainwater harvested would amount to 42.98 million m³/a.

For conjunctive use of rainwater for 'outdoor uses' (Scenario M2), a higher cost of implementation is assumed (R10 000/5kl), but a greater proportion of water savings fall into the higher tariff blocks, therefore the price of water is taken at R15/kl. This results in a URV of R10.19, payback period of eight years, and benefit/cost ratio of 1.47. Total cost of implementation over five years is R4.78bn and the average volume of rainwater harvested is 32.86 million m³/a.

Please note that implementation strategies should be underpinned by more specific targeting per area, based on calculation for actual circumstances.

Household perspective: Potential roof rainwater yield

Conjunctive use (where reliable alternative water supply is in place):

One's intuition is to use water very sparingly from a rainwater tank. However, calculation of a variety of situations quickly showed the folly of this approach in a conjunctive use situation. The tremendous effect of rainwater demand (daily drawdown) on annual rainwater yield is clearly illustrated in Table 8 scenarios H2, H3, H5 and H6. This means that households on mains supply will derive maximum benefit from their investment by withdrawing as much as possible of their water requirement from rainwater tanks, and switching to mains supply only for periods when the tank is empty. The more water is withdrawn, the more storage capacity is ready to receive the next rainfall event. Another surprising finding was that for conjunctive use, both tank and roof size had less effect on rainwater yield than expected.

Table 8: Rainwater yield and economic analysis of an average suburban house and an RDP house

	Roof size	Tank size	Capital cost (once-off)	Drawdown target		Rainwater yield	Dry tank days	URV (20 years)	Payback period	NPV of cost savings
	m ²	kl	R	Summer kl/m	Winter kl/m	kl/a	days/a	(@2%)	years	R
H1	200	15	10500	15	6	109	3	R 6.23	6	15633
H2	200	15	10500	30	30	144.3	not applicable	R 4.70	4	24292
H3	200	5	3500	30	30	117.1	not applicable	R 1.93	2	25021
H4	40	5	3500	5	0.5	26	2	R 8.70	13	551
H5	40	5	3500	6	6	30.6	not applicable	R 7.40	11	1303
H6	60	5	3500	6	6	41.1	not applicable	R 5.51	8	3020

H1 Average house, conservative approach (=minimising dry tank days).

H2 Average house, conjunctive use, automatic switching to mains on empty tank.

H3 Average house, conjunctive use, automatic switching to mains on empty tank, small tank.

H4 RDP house, conservative approach (=minimising dry tank days).

H5 RDP house, conjunctive use, automatic switching to mains on empty tank.

H6 RDP house, conjunctive use, automatic switching to mains on empty tank, larger roof.

In Table 8, scenarios H1 and H2 have exactly the same configuration, namely a 200 m² house with 15 kl storage capacity. Yet, rainwater yield increases by 25% (from 109 to 144.3 kl/a) by changing from conservative drawdown to a conjunctive use approach. Similarly, in the 40 m² RDP house scenarios H4 and H5, rainwater yield increases from 26 to 30.6 kl/a (i.e. an increase from 36% to 43% of the annual Free Basic Water (FBW) demand). An RDP house with larger roof size (H6) can harvest 57% of the annual FBW off its roof.

In the 200 m² house conjunctive use examples H2 and H3, a two-thirds reduction in storage capacity (5 kl instead of 15 kl), resulted in only 23% reduction in annual rainwater yield (144.3 kl/a (H2) dropped to 117.1 kl/a (H3)). More importantly, the economic analysis showed a significant improvement in URV

(from R4.70 to R1.93) and payback period (from 4 down to 2 years) as a result of the reduced installed cost. A greater Net Present Value (NPV) of cost savings was also achieved.

Conservative drawdown (where alternative water supply is unavailable or not reliable):

Scenario H4 shows that in Durban Quaternary U60F, a 40 m² house can harvest 36% of the FBW allocation off its roof and experience only 2 dry tank days per year on average. In Table 9, the options for conservative drawdown are investigated further.

Table 9: Rainwater yield on a 40 m² RDP house with 5 kl storage, using conservative drawdown

	Drawdown target		Rainwater yield kl/a	Dry tank days days/a	% of FBW %	
	Summer kl/m	Winter kl/m				
R1	6	6	30.6	not applicable	43%	Full conjunctive use
R2	6	0	25.7	61	36%	Zero winter use
R3	5	0	24.6	39	34%	
R4	3	0	17.8	3	25%	
R5	3	0.5	20.6	9	29%	
R6	3	1	23.2	16	32%	Half FBW drawdown in summer; some winter use
R7	3	1.5	25	35	35%	
R8	3	2	25.8	63	36%	
R9	6	0	23.5	1	33%	
R10	6	1	27.5	2	38%	
R11	6	1.5	28.3	4	39%	
R12	6	2	28.7	6	40%	
R13	1	0	6.1	0	8%	Historic Firm Yield (i.e. limiting daily drawdown to cater for the worst case scenario, i.e. so that the tank will not run empty, even in the worst year)

Scenario R1 is the same as H5, and shows the rainwater yield with 6 kl/month drawdown in a conjunctive use scenario. 43% of FBW can be harvested if ‘dry tank days’ are not a consideration.

In scenarios R2-R8, a conservative management strategy is followed to minimise ‘dry tank days’, by drastically reducing drawdown in winter and to varying degree in summer. In scenario R4 ‘dry tank days’ per year are kept down to an average of only 3 days per year, but then rainwater yield is only 25% of the FBW amount.

In scenarios R9-R12, ‘adaptive demand’ is practiced by reducing drawdown to 50% of the daily amount once the tank level drops below half, and to 25% once the tank is below a quarter of capacity. In scenario R12, 40% of FBW is harvested and an average of only 6 dry tank days per year experienced. The

worst year for scenario R12 was 1992, when a total of 107 dry tank days would have been experienced. The highest number of consecutive dry tank days with scenario R12 was 91 days (three months) in the fifty year period from 1950 to 1999.

Scenario R13 reflects the situation for Historic Firm Yield, in other words, where drawdown is reduced to the extent that no dry tank days are experienced, even in the worst years. Predictably, this results in very low yield; in this case only 6.1 kl/a, or 8% of FBW. The price of such a high assurance of supply is severe under-utilisation of storage capacity, particularly in 'average' and 'good' years.

The economic analysis of 'conjunctive use' (scenarios H5 and H6 above) produced URVs of R7.40 and R5.51 respectively for roof sizes of 40 and 60m², and payback periods of 11 and 8 years. With the lower rainwater yields achieved with conservative drawdown (scenarios R2-R12), URVs increase to between R7.89 (scenario R12, best case) and R12.71 (scenario R4, worst case). For Historic Firm Yield (R13) the URV is very high at R37.10 because of the very low yield.

Accurate calculation of the payback period and the Net Present Value of cost savings would require more information on the actual circumstances, and on whose viewpoint is taken:

- In cases where the municipalities provide Free Basic Water (i.e. the households don't pay for this water), the analysis would be from the viewpoint of the municipality and the comparison would be with the current cost of supply. Two cases are analysed below, namely:
 - i. where water is trucked to households at an approximate cost of R170/kl; and
 - ii. at an assumed cost of R10/kl for piped supply of FBW (actual figures for the latter case were not available to the team).
- Where low income households currently rely on water vendors (in rural areas this can typically amount to R20/200 liter drum, i.e. R100/kl), cost savings through rainwater harvesting would accrue directly to the household, but they could not be expected to carry the investment cost for a rainwater tank. In this case, the investment by the municipality can be viewed as a direct and once-off contribution to poverty alleviation, enabling household avoidance of ongoing expenditure.

Table 10: Economic analysis of rainwater harvesting for a 40m² RDP house with a 5 kl rainwater tank, for various drawdown scenarios

	Rainwater yield (kl/a)	URV (20 years) (@2%)	Against water trucked at a cost of R170/kl		Against cost of supply assumed at R10.00/kl	
			Payback period (years)	NPV of cost savings (R)	Payback period (years)	NPV of cost savings (R)
R 1	30.6	R 7.40	<1	81360	11	1303
R 2	25.7	R 8.81	<1	67739	13	502
R 3	24.6	R 9.20	<1	64681	14	322
R 4	17.8	R 12.71	<1	45779	19	-790
R 5	20.6	R 10.99	<1	53562	16	-332
R 6	23.2	R 9.75	<1	60790	15	93
R 7	25	R 9.05	<1	65793	14	387
R 8	25.8	R 8.77	<1	68017	13	518
R 9	23.5	R 9.63	<1	61624	14	142
R 10	27.5	R 8.23	<1	72743	12	796
R 11	28.3	R 8.00	<1	74966	12	927
R 12	28.7	R 7.89	<1	76078	12	992
R 13	6.1	R 37.10	3.1	13256	>20	-2703

From these results it is clear that rainwater harvesting is a very good option to reduce the cost of water supply where water needs to be trucked at great expense.

Industrial example: Flood attenuation and rainwater utilisation

The following example was included to illustrate the potential for surface runoff collection to reduce the use of potable supplies for non-potable industrial uses. A proposed service station development on Inanda Road was taken as example. eThekweni Municipality is enforcing a building regulation which requires all new developments to maintain peak stormflow generation from their site at pre-development levels. This often requires the establishment of on-site water storage structures to hold and release flood flows offpeak. This creates an opportunity for flood attenuation measures to be employed as rainwater harvesting initiatives, through beneficial utilisation of captured stormwater. To ensure that the original flood attenuation objective is not jeopardised, this may require some increase in the storage capacity to be created, but at marginal additional cost.

At the Inanda Road site, onsite stormwater storage capacity of 165kl was required to capture flood flows off paved surfaces and roofs to a total of 850m². Annually, a total of 475kl harvested rainwater could be used for washing the forecourt, landscaping, and general cleaning purposes, representing an estimated reduction in overall potable water use of up to 50%.

Commercial and industrial users represent only 4% of the number of connections, but 44% of the total water use in eThekweni. Therefore attention to their potential use of harvested rainwater could represent a significant saving on municipal potable water supplies.



Summary of findings on rainwater harvesting

South Africa is at different stages with different RWH applications:

'Water for food':

DWA is well advanced with the establishment of a programme to implement large tanks (20 to 30 kl) to catch surface runoff for households to use for productive uses. Installations have been completed at approximately 500 households in five provinces; preparations are well advanced for further expansion in close collaboration with the regional offices. Wisely, the Department had allowed a period of action research to



allow learning, and valuable lessons have been captured on social and implementation aspects. An urgent next step is to revisit installations for technical infield evaluation, including aspects such as actual rainwater harvesting yields achieved, structural performance of tanks and associated works, and the impact of water management strategies used by the households.



eThekwini Municipality has already installed 1000 ferrocement tanks (standard 5 kl size) for home fruit and vegetable gardening. Home food production is most rewarding – and therefore most sustainable – with low cost, high yielding production methods. Therefore the eThekwini Agricultural Development Unit initiative towards a training programme for households on intensive organic production methods



is of fundamental importance. This should be continued and expanded, with full attention to maximising production potential through rainwater harvesting run-on methods.

eThekweni has recently completed an evaluation of mainly the social aspects of installations. This needs to be augmented by a technical performance analysis in the different quaternary catchments within the municipal area, to assess

actual rainwater harvesting yields achieved and the water management strategies employed by households. The results of such analysis can be built into future training for best practice household water management strategies.



Urban rainwater harvesting:

In Jansenville, roof rainwater tanks are being installed at all interested households; other municipalities across South Africa have implemented to varying degree. There is significant experience in South Africa with the installation of roof rainwater tanks, but a number of aspects need attention.

There is currently no SABS standard for the manufacture of plastic rainwater tanks. In the face of expected surge in implementation, this needs to be addressed urgently.



Little use is currently made in South Africa of ‘first flush’ technology. This should be standard practice on all installations to improve the quality of water captured and stored in the tanks. Simple, cost effective methods are possible, using low cost, off-the-shelf components (e.g. plastic piping, T-piece, end cap).

eThekweni is using a standardised construction manual for the installation of 5 kl ferrocement tanks. A standardised construction manual for national use would be of great value. This should incorporate detail for the construction of the cost effective 20 kl ferrocement tank which was recently the subject of a hands-on training workshop in Limpopo, lead by experienced tank builders from Brazil.

The literature recommends that rainwater tank capacity be determined for each dwelling and location (Ghisi *et al*, 2006). Rainwater yield depends on tank size, daily rainfall data, rainwater demand (drawdown), and roof area. The calculations used in this report are based on the rainfall data for one quaternary catchment (U60F), although the study area for the KZN Coastal Metropolitan Areas covers 20 quaternaries. More accurate calculation of tank sizes, rainwater yield and economic analysis is needed to underpin planning for rainwater implementation.

The current rainwater harvesting investigation for the KZN Coastal Metropolitan Areas water reconciliation strategy study has found the following:

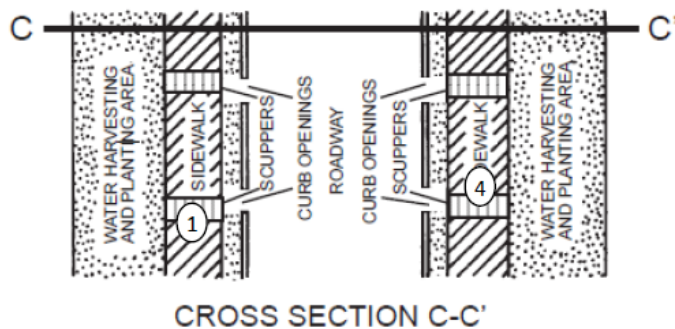
- Preliminary calculations suggest that an average 200 m² house in Durban could supply half its annual water demand from its own roof.
- Roof rainwater harvesting can usually supplement, but not replace conventional bulk supplies. Internationally, rainwater harvesting is more advanced than in South Africa. Average potential for potable water savings in south-eastern Brazil is 41%. In Australia current potable water savings are estimated at 23 220 billion liters per year (assuming 120 m² roof area, 600 mm rainfall, and 90% capture co-efficient); 54 000 liters per annum is saved per tank installation.
- Due to rainfall amount and frequency, the prognosis for roof rainwater harvesting is better in the KZN Coastal Metropolitan Areas than in most other parts of South Africa. At least one municipality in the arid Karoo is reported to have provided, on demand, all houses with rainwater tanks. In some parts roof rainwater harvesting is not feasible at current low municipal water tariffs.
- Counter-intuitively, what counts is using the rainwater during the rainy season. Rainwater yield potential reduces dramatically by 'saving it' for the dry season. 'Dry tank days' are not important if there is alternative water (i.e. conjunctive use). Also surprising, is how small the rainwater tanks need to be for conjunctive use.
- Roof rainwater harvesting, where feasible, provides a dual impact: cost savings for the user and extended dam capacity for the supplier.
- Rural water supply examples include Inanda, where a roof area of 80 m² and two 4.5 kl tanks can provide 6 kl/month in summer and 3 kl/month in winter. Rainwater harvesting yield is 45 kl/a, which is 84% of FBW. Where Free Basic Water (6 kl/m) is provided, RWH can supplement significantly in the rainy season. Where only standpipe (25 l/p/d) supplies are

provided, RWH can supplement to near FBW level, depending on rainfall. Where there is no fallback supply, RWH brings a huge improvement, but not to FBW level of supply.

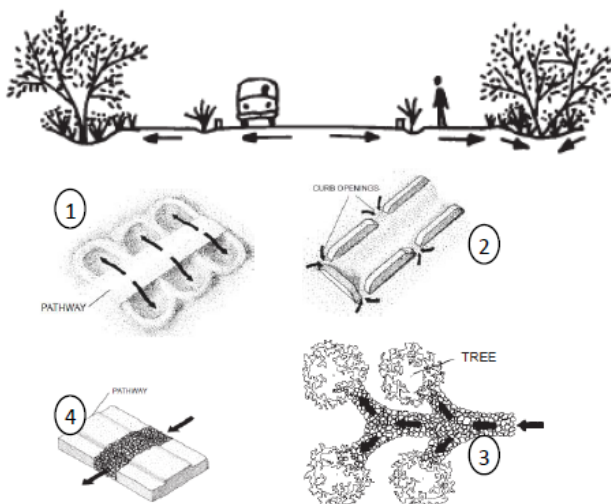
- Some areas can grow food just with run-on RWH; but mostly water storage is needed to get through the dry season. Food security strategies should be based on making maximum use of run-on stormwater to augment direct rainfall on deep fertile beds, with the surplus being diverted to storage tanks for continuation of production during the dry season.

Rainwater harvesting and urban stormwater management:

Managing stormwater runoff within urban precincts is an essential element of rainwater harvesting, but not usually considered by water planners, because it has not traditionally been viewed as a potential water resource. However, there is significant possibility to capture and store water for non-potable uses, whilst reducing peak stormwater flows.



For example, the City of Tucson Land Use Code requires that rainwater be harvested and put to beneficial use to support vegetation at new commercial developments, subdivisions, public buildings and public rights-of-way (Tucson, 2005).



1. Microbasins off pathways retain water to sustain plant growth.
2. In parking lots, depressed tree holes can receive runoff through curb openings.
3. Branched French drain to direct water to different planting areas.
4. French drain across pathway to allow runoff to flow through.

By managing small volumes of water at the top and throughout the watershed, the need to manage a large volume of stormwater at the bottom of the watershed is decreased. In eThekweni, new regulation requires all new developments to limit stormwater runoff peaks to the pre-development levels, which often requires onsite water storage and off-peak release. This creates significant opportunities to use harvested rainwater for non-potable applications, leading to savings on potable supplies – provided the flood attenuation objective is not compromised.

Rainwater harvesting in water planning tools

“Indeed, rainwater harvesting should become an integral component of all our water planning tools, including reconciliation strategies, water services development plans and Water Master Plans” (Civil Engineer magazine, October 2009).

This statement was confirmed in a DWA Seminar on rainwater harvesting in November 2009, and broadened to include further water planning tools at national and municipal level, such as the National Water Resources Strategy, Catchment Management Strategies, the Water for Growth and Development Strategy, and the All Towns studies.

The range of technical solutions for rainwater harvesting should continue to widen in South Africa. There is room for a technical rainwater harvesting manual to assist municipalities in implementation of roof rainwater harvesting, ‘water for food’ and rainwater harvesting to support vegetation at new commercial developments, subdivisions, public buildings and public rights-of-way.

Engineering curricula at Universities and other learning institutions need to incorporate rainwater harvesting as well as the new approaches to stormwater management and flood attenuation.

Rainwater harvesting in financing mechanisms

Financing mechanisms often narrowly supports only new infrastructure, with little or no provision for upgrading, retrofitting and maintenance work. Constraints to the financing of rainwater harvesting should be assessed and rectified in financing mechanisms such as the Municipal Infrastructure Grant (MIG), etc. The use of innovative financing mechanisms, such as the Bangladesh Model in conjunction with the Bulk Infrastructure Grant (BIG) or similar tools, warrants investigation.

With the Bangladesh Model an authority prefinances and provides infrastructure or equipment directly to households, and raises a financing levy on the services bill. The levy is offset by savings through reduced usage, meaning that the users see little or no difference on their services bill until the infrastructure is paid off, at which point the services bill reduces.

Regulations for rainwater harvesting

Work is needed to develop suitable regulation according to the feasibility and potential for rainwater harvesting in different municipalities. In some municipalities it is still forbidden to harvest and use rainwater and to reuse waste water; in some only the use of rainwater for drinking is prohibited. Restrictions on interconnections between rainwater supply systems and household reticulation usually aim to prevent contamination of municipal pipelines with backflow from systems that the municipality cannot control the quality of. These regulations and interactions with relation legal requirements need to be reviewed (e.g. requirements for flood attenuation).

Rainwater harvesting in environmental restoration

Soil stabilisation is key to the Restoration of Natural Capital (<http://www.rncalliance.org/>). Rainwater harvesting techniques for the control and infiltration of surface runoff contribute powerfully to soil stabilisation, and thus to the restoration of landscapes, prevention of degradation and increased vegetative production as a climate change mitigation measure (FAO 2009). The development of Payment for Ecosystem Services (PES) and carbon and water credits could help finance the implementation of restoration measures, including the harvesting and control of surface runoff. The potential use of PES is highlighted in the April 2009 release of the ASGISA 2008 annual report and is also a cornerstone intervention strategy of the 2nd economy project (http://www.tips.org.za/files/Second_Economy_Strategy_Framework_Jan_09_0.pdf).

At the same time, these measures contribute directly to the food-water-energy nexus for sustainable development. This relates closely to 'Plan 3' of the eThekweni Municipality which focuses on quality of living for all.

The photographs below show examples of earth and stone terraces in steep terrain; trees protecting the an upper catchment while vegetative strips lower down increase infiltration and thus help stabilise river baseflows; and stone lines in Drakensberg-type veld serving the same purpose. All of these can be implemented as major public job creation programmes which earn carbon credits.



Conclusions and recommendations on rainwater harvesting

This was only a limited study on the potential for rainwater harvesting in an urban context in South Africa. The assessment used data for eThekweni Municipal area. Findings have shown that rainwater harvesting holds significant potential and thus warrants closer investigation.

City-wide, the upper limit of rainwater harvesting was calculated at 42.98 million kl/annum for all formal residences with standard water connections. The Unit Reference Value is R5.23 at 2% discount rate, or R7.71 at 8%. Average annual usage of this water use sector in eThekweni was approximately 115 kl/annum based on figures for June 2009. Note that this is an indication of potential only, as it is unlikely that all households will implement rainwater harvesting.

From the results it is clear that rainwater harvesting is not a replacement for conventional water supplies, and is indeed most effective in conjunctive use with a reliable alternative source (such as normal municipal reticulation). This characteristic could be advanced further by introducing appropriate water reuse measures in conjunction with rainwater harvesting.

With full conjunctive use of rainwater using a 9kl storage tank and household point-of-use treatment of drinking water, an average-sized house of 200m² could harvest 144kl rainwater per year, at a Unit Reference Value of R4.70, payback period of four years and with a Net Present Value of savings on their municipal account of R24 292 over a twenty year period.

To be taken seriously by households, rainwater solutions have to offer seamless integration with existing supply and use systems:

- i. for rooftop rainwater harvesting this would require more work on plumbing solutions, through further refinement of a variety of solutions available locally and globally;
- ii. for garden use of stormwater runoff, garden layout can be adjusted to automatically slow down and infiltrate more water into garden soil, whilst ensuring safe outflow of excess water without erosion damage; and
- iii. the household's rainwater planning should consider how their permeable and impermeable surfaces contribute to the desired flows, infiltration and storage of rainwater.

Review of regulation could include changes to building regulations (local and national) requiring a Rainwater Harvesting Plan for all new developments, with appropriate minimum requirements and due consideration of interactions with other regulations, such as for flood attenuation and water quality aspects.

Rainwater harvesting needs to be included formally in water planning tools and studies, and especially in the All Towns studies. One possible approach would be to use the recent authoritative McKinsey report and refine the broad assumptions used in that report to develop a comprehensive suite of interventions and their mutual interactions for improved water use and management across all water use sectors.

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