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REPUBLIC OF SOUTH AFRICA

REPORT NO: P WMA 11/U10/00/3312/2/2

The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water

WATER REQUIREMENTS AND RETURN FLOWS REPORT

FINAL

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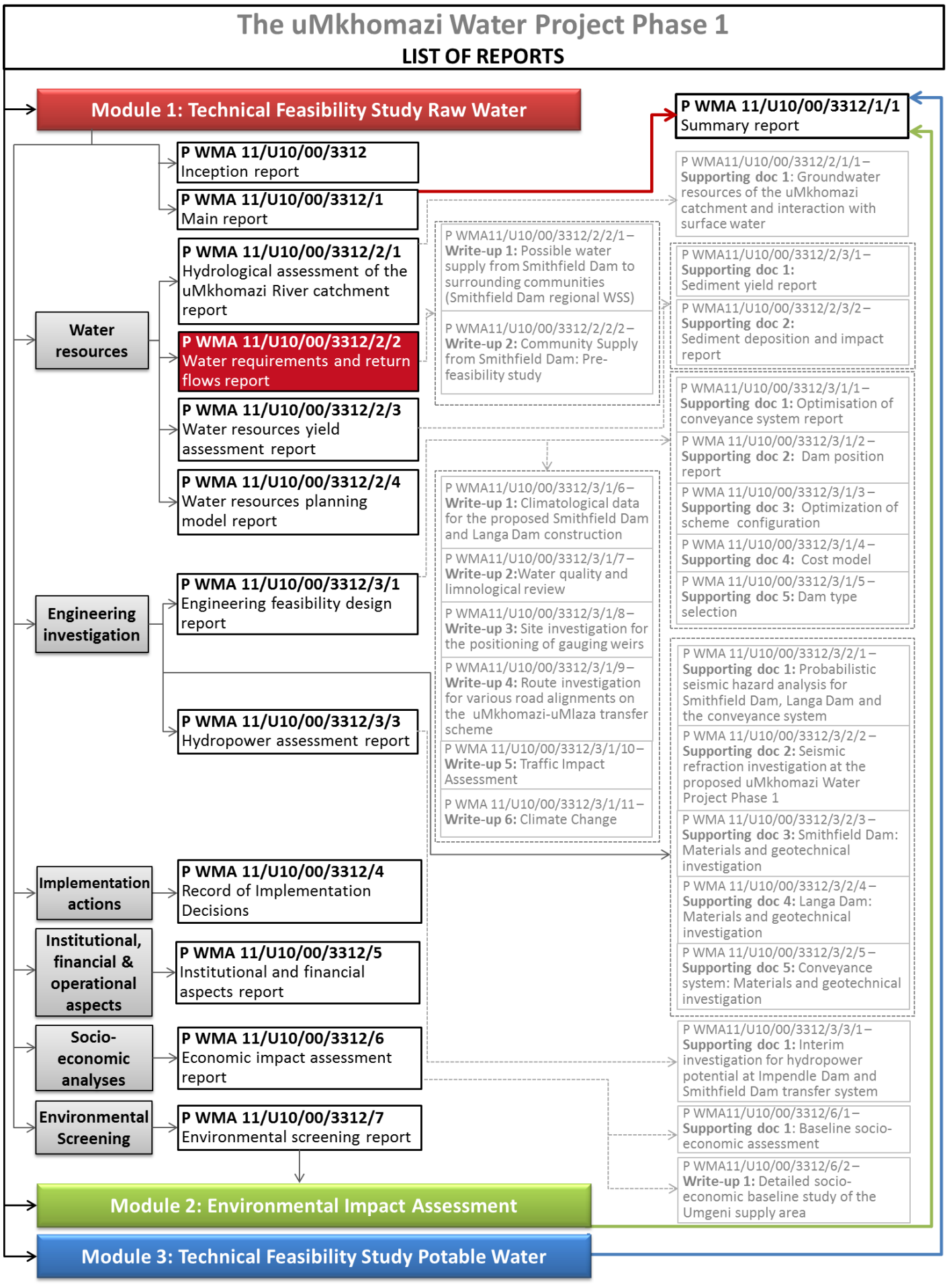
PREAMBLE

1. In June 2014, two years after the commencement of the uMkhomazi Water Project Phase 1 Feasibility Study, a new Department of Water and Sanitation was formed by Cabinet, including the formerly known Department of Water Affairs.

   In order to maintain consistent reporting, all reports emanating from Module 1 of the study will be published under the Department of Water Affairs name.

2. In September 2013, one year after the commencement of the uMkhomazi Water Project Phase 1 Feasibility Study, Sisonke District Municipality was renamed to Harry Gwala District Municipality, as published in the KZN Provincial Gazette 2013.

   The use of Sisonke District Municipality was adopted in numerous reports at the commencement of the study. Reference to Harry Gwala District Municipality was then addressed in reports emanating at a later stage of the study.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Module 3: Technical Feasibility Study Potable Water

Executive summary

The purpose of this report is to provide a comprehensive assessment of:

- *The historical, current and future water requirements for all water use sectors within the uMkhomazi and upper uMlaza river catchments; and*
- *The water requirement projections for the integrated Mgeni Water Supply System (WSS) – comprising the Midmar, Albert Falls, Nagle, Inanda and Spring Grove Dams and a transfer scheme from the Mooi River – and how these drive the need for the proposed transfers of water from the uMkhomazi River catchment. This included separate estimates of water requirements for various supply areas including:*
  - *The Mgeni WSS as a whole;*
  - *The uMWP-1 water transfer supply area within the Mgeni WSS;*
  - *North and South Coast supply areas for the purposes of comparing the proposed uMWP-1 project against other augmentation options such as desalination and direct re-use of water.*

For planning purposes a planning horizon of approximately 40 years was adopted from 2012 to 2050.

UMKHOMAZI AND UMLAZA RIVER CATCHMENTS

The uMkhomazi River catchment is currently fairly undeveloped, with the notable exception of extensive tracts of commercial forestry and irrigated areas in the central catchment areas around the towns of Richmond, Ixopo, Bulwer and Impendle, as well as water abstractions for the SAPPI-SAICCOR mill located near the coastal town of Umkomaas upstream of the uMkhomazi River estuary. Other water users include small towns and rural settlements, stock watering, dry-land sugarcane and invasive alien plants. The current net water use within the uMkhomazi River catchment totals 159 million m^3/a (15% of the total natural mean annual runoff of the catchment) and it is estimated that this may grow to 192 million m^3/a by 2050. A summary of the net water use in the uMkhomazi River catchment at both development levels is provided below.

In contrast, the upper uMlaza River catchment is highly developed, predominantly for the cultivation and irrigation of sugarcane and vegetables, with a total current net water requirement of 36 million m^3/a (over 60% of the natural mean annual runoff). Water requirement projections were not developed for the upper uMlaza River catchment since the proposed uMWP balancing dam will be located on a small tributary of the uMlaza

River and it is unlikely that further development will be allowed within the small upstream catchment area.

TRANSFER REQUIREMENTS OF THE UMWP-1 AND INCORPORATION INTO THE MGENI WSS

The proposed uMkhomazi Water Project Phase 1 (uMWP-1) is intended to augment the water supply of the Mgeni WSS, by supplying water into a portion of the system with a current total water requirement of approximately 400 million m^3/a. This supply area and the associated water requirements for the first phase of the uMWP, namely Smithfield Dam, have been determined in detail by the Module 3: Technical Feasibility Study: Potable Water study team.

The water from the uMWP-1 will be transferred to Baynesfield where it will be treated at a new water treatment plant (WTP) and then fed to the Umlaas Road Reservoir via gravity for distribution, through the Western and Northern Aqueducts. In this way it will supply users currently fed by the Durban Heights WTP, thereby reducing the load on the existing resources in the Mgeni WSS. The supply from the uMWP-1 is planned to be increased as the infrastructure in the Mgeni WSS reaches its operating capacity. This means that water use will be shed off the Mgeni WSS onto the uMWP in such a way that makes full utilisation of the existing bulk infrastructure, and delays unnecessary capital expenditure.

The projected water requirements for the identified uMWP-1 supply area grow from approximately 110 million m^3/a in 2013 to around 230 million m^3/a in 2050. The anticipated water requirements in 2023, the earliest possible implementation date of the uMWP-1, are in the order of 150 million m^3/a. Based on the above as well as updated water requirement projections for other areas within the Mgeni WSS, including the expanded supply area along the North and South Coast, a new water requirement projection scenario was developed for the system as a whole. According to this scenario the total system water requirement will grow from the current 398 million m^3/a to around 480 million m^3/a in 2023 and 612 million m^3/a in 2040.

RECOMMENDATIONS

Based on the results presented in this report it is recommended that:

- *Estimates of historical water use in the uMkhomazi and upper uMlaza river catchments should be used in the hydrological analysis of this Feasibility Study for the purpose of rainfall-runoff model calibration and the naturalisation of gauged stream flows for the catchments in question.*

- *Projected water requirement scenarios developed for the uMkhomazi River catchment should be used for assessing the potential impacts of future in-catchment developments on the yield of both phases of the uMWP, namely Smithfield and Impendle dams.*
- *Projected water requirement scenarios developed for the uMWP-1 transfer supply area, as well as for other supply areas within the Mgeni WSS, should be used for the purpose of future system water availability and water balance assessments.*
- *Some activities involved in determining water requirement projections for the Mgeni WSS overlapped with the scope of the recently commissioned DWA study Continuation of the Reconciliation Strategy of the KwaZulu-Natal Coast Metropolitan Area: Phase 2. That study should therefore aim to integrate the uMWP-1 supply area information into the Mgeni WSS and also to ensure that the level of detail of the remaining portions of the Mgeni WSS is brought up to a similar level of detail.*
- *With regard to the above it is important to ensure that the double-counting or missing of water users does not occur and also that the return flow volumes resulting from the new water requirement projections are updated accordingly and the impact on the Mgeni WSS verified.*
- *Water requirement and return flow projection scenarios presented here were developed based on a number of assumptions and limitations as described in the report. It is therefore recommended that the actual water use and return flows in the study area should be monitored and that, as part of the Reconciliation Strategy and other relevant initiatives, projections are continuously re-evaluated and revised accordingly.*

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AADD	Average Annual Daily Demand
AGES	Africa Geo-Environmental Services (Pty) Ltd
ARC	Agricultural Research Council
BKS	*legacy* BKS (Pty) Ltd
DAFF	Department of Agriculture, Forestry and Fisheries
DLF	Design Loss Factor
D:NWRP	Directorate: National Water Resource Planning
DM	District Municipality
DWA	Department of Water Affairs
EKZNW	Ezemvelo-KZN Wildlife
ET_0	Reference Evapotranspiration
ET_C	Crop Evapotranspiration
ETM+	Multi-temporal Landsat 7 Enhanced Thematic Mapper
GG	Government Gazette
HDI	Previously Disadvantaged Individual
IAP	Invasive Alien Plant
KZN	KwaZulu-Natal
LM	Local Municipality
LSU	Large Stock Unit
MAR	Mean Annual Runoff
MM	Metropolitan Municipality
MMA	Mogoba Maphuthi and Associates
MMTS-1	Mooi-Mgeni Transfer Scheme – Phase 1
MMTS-2	Mooi-Mgeni Transfer Scheme – Phase 2
NDA	National Department of Agriculture
NLC 2000	South African National Land Cover 2000
NS	Ninham Shand
PMC	Project Management Committee
PSC	Project Steering Committee
RSA	Republic of South Africa
SASRI	South African Sugarcane Research Institute
SCA	South Coast Augmentation
SCP	South Coast Pipeline
SDD	Summer Daily Demand
SFR	Stream Flow Reduction
SKZN-WRPFS	Southern KwaZulu-Natal Water Resources Pre-feasibility Study
SPF	Summer Peak Factor
SSU	Small Stock Unit

uMWP	uMkhomazi Water Project
uMWP-1	uMkhomazi Water Project – Phase 1
uMWP-2	uMkhomazi Water Project – Phase 2
UW	Mgeni Water
VIP	Ventilated Improved Pit Latrines
WARMS	Water Authorisation and Registration Management System
WRC	Water Research Commission
WRSM2000	Water Resources Simulation Model 2000
WRYM	Water Resources Yield Model
WRPM	Water Resources Planning Model
WSA	Water Service Authority
WSS	Water Supply System
WTW	Water Treatment Works
WwTW	Wastewater Treatment Works

LIST OF UNITS

cm	centimetre
ha	hectares
kℓ	kilolitre
km^2	square kilometres
ℓ	litre
ℓ/c/d	litre per capita per day
m	metre
mm	millimetre
m^3	cubic metre
m^3/s	cubic metre per second
million m^3/a	million cubic metre per annum
Mℓ	mega (million) litre

1 INTRODUCTION

The Department of Water Affairs appointed **BKS (Pty) Ltd** in association with three sub-consultants **Africa Geo-Environmental Services, MM&A and Urban-Econ** with effect from 1 December 2011 to undertake the **uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study Raw Water**.

On 1 November 2012, BKS (Pty) Ltd was acquired by **AECOM Technology Corporation**. The new entity is a fully-fledged going concern with the same company registration number as that for BKS. As a result of the change in name and ownership of the company during the study period, all the final study reports will be published under the AECOM name.

In 2010, the Department of Arts and Culture published a list of name changes in the Government Gazette (GG No 33584, 1 October 2010). In this list, the Mkomazi River's name was changed to the **uMkhomazi River**. *The published spelling will thus be used throughout this technical feasibility study.*

1.1 BACKGROUND TO THE PROJECT

The current water resources of the Integrated Mgeni WSS are insufficient to meet the long-term water requirements of the system. The Integrated Mgeni WSS is the main water source that supplies about five million people and industries in the eThekwini Municipality, uMgungundlovu District Municipality (DM) and Msunduzi Local Municipality (LM), all of which comprise the economic powerhouse of the KwaZulu-Natal Province.

The Integrated Mgeni WSS comprises the Midmar, Albert Falls, Nagle and Inanda Dams in KwaZulu-Natal, a water transfer scheme from the Mooi River and the newly constructed Spring Grove Dam. The current system (Midmar, Albert Falls, Nagle and Inanda Dams and the MMTS-1) has a stochastic yield of 334 million m^3/a (measured at Inanda Dam) at a 99% assurance of supply. The short-term augmentation measure, Phase 2 of the Mooi Mgeni Transfer Scheme (MMTS-2), currently being implemented with the construction of Spring Grove Dam, will increase water supply from the Integrated Mgeni WSS by 60 million m^3/a. However, this will not be sufficient to meet the long-term requirements of the system.

Pre-feasibility investigations indicated that Phase 1 of the uMkhomazi Water Project (uMWP-1), which entails the transfer of water from the undeveloped uMkhomazi River to the existing Integrated Mgeni WSS, is the scheme most likely to fulfil this requirement. The uMkhomazi River is the third-largest river in KwaZulu-Natal in terms of mean annual runoff (MAR).

Eight alternative schemes were initially identified as possible alternatives, and the Impendle and Smithfield scheme configurations have emerged as suitable for further investigation. The pre-feasibility investigation, concluded in 1998, recommended that the Smithfield Scheme be taken to a detailed feasibility-level investigation as its transfer conveyances would be independent of the existing Integrated Mgeni WSS, thus reducing the risk of limited or non-supply to eThekwini and some areas of Pietermaritzburg, and providing a back-up to the Integrated Mgeni WSS.

The ***Mkomazi-Mgeni Transfer Pre-feasibility Study*** concluded that the first phase of the uMWP would comprise a new dam at Smithfield on the uMkhomazi River near Richmond, a multi-level intake tower and pump station, a water transfer pipeline/tunnel to a balancing dam at Baynesfield Dam or a similar in-stream dam, a water treatment works at Baynesfield in the uMlaza River valley and a gravity pipeline to the Mgeni bulk distribution reservoir system, below the reservoir at Umlaas Road. From here, water will be distributed under gravity to eThekwini and possibly low-lying areas of Pietermaritzburg. Phase two of the uMWP may be implemented when needed, and could comprise the construction of a large dam at Impendle further upstream on the uMkhomazi River to release water to the downstream Smithfield Dam. Together, these developments have been identified as having a 99% assured stochastic yield of about 388 million m^3/a.

The DWA aims to have this scheme implemented by 2023.

1.2 OBJECTIVE OF THE STUDY

According to the Terms of Reference (November 2010), the objective of the study project is to undertake a feasibility study to finalise the planning of the proposed ***uMkhomazi Water Project (uMWP)*** at a very detailed level for the scheme to be accurately compared with other possible alternatives and be ready for implementation (detailed design and construction) on completion of the study.

The feasibility study has been divided into the following modules, which will run concurrently:

- Module 1: Technical Feasibility Raw Water (DWA) (*defined below*);
- Module 2: Environmental Impact Assessment (DWA); and
- Module 3: Technical Feasibility Potable Water (Umgeni Water) (*ranging from the Water Treatment Plant to the tie-in point with the eThekwini distribution system*).

This module, the raw water technical feasibility study, considers water resources aspects, engineering investigations and project planning and scheduling and implementation tasks, as well as an environmental screening and assessment of socio-economic impacts of the proposed project.

Some specific objectives for this study, recommended in the ***Mkomazi-Mgeni Transfer Scheme Pre-feasibility*** are listed below:

- Smithfield Dam (Phase 1) to be investigated to a detailed feasibility level;
- Investigate the availability of water from Impendle Dam (Phase 2) as a future resource to release to Smithfield Dam, and refine the phasing of the selected schemes;
- Optimise the conveyance system between Smithfield Dam and the proposed Baynesfield Water Treatment Plant;
- Undertake a water resources assessment of the uMkhomazi River Catchment, including water availability to the lower uMkhomazi;
- Evaluate the use of Baynesfield dam as a balancing dam; and
- Investigate the social and economic impact of the uMWP.

This one of three studies, was undertaken in close collaboration with the DWA, Mgeni and the PSPs of the other modules.

1.3 GOVERNANCE AND ORGANISATION OF THE STUDY

As the main objective of the project is to augment water supply to the Integrated Mgeni WSS, an area that is managed by Umgeni Water with users mainly from eThekwini Municipality, the study will require the participation from the three spheres of government. Liaison with the Client, key stakeholders, interested and affected parties and team members will be managed through various committees, as shown in the diagram below.

The ***Project Steering Committee's*** (PSC) main function was to assist the DWA with strategic matters and to coordinate the contributions of other authorities. This committee oversees the total project, including the Raw Water, Treated Water and Environmental Impact Assessment project modules.

The ***Project Management Committee*** (PMC) is responsible for governing and driving the feasibility study, comprising the DWA Project Manager, Umgeni Water, the PSP Study Leader (supported by technical specialists) and representatives of any DWA Directorate wishing to participate at any stage of the project. eThekwini Municipality is an *ad hoc* member, to ensure that the local considerations and situation of interested and affected parties are also accounted for at the appropriate level.

Integration management for sound project management and a strong working relationship within the project team and between the project team and the Client is dealt with in the ***Project Management and Administration Committee***.

The required activities for this project have been organised into ***8 main tasks***, defined in the ToR, the BKS Tender and confirmed in the Inception Report, shown **Figure 1.1**.

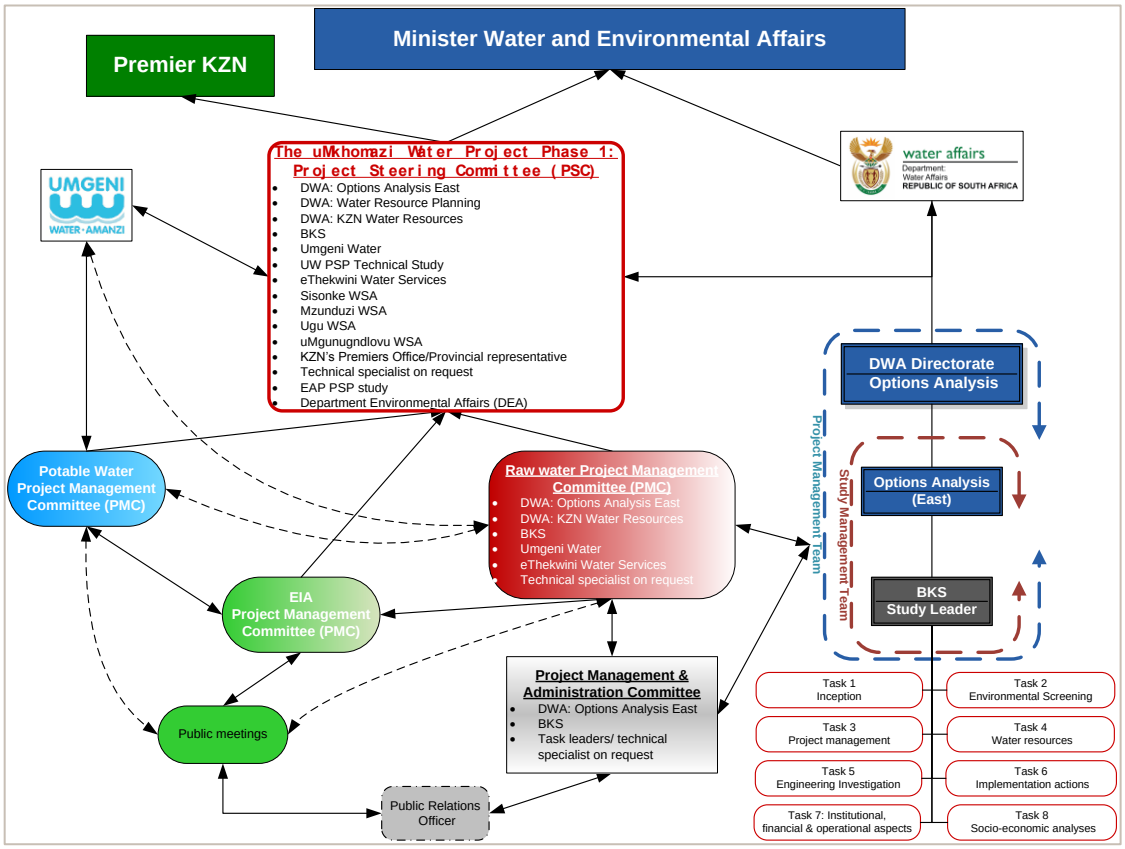

Figure 1.1: uMWP governance structure

1.4 STUDY AREA

The study focus and key objective is related to the feasibility investigation of the Smithfield Dam in the uMkhomazi River catchment and related raw water conveyance infrastructure into the Mgeni River catchment and the associated water supply system. The study area is thus defined as the uMkhomazi River catchment, stretching to the north to include the Mgeni River catchment, refer to **Figure A.1** in **Appendix A**.

The various tasks have a specific focus area, defined as:

- Water Resources: uMkhomazi and Mgeni River catchments;
- Water requirements: water users in the Integrated Mgeni WSS and the uMkhomazi River catchment;
- Engineering Investigations: proposed dams at Impendle (only for costing purposes) and Smithfield, and the raw water conveyance infrastructure corridor between Smithfield Dam and the Water Treatment Plant of Mgeni Water;
- Environmental screening as input for the Environmental Impact Assessment;

- Socio-economic impact assessment: regional, provincial (KwaZulu-Natal (KZN)) and national.

1.5 SCOPE OF THIS REPORT

The scope of this report is to present:

- Historical, current and future water requirements for all water use sectors within the uMkhomazi and upper uMlaza river catchments. These sectors include domestic (urban and rural), irrigation, industrial and stock watering, as well as commercial forestry, dry-land sugarcane and invasive alien plants (see **Section 2**).
- The water requirement projections for the integrated Mgeni Water Supply System (WSS) and how these drive the need for the proposed transfers of water from the uMkhomazi River catchment (see **Section 3**). This included separate estimates of water requirements for various supply areas including:
  - The Mgeni WSS as a whole;
  - The uMWP-1 water transfer supply area within the Mgeni WSS;
  - North and South Coast supply areas for the purposes of comparing the proposed uMWP-1 project against other augmentation options such as desalination and direct re-use of water.

For planning purposes a planning horizon of approximately 40 years was adopted from 2012 to 2050.

2 uMKHOMAZI AND UPPER uMLAZA RIVER CATCHMENTS

2.1 AREA OF INTEREST

The study area for the uMWP-1 comprises both the uMkhomazi River catchment (U10A to U10M) as well as the upper reaches of the uMlaza River catchment (U60A and U60B). The following sections provide detailed information on the historical, current and projected future water use in the uMkhomazi and upper uMlaza river catchments, including domestic and industrial users, irrigation, stock watering, commercial forestry, dry-land sugarcane and invasive alien plants. Historical water use information was applied in the hydrological analysis undertaken as part of this study, while current and projected water requirements were used for planning purposes.

In this regard it should be noted that water requirement projections were not developed for land use developments in the upper uMlaza River catchment. Although the proposed balancing dam for the uMWP is likely to be located near Baynesfield on a tributary of the uMlaza River, the upper uMlaza is already highly developed and it is unlikely that further development will be allowed within the small catchment area upstream of the balancing dam.

2.2 DOMESTIC (URBAN AND RURAL)

2.2.1 Methodology

The methodology adopted to determine historical, current and future domestic water requirements within the study area included the following:

- Obtain population data per sub-place/enumeration area for the study area from the *2011 Census* (Statistics South Africa, 2012).
- Establish 2001 domestic water requirements and return flows within the study area per (i) municipality, (ii) quaternary catchment and (iii) water supply area (WSA):

- Based on population and average per capita consumption for five categories of consumption (based on the level of access to water from the *2011 Census)*;
- Including residential and non-residential (i.e. schools and medical facilities) domestic water requirements;
- Providing a split in sources(s) of supply i.e. surface water or groundwater;
- Excluding domestic water requirements of sub-places/enumeration areas supplied from outside of the study area; and
- Taking into consideration design loss factors as well as summer peaks factors.

- Determine historical (1925) domestic water requirements and return flows by assuming linear population growth.
- Determine current (2012) domestic water requirements and return flows based on (1) population growth (annual population growth rates from Urban-Econ (AECOM, et al., 2014) and (2) average per capita consumption.
- Project future (2042) domestic water requirements and return flows for three population growth scenarios namely High-, Medium- and Low-growth scenarios, based on population growth (annual population growth rates from Urban-Econ (AECOM, et al., 2014) and average per capita consumption.

2.2.2 Population data

Population data per sub-place/enumeration area was obtained from the *2011 Census*. A sub-place/enumeration area is defined as a pocket-sized piece of country which was visited by an enumerator during the *2011 Census*. Sub-places/enumeration areas within the study area are shown on **Figure A.2** of **Appendix A**.

As the boundaries of the sub-place/enumeration areas did not coincide with the boundaries of either the study area or the quaternary catchments, estimates were made of the portion of the population within each sub-place/enumeration area that is contained within (i) the study area, and (ii) each respective quaternary catchment.

In addition, each sub-place was assigned to a specific water supply area. Water supply areas were defined by the study *Development of a Water Reconciliation Strategy for All Towns in the Eastern Region* (Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates, 2011) as a specific area supplied

from a source(s) of water and serviced by bulk water infrastructure. For this purpose consideration was taken of the location of urban and rural settlements, which were obtained from the respective District Municipalities within the study area and compared to the *2008 KZN Province Land-cover Mapping* (EKZNW, 2010) data set which is based on SPOT5 satellite imagery dated 2008, as shown in **Figure A.3** of **Appendix A**. A summary of the four district municipalities and nine local municipalities within which the study area is located is provided in **Table 2.1** and shown on **Figure A.4** of **Appendix A**. Furthermore, **Table 2.2** provides a summary of the 14 water supply areas within the study area and the location of each can be seen in **Figure A.5**.

Table 2.1: Municipalities within the study area

No.	District / local municipality name	% Area (estimated)
1	**Sisonke District Municipality**	**-**
1a	Kwa Sani Local Municipality	30%
1b	Ingwe Local Municipality	50%
1c	Ubuhlebezwe Local Municipality	40%
1d	Mkhomazi Wilderness Area	
2	**uMgungundlovu District Municipality**	**-**
2a	Impendle Local Municipality	90%
2b	Richmond Local Municipality	40%
2c	Msunduzi Local Municipality	Only a very small area of the Msunduzi LM falls within the uMkhomazi River catchment. However, these water users will benefit from the scheme.
2d	Mkhambathini Local Municipality	10%
3	**eThekwini Municipality**	Only a small area of the eThekwini Municipality falls within the uMkhomazi River catchment. However, these water users will benefit from the proposed scheme.
4	**Ugu District Municipality**	**-**
4a	Vulamehhlo Local Municipality	20%

Table 2.2: Water supply areas within the study area

No.	Description
1	Bulwer Donnybrook Water Supply Area
2	Ixopo/Carisbrooke Water Supply Area
3	Masameni Water Supply Area
4	Springvale Water Supply Area
5	Makhuzeni/Integrated Stoffleton Water Supply Area
6	Pitela Water Supply Area
7	Richmond/Ndaleni Water Supply Area
8	Hopewell Water Supply Area
9	Impendle Town and Enguga Water Supply Area
10	Embuthweni and Ogagwini Water Supply Area
11	KwaLembe Water Supply Area
12	Mgeni Water Supply Area
13	eThekwini MM Water Supply Area
14	Other water supply areas

Population data for the 2001 scenario per (i) water supply area; (ii) municipality; as well as (iii) quaternary catchment are shown in **Table 2.3**, **Table 2.4** and **Table 2.5**, respectively. Eight formal towns/urbanised areas were identified within the 14 water supply areas (location of these shown on **Figure A.6** of **Appendix A**) and the population of these are shown separately in **Table 2.3**. These towns/urbanised areas are:

- Bulwer
- Ixopo
- Richmond
- Hopewell
- Impendle Town
- Umkomaas
- Craigieburn
- Magabeni

Table 2.3: Population data per water supply area within the study area

Water supply area	Total population within the study area (2001 scenario)
Bulwer Donnybrook Water Supply Area	43 885
Ixopo/Carisbrooke Water Supply Area	8 434
Masameni Water Supply Area	9 805
Springvale Water Supply Area	7 407
Makhuzeni/Integrated Stoffleton Water Supply Area	10 269
Pitela Water Supply Area	296
Richmond/Ndaleni Water Supply Area	13 032
Hopewell Water Supply Area	10 699
Impendle Town and Enguga Water Supply Area	25 081
Embuthweni and Ogagwini Water Supply Area	10 294
KwaLembe Water Supply Area	7 467
Mgeni Water Supply Area	11 368
eThekwini MM Water Supply Area	17 171
Other water supply areas	40 431
TOTAL:	**215 639**

Table 2.4: Population data per municipality within the study area

Municipality	Total population within the study area (2001 scenario)
Sisonke DM	
Kwa Sani LM	6 127
Ingwe LM	53 272
Ubuhlebezwe LM	32 396
Mkhomazi Wilderness Area	409
uMgungundlovu DM	
Impendle LM	32 171
Richmond LM	42 722
Msunduzi LM	2 294
Mkhambathini LM	10 242
eThekwini MM	**17 171**
Ugu DM	
Vulamehhlo LM	18 835
TOTAL:	**215 639**

Table 2.5: Population data per quaternary catchment

Quaternary catchment	Total population within the study area (2001 scenario)
uMkhomazi River catchment	
U10A	3 331
U10B	4 336
U10C	3 036
U10D	10 167
U10E	21 715
(Impendle Town only)	*9 198*
U10F	22 192
(Bulwer only)	*731*
U10G	5 545
U10H	19 514
U10J	31 148
(Richmond only)	*10 185*
U10K	12 822
(Ixopo only)	*8 434*
U10L	14 802
U10M	42 325
(Umkomaas only)	*940*
(Craigieburn only)	*7 303*
(Magabeni only)	*2 062*
Sub-total:	**190 931**
Upper uMlaza River catchment	
U60A	4 702
U60B	20 005
(Hopewell only)	*10 699*
Sub-total:	24 708
TOTAL:	**215 639**

Note: The population of the formal towns (in blue italics) are included in the figures shown for the respective quaternary catchments.

2.2.3 Water requirements for the 2001 scenario

a) Typical per capita consumption for residential and non-residential domestic water requirements

Domestic water requirements were determined based on average per capita consumption using water use benchmarks at the point of use. Both residential and non-residential domestic water requirements were taken into consideration.

Residential domestic water requirements took cognisance of five categories of consumption which were based on the level of access to water from the *2011 Census* (as shown in **Table 2.6**).

Table 2.6: Average per capita consumption for residential domestic water users

Level of access to water	Source of water	Typical consumption (ℓ/c/d)
Formal towns	Regional/local water scheme	150
Piped water inside dwelling	Regional/local water scheme	90
Piped water inside yard	Regional/local water scheme	60
Piped water on community stand: distance less than 200m from dwelling	Regional/local water scheme	50
Piped water on community stand: distance integrated than 200m from dwelling or No access to piped water	Regional/local water scheme OR Borehole/spring/rainwater tank/dam/pool/stagnant water/river/stream/water vendor/other	25

Figure 2.1 gives an indication of the access to water households have within the study area.

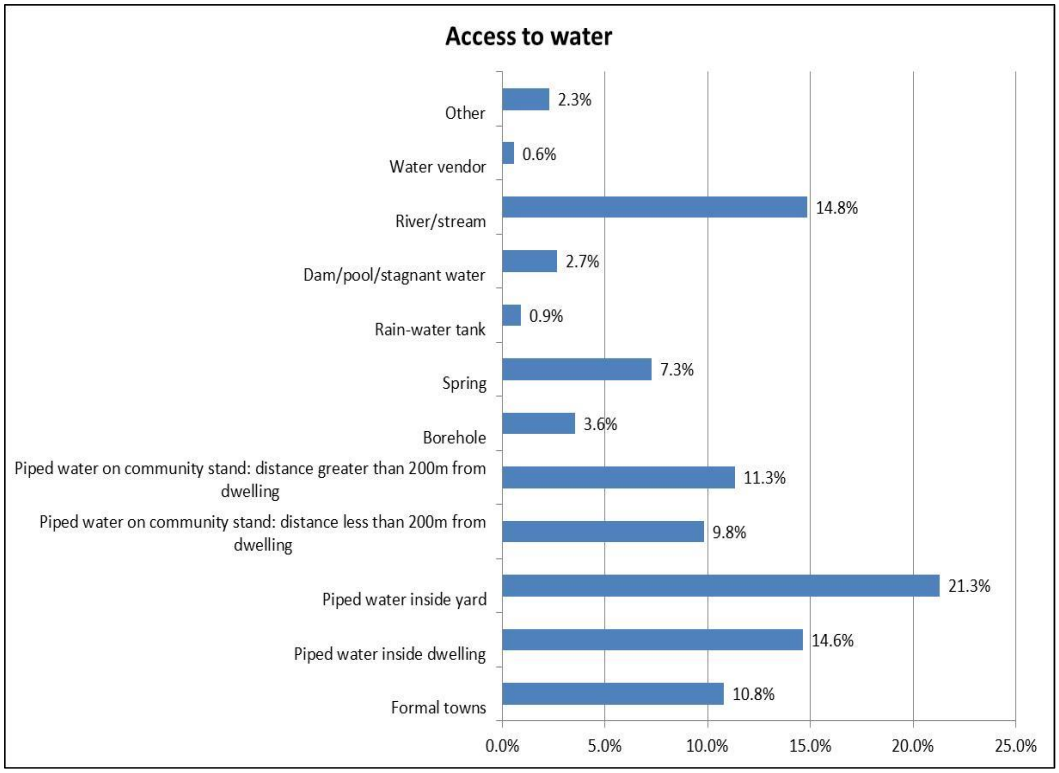

Figure 2.1: Access to water of households within the study

Similarly non-residential domestic water requirements to cater for schools and medical facilities, i.e. hospitals and clinics, were based on average non-domestic per capita consumption (CSIR Building and Construction Technology, 2000) as shown in **Table 2.7**. The number of schools and medical facilities within the study area was obtained from counts conducted from aerial imagery (dated 2009) and accumulated to 209 schools and 26 clinics within the study area.

Table 2.7: Average per capita consumption for non-residential domestic water users

Source of water	Typical consumption (ℓ/d)
Schools * based on 100 pupils at 15 ℓ/pupil/day	1 500
Clinics *based on 500 in-patients at 40 ℓ/bed/day	20 000
Hospitals * based on 700 beds at 220 ℓ/bed/day	154 000

b) Source(s) of supply and return flows

Information on the source(s) of supply for each water supply area, and hence each sub-place/enumeration area, was obtained from the study *Development of a Water Reconciliation Strategy for All Towns in the Eastern Region* (Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates, 2011). This information was used to determine the portion of supply for each sub-place/enumeration area from groundwater and surface water respectively.

Domestic water requirements were also independently determined for all eight formal towns/urbanised areas identified in the study area. The following is a summary of the source(s) of supply and abstraction points as well as return flows for each water supply area. A summary of these are also given in **Appendix B**. Where applicable, information for the eight formal towns/urbanised areas is provided separately.

- ***Bulwer Donnybrook Water Supply Area (including Bulwer)***

Water sources and abstraction points

The Bulwer Donnybrook WSA is supplied from both groundwater (i.e. boreholes and abstraction from a spring), as well as surface water via a weir on the Mkobeni River. Only one formal town, namely Bulwer, exists within this WSA. Water from the spring is used to supply the main town of Bulwer, however, during winter months the spring supplying Bulwer is not adequate and supply is supplemented from a weir on the Mkobeni River (approximately a third of the total supply to Bulwer). Raw water from the spring and the Mkobeni River is delivered to Bulwer WTW where it is treated to potable drinking water quality standards. Areas surrounding Bulwer, namely Donnybrook and Highflats, are currently supplied from boreholes.

Return flows

Only one formal wastewater treatment works, namely the Bulwer WwTW discharging water to the Mkobeni River, exists within the Bulwer Donnybrook WSA. As no information could be obtained on the actual water returned to the Mkobeni River, an assumption was made that 30% of the water supplied to this WSA is discharged as return flows.

- ***Ixopo/Carisbrooke Water Supply Area (including Ixopo)***

Water sources and abstraction points

The Ixopo/Carisbrooke WSA is supplied from both groundwater, i.e. boreholes, as well as surface water. Only one formal town, namely Ixopo, exists within this WSA. Ixopo receives its water from the Ixopo Dam on the Xobho River (previously known as Solly Butler Dam or Homefarm Dam) as well as a production borehole. These two sources are used in a conjunctive manner. During times when Ixopo Dam (surface water supply) is spilling the borehole abstraction rate is reduced. If there are operational problems at the WTW the borehole is often used to make up shortfalls during shutdowns or reduced production.

Ixopo Dam supplies its own water requirements without the support of the two upstream farm dams until the dam storage has dropped to 20%. A 20% storage level at Ixopo Dam triggers the need for support from both the farm dams. These dams continue to support Ixopo Dam until they reach dead storage. Restrictions are imposed in the system when the farm dams have reached their dead storage level.

Raw water from the Ixopo Dam and the borehole is delivered to Ixopo WTW where it is treated to potable drinking water quality standards. Areas surrounding Ixopo are currently supplied from boreholes.

Return flows

Only one formal wastewater treatment works, namely the Ixopo WwTW, exists within the Ixopo/Carisbrooke WSA. However, this wastewater treatment works does not discharge water to the river; instead sludge is dried on beds and disposed of on a local farm owned by Mgeni Water.

- ***Masameni Water Supply Area***

No information could be obtained on the Masameni WSA, hence an assumption was made that the population within this WSA is equally supplied from groundwater and surface water. In addition return flows from this WSA were assumed to be negligible.

- ***Springvale Water Supply Area***

No information could be obtained on the Masameni WSA, hence an assumption was made that the population within this WSA is equally supplied from groundwater and surface water. In addition return flows from this WSA were assumed to be negligible.

- ***Makhuzeni/Integrated Stoffleton Water Supply Area***

Water sources and abstraction points

The Makhuzeni/Integrated Stoffleton WSA comprises two sub-systems with two separate sources of supply. No formal towns exist within the Makhuzeni/Integrated Stoffleton WSA. The main source of supply for sub-places within the Integrated Stoffleton area is the uMkhomazi River. Raw water from the uMkhomazi River is delivered to the Makhuzeni WTW where it is treated to potable drinking water quality standards. In addition, the areas of Makhuzeni and Stepmore have stand-alone schemes currently supplied by boreholes.

Return flows

No formal wastewater treatment works exists within the Makhuzeni/Integrated Stoffleton WSA, as the area is still largely dependent on ventilated improved pit latrines (VIPs).

- ***Pitela Water Supply Area***

No information could be obtained on the Pitela WSA, hence an assumption was made that the population within this WSA is equally supplied from groundwater and surface water.

- ***Richmond/Ndaleni Water Supply Area (including Richmond)***

Water sources and abstraction points

The Richmond/Ndaleni WSA is supplied from both surface water as well as groundwater, i.e. boreholes. Only one formal town, namely Richmond, exists within this WSA. Richmond receives its water from the Beaulieu Dam on the Lovu River as well as a few boreholes providing a small quantity of supplementary flow. Raw water from the Beaulieu Dam and the boreholes is delivered to Richmond WTW where it is treated to potable drinking water quality standards.

Return flows

Only one formal wastewater treatment works, namely the Richmond WwTW, discharging water to the Lovu River, exists within the Richmond/Ndaleni WSA. As no information could be obtained on the actual water returned to the Lovu River, an assumption was made that 30% of the water supplied to this WSA is discharged as return flows.

- ***Hopewell Water Supply Area (including Hopewell)***

Water sources and abstraction points

The Hopewell WSA is supplied from surface water from Mgeni Water's Upper Integrated Mgeni WSS (via the Midmar WTW to Umlaas Road Reservoir Sub-system). The main town within the Hopewell WSA is Hopewell.

Return flows

No information could be obtained on the return flows from the Hopewell WSA. An assumption was made that the return flows are negligible.

- ***Impendle Town and Enguga Water Supply Area (including Impendle Town)***

Water sources and abstraction points

The Impendle Town and Enguga WSA depends on both surface water and groundwater as its source of supply. The main town within this WSA, namely Impendle Town, as well as Enguga, are dependent on raw water supplies from the Nzinga River, whilst groundwater development supplies the surrounding communities within the WSA. Raw water from the Nzinga River is delivered to the Impendle WTW where it is treated to potable drinking water quality standards.

Return flows

No formal wastewater treatment works exists within the Impendle Town and Enguga WSA, as the area is still largely dependent on ventilated improved pit latrines (VIPs).

- ***Embuthweni and Ogagwini Water Supply Area***

Water sources and abstraction points

The Embuthweni and Ogagwini WSA comprise two sub-systems with two separate sources of supply and are dependent on groundwater as well as bulk water supply from Mgeni Water. The Ogagwini supply area is currently supplied by a bulk water supply pipeline from the Mgeni bulk water supply system, whereas the Embuthweni supply area depends on boreholes which have been drilled to supply the area. No formal towns or WTW exist within this WSA.

Return flows

No formal wastewater treatment works exists within the Embuthweni and Ogagwini WSA, as the area is still largely dependent on ventilated improved pit latrines (VIPs).

- ***KwaLembe Water Supply Area***

  Water sources and abstraction points

  The KwaLembe WSA depends on surface water only i.e. run-of-river abstraction from the uMkhomazi River. Raw water from the uMkhomazi River is delivered to the KwaLembe WTW where it is treated to potable drinking water quality standards. No formal towns exist within this WSA.

  Return flows

  No formal wastewater treatment works exists within the KwaLembe WSA, as the area is still largely dependent on ventilated improved pit latrines (VIPs).

- ***Mgeni Water Supply Area***

  This area is covered in detail in **Section 3**.

- ***eThekwini MM Water Supply Area (including Umkomaas, Craigieburn and Magabeni)***

  This area is covered in detail in **Section 3**.

- ***Other water supply areas***

  Water sources and abstraction points

  No information could be obtained for areas falling outside of the thirteen water supply areas mentioned above, however, these are considered rural areas and an assumption was made that the main source of supply to these areas is from groundwater. In addition return flows were regarded as negligible.

  Based on the above information the following split between groundwater and surface water was assumed for each water supply area within the study area (shown in **Table 2.8**).

Table 2.8: Split between groundwater and surface water

Water supply area	Groundwater	Surface water
Bulwer Donnybrook Water Supply Area	70%	30%
Bulwer	*70%*	*30%*
Ixopo/Carisbrooke Water Supply Area	20%	80%
Ixopo	*20%*	*80%*
Masameni Water Supply Area	50%	50%
Springvale Water Supply Area	50%	50%
Makhuzeni/Integrated Stoffleton Water Supply Area	50%	50%
Pitela Water Supply Area	50%	50%
Richmond/Ndaleni Water Supply Area	30%	70%
Richmond	*30%*	*70%*
Hopewell Water Supply Area	0%	100%
Hopewell	*0%*	*100%*
Impendle Town & Enguga Water Supply Scheme	50%	50%
Impendle Town	*50%*	*50%*
Embuthweni & Ogagwini Water Supply Area	90%	10%
KwaLembe Water Supply Area	0%	100%
Mgeni Water Supply Area	0%	100%
eThekwini MM Water Supply Area	0%	100%
Umkomaas	*0%*	*100%*
Craigieburn	*0%*	*100%*
Magabeni	*0%*	*100%*
Other water supply areas	100%	0%

Note: Stand-alone formal towns/urbanised areas shown in italics.

c) Sub-places/enumeration areas supplied from outside of the study area

The study area comprises of predominantly Sisonke DM (including Kwa Sani, Ingwe and Ubuhlebezwe LM), uMgungundlovu DM (including Richmond, Impendle, Mkhabathini and Msunduzi LM), Ugu DM (including Vulamehlo LM) and eThekwini MM. As some/part of these municipalities are supplied from sources outside of the demarcated study area as stated in the previous section domestic water requirements for these were not considered when determining the total requirements for the study area. These included domestic water requirements of parts of Richmond LM (within U10J to U10L) as well as Mkhabathini LM, Vulamehlo LM and eThekwini MM (within U10M).

d) Design loss factors as well as summer peak factors

To take into consideration the losses within bulk storage and bulk supply systems a design loss factor (DLF) as well as a summer peak factor (SPF) was to be considered.

Design loss factors within catchment areas with similar catchment characteristics, typically range from 20% to 25%. A decision was therefore made to adopt a total design loss factor of 25% for the purposes of this study.

In addition, a decision was made not to adopt any summer peaks as these would generally be considered for bulk supply infrastructure only.

As a result the following formulas were used to determine the final domestic water requirements within the study area:

$$AADD = Design\ horizon\ population\ \times Average\ per\ capita\ consumption$$

$$GAADD = (1 + DLF)\ \times AADD$$

$$SDD = SPF\ \times GAADD$$

Where:

- AADD = Annual average daily demand
- GAADD = Gross annual average daily demand
- SDD = Summer daily demand
- DLF = Design loss factor
- SPF = Summer peak factor

e) Results

A summary of the estimated 2001 domestic (urban and rural) water requirements and return flows is provided **Table C.2** of **Appendix C** for quaternary catchments in the uMkhomazi and upper uMlaza river catchments.

2.2.4 Water requirements for the historical (1925) scenario

Domestic water requirements for the historical (1925) scenario were calculated by assuming linear population growth from zero population in 1920 to the 2001

population captured by the *2011 Census*, together with the average per capita consumption (as discussed in **Section 3.2.3**). For this scenario the following two assumptions were made on supply and return flows:

- Domestic water requirements supplied equally from surface water and groundwater; and
- No formal WwTW existed in the study area in 1925, i.e. zero return flows.

A summary of the estimated 1925 domestic (urban and rural) water requirements and return flows is provided **Table C.1** of **Appendix C** for quaternary catchments in the uMkhomazi and upper uMlaza river catchments.

2.2.5 Water requirements for the current (2012) scenario

Domestic water requirements for the current (2012) scenario were determined based on projected population figures and average per capita consumption (as discussed in **Section 3.2.3**). Population figures for 2012 were estimated based on the 2001 population captured by the *2011 Census* and annual population growth rates per sub-place/enumeration area obtained from Urban-Econ (AECOM, et al., 2014).

These annual growth rates for individual municipalities in the study area are summarised in **Table 2.9** and were calculated for the purpose of this study by a population model developed by Quantec for Urban-Econ. The population growth per municipality is also shown graphically in **Figure 2.2**.

Table 2.9: Annual population growth rates (2001 to 2012)

Municipality	Annual population growth rates
Sisonke District Municipality	
Kwa Sani Local Municipality	-0.1%
Ingwe Local Municipality	1.1%
Ubuhlebezwe Local Municipality	-0.8%
Mkhomazi Wilderness Area	-1.3%
uMgungundlovu District Municipality	
Impendle Local Municipality	1.4%
Richmond Local Municipality	-0.3%
Msunduzi Local Municipality	1.4%
Mkhambathini Local Municipality	-0.8%
eThekwini Municipality	1.6%
Ugu District Municipality	
Vulamehhlo Local Municipality	-1.1%

A summary of the estimated 2012 domestic (urban and rural) water requirements and return flows is provided **Table C.3** of **Appendix C** for quaternary catchments in the uMkhomazi and upper uMlaza river catchments.

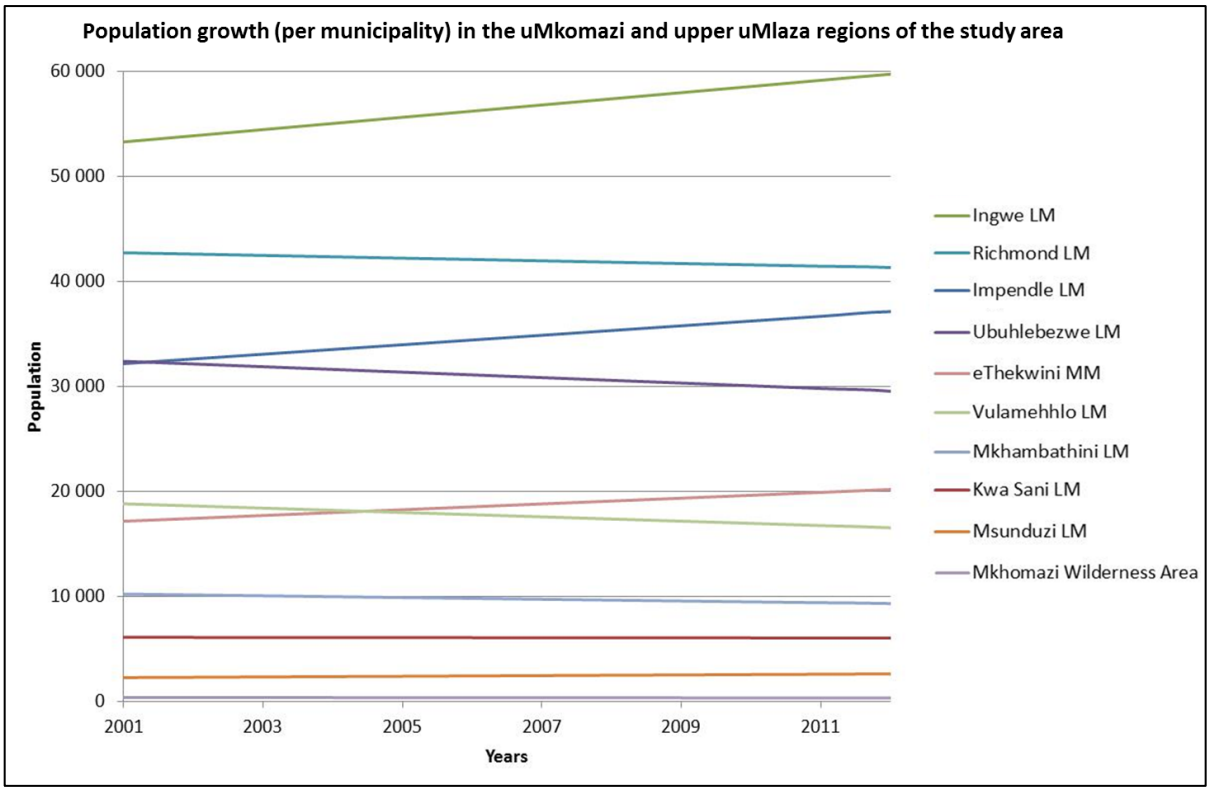

Figure 2.2: Population growth per municipality in the study area

2.2.6 Water requirements for the future (2042) scenario

A 30-year planning horizon (until 2042) was deemed sufficient for planning purposes. As for the current (2012) scenario, domestic water requirements for the future (2042) scenario were determined based on projected population in 2042 and the average per capita consumption (as discussed in **Section 3.2.5**). For this purpose, three population growth scenarios were developed, namely High-, Medium- and Low-growth, based on population growth rates obtained from Urban-Econ (AECOM, et al., 2014), as summarised in **Table 2.10**. Again these growth rates were calculated by the population model discussed in **Section 3.2.5** and reflect the minimum, maximum and average growth rates for each individual municipality.

The population growth per municipality is also shown graphically for each of the growth scenarios in **Figure 2.3** to **Figure 2.5**, respectively.

Table 2.10: Annual population growth rates (2012 to 2042)

Municipality	Annual population growth rates for indicated growth scenario		
	Low	Medium	High
Sisonke District Municipality			
Kwa Sani Local Municipality	-0.9%	-0.1%	0.6%
Ingwe Local Municipality	0.8%	1.1%	1.4%
Ubuhlebezwe Local Municipality	-3.1%	-0.8%	1.7%
Mkhomazi Wilderness Area	-4.7%	-1.3%	0.6%
uMgungundlovu District Municipality			
Impendle Local Municipality	-0.5%	1.4%	2.3%
Richmond Local Municipality	-1.3%	-0.3%	0.5%
Msunduzi Local Municipality	0.6%	1.4%	1.7%
Mkhambathini Local Municipality	-3.1%	-0.8%	1.9%
eThekwini Municipality	1.1%	1.6%	1.9%
Ugu District Municipality			
Vulamehhlo Local Municipality	-2.5%	-1.1%	0.5%

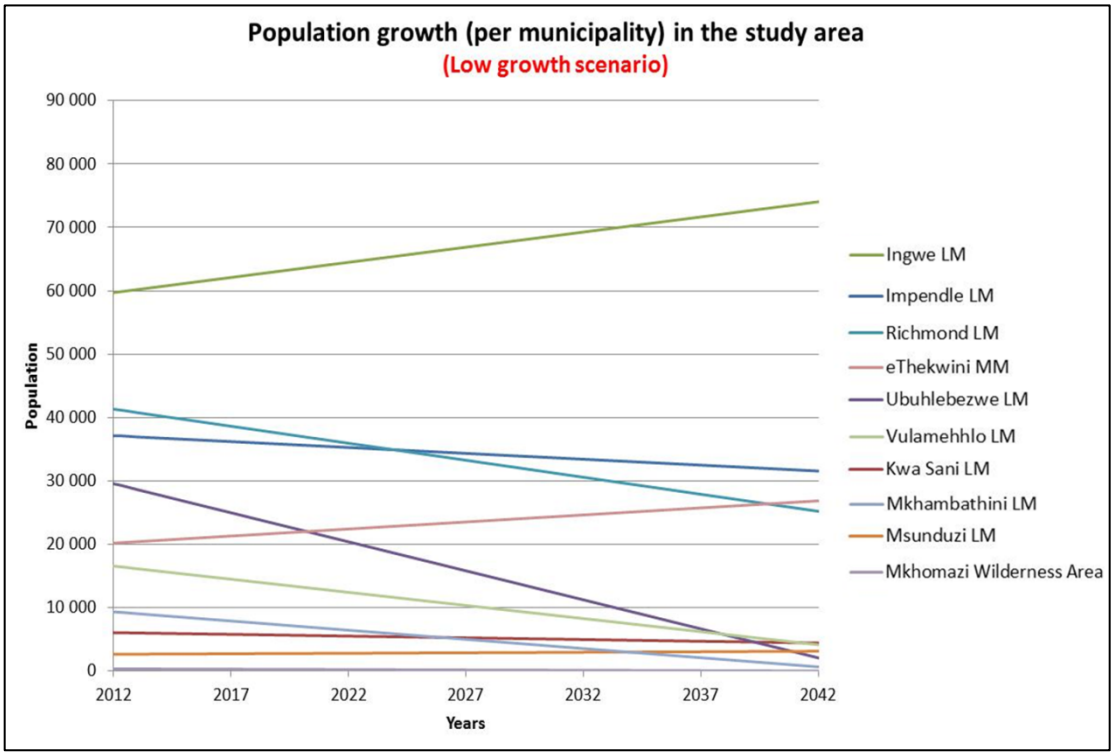

Figure 2.3: Population growth per municipality in the study area (Low scenario)

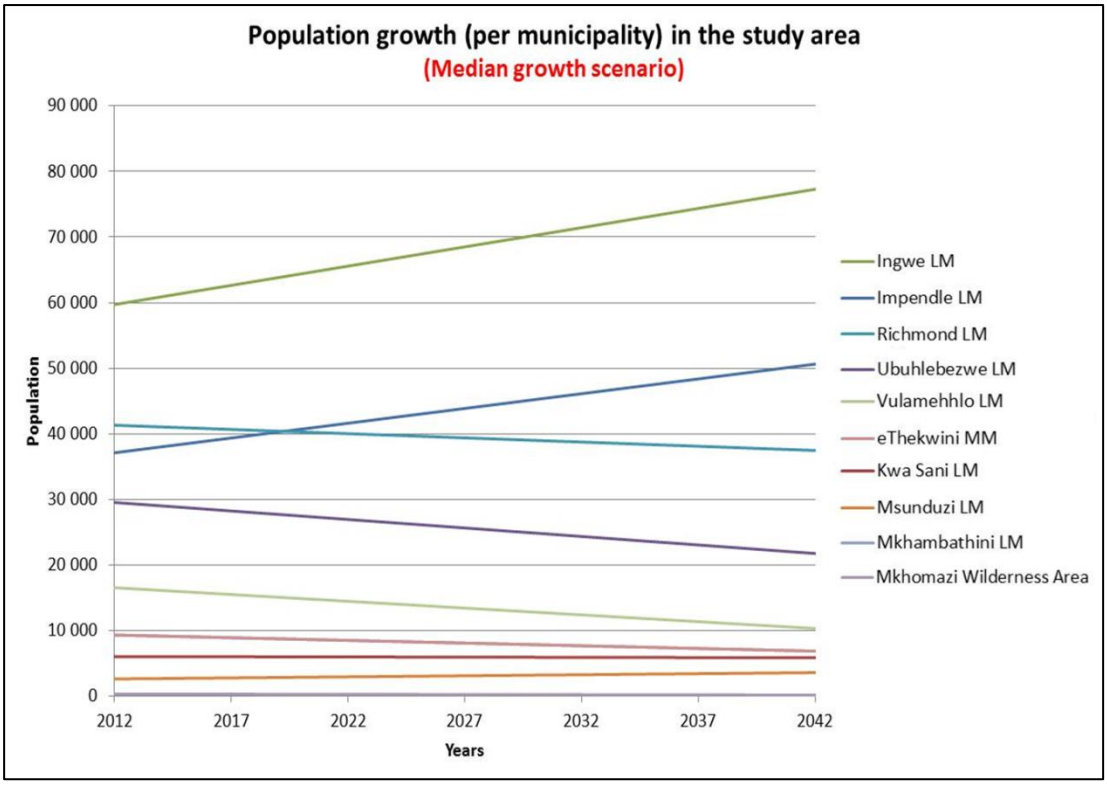

Figure 2.4: Population growth per municipality in the study area (Medium-scenario)

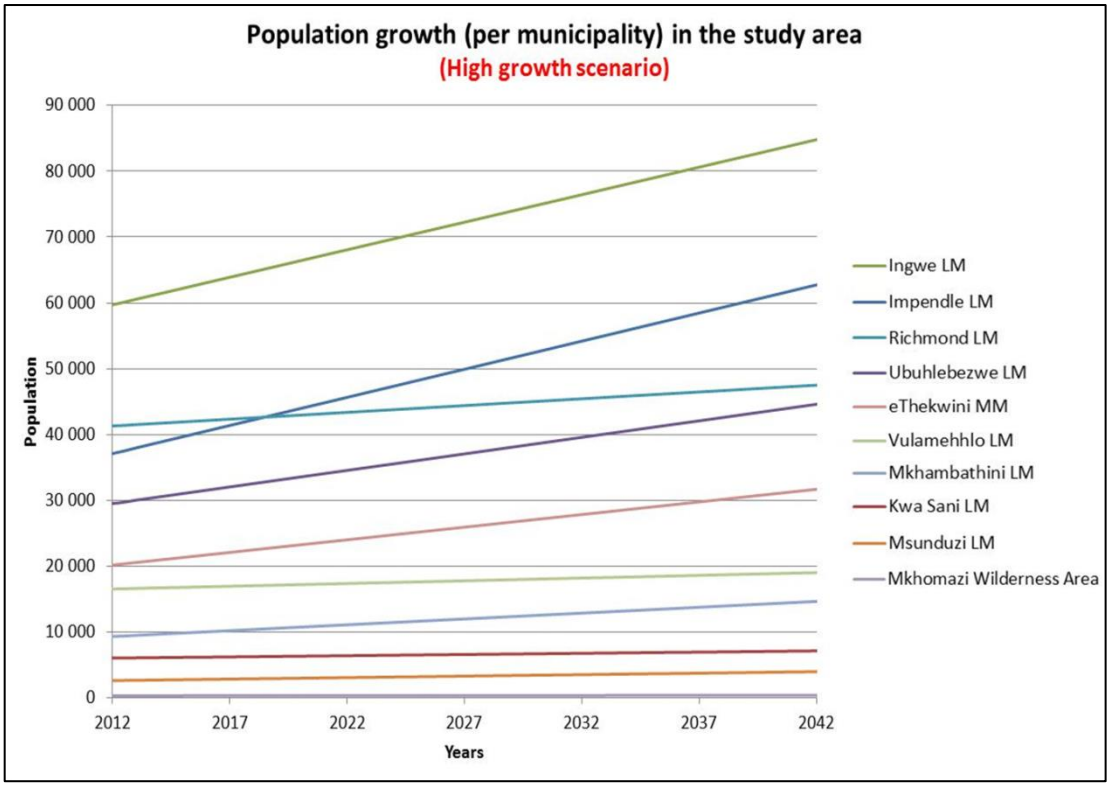

Figure 2.5: Population growth per municipality in the study area (High scenario)

The resulting population (2012 to 2042) per water supply area is shown in **Table 2.11**. These figures compared well with that from the scenarios developed for the study *Development of a Water Reconciliation Strategy for All Towns in the Eastern Region* (Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates, 2011).

Table 2.11: Population data per water supply area within the study area

Water supply area	Population for indicated development level and growth scenario			
	2012	2042		
		Low	Medium	High
Bulwer Donnybrook Water Supply Area	49 195	61 002	63 677	69 857
Ixopo/Carisbrooke Water Supply Area	7 692	538	5 668	11 615
Masameni Water Supply Area	8 942	626	6 589	13 503
Springvale Water Supply Area	6 755	473	4 977	10 200
Makhuzeni/Integrated Stoffleton Water Supply Area	10 954	8 666	12 822	15 772
Pitela Water Supply Area	293	214	284	345
Richmond/Ndaleni Water Supply Area	12 602	7 687	11 429	14 492
Hopewell Water Supply Area	10 346	6 311	9 383	11 898
Impendle Town and Enguga Water Supply Area	28 944	24 602	39 478	48 915
Embuthweni and Ogagwini Water Supply Area	9 770	4 313	8 342	12 517
KwaLembe Water Supply Area	6 563	1 641	4 099	7 548
Mgeni Water Supply Area	9 992	2 498	6 241	11 491
eThekwini MM Water Supply Area	20194	26 857	28 436	31 704
Other water supply areas	40 606	26 648	41 083	56 777
TOTAL:	**222 848**	**172 077**	**242 509**	**316 633**

A summary of the estimated 2042 domestic (urban and rural) water requirements and return flows is provided **Tables C.4** to **C.6** of **Appendix C** for the Low-, Medium- and High-growth scenarios, respectively.

2.2.7 Summary of water requirements and return flows

A summary of the estimated domestic (urban and rural) water requirements in the uMkhomazi and upper uMlaza river catchments is provided **Table 2.12** for the 1925-, 2001-, 2012- and 2042-development levels – the latter including the High-, Medium- and Low-growth scenarios. Distinction is also made between water supplied from surface and groundwater sources. Corresponding return flows are summarised in **Table 2.13**.

Table 2.12: Summary of domestic water requirements within the study area

Catchment	Units	Total domestic water requirement, for indicated development level, growth scenario and water source (groundwater or surface water)																	
		1925			2001			2012			2042								
											Low			Medium			High		
		Total	*GW*	*SW*	Total	*GW*	*SW*	Total	*GW*	*SW*	Total	*GW*	*SW*	Total	*GW*	*SW*	Total	*GW*	*SW*
uMkhomazi	(kℓ/d)	636	*318*	*318*	10 307	*5 573*	*4 734*	10 829	*5 955*	*4 874*	8 486	*5 236*	*3 232*	12 252	*7 003*	*5 250*	15 828	*8 650*	*7 178*
	(million m^3/a)	0.23	*0.12*	*0.12*	3.76	*2.03*	*1.73*	3.95	*2.17*	*1.78*	3.09	*1.91*	*1.18*	4.47	*2.56*	*1.92*	5.78	*3.16*	*2.62*
Upper uMlaza[(1)]	(kℓ/d)	184	*92*	*92*	2 973	*967*	*2006*	2 871	*931*	*1 940*	1 586	*403*	*1 183*	2 593	*834*	*1 759*	3 550	*1 319*	*2 231*
	(million m^3/a)	0.07	*0.03*	*0.03*	1.09	*0.35*	*0.73*	1.05	*0.34*	*0.71*	0.58	*0.15*	*0.43*	0.95	*0.30*	*0.64*	1.30	*0.48*	*0.18*
TOTAL:	**(kℓ/d)**	**820**	***410***	***410***	**13 280**	***6 540***	***6 740***	**13 700**	***6 886***	***6 813***	**10 054**	***5 638***	***4 415***	**14 845**	***7 836***	***7 009***	**19 377**	***9 968***	***9 409***
	(million m^3/a)	**0.30**	***0.15***	***0.15***	**4.85**	***2.39***	***2.46***	**5.00**	***2.51***	***2.49***	**3.67**	***2.06***	***1.61***	**5.42**	***2.86***	***2.56***	**7.07**	***3.64***	***3.43***

Note: (1) Comprising of quaternary catchments U60A and U60B.

Table 2.13: Summary of domestic return flows within the study area

Catchment	Units	Total domestic return flows, for indicated development level and growth scenario					
		1925	2001	2012	2042		
					Low	Medium	High
uMkhomazi	(kℓ/d)	0	614	600	395	562	703
	(million m^3/a)	0.00	0.22	0.22	0.14	0.21	0.26
Upper uMlaza(1)	(kℓ/d)	0	0	0	0	0	0
	(million m^3/a)	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**(kℓ/d)**	**0**	**614**	**600**	**395**	**562**	**703**
	(million m^3/a)	**0.00**	**0.22**	**0.22**	**0.14**	**0.21**	**0.26**

Note: (1) Comprising of quaternary catchments U60A and U60B.

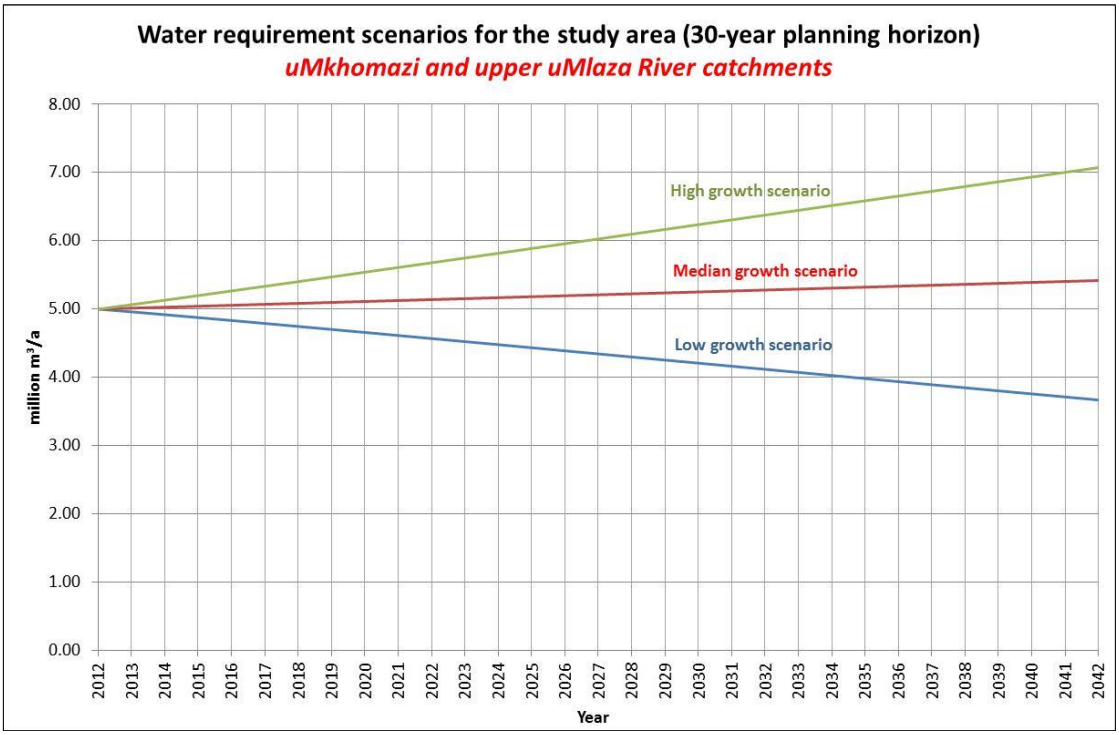

Figure 2.6: Water requirement scenarios for the study area

2.2.8 Future augmentation options within the uMkhomazi River catchment

For planning purposes it is important to take into consideration future plans of the municipalities within the study area to augment supply of the various water supply areas. **Table 2.14** provides a summary of future augmentation options for the various water supply areas within the study area that was obtained from the study *Development of a Water Reconciliation Strategy for All Towns in the Eastern Region* (Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates, 2011).

Table 2.14: Future augmentation options for water supply areas within the study area

Water supply area	Future augmentation options
Bulwer Donnybrook Water Supply Area	▪ Groundwater development ▪ Implement WC/WDM programme ▪ Development of storage capacity on the Luhane River (Bulwer Dam to be augmented from the Pholela River at a later stage) ▪ Development of a regional bulk water scheme from the Luhane River
Ixopo/Carisbrooke Water Supply Area	▪ Implement WC/WDM programme ▪ Transfer from other water supply areas i.e. Bulwer Donnybrook WSA
Masameni Water Supply Area	No information available
Springvale Water Supply Area	No information available
Makhuzeni/Integrated Stoffleton Water Supply Area	▪ Implement WC/WDM programme ▪ Groundwater development ▪ Upgrading of the water supply infrastructure ▪ Augmentation of water supplies from the uMkhomazi River (development of water supply system or proposed Impendle Dam)
Pitela Water Supply Area	No information available
Richmond/Ndaleni Water Supply Area	▪ Bulk water supply infrastructure from the Integrated Mgeni WSS (Proposed Mgeni Water Richmond pipeline which will involve construction of a pipeline from the ’61 pipeline system) ▪ Implement WC/WDM programme ▪ Water resource development in the Lovu River (raising of Beaulieu Dam or building of a new dam)
Hopewell Water Supply Area	▪ No information available ▪ Assumed increased supply from integrated Mgeni River system

Water supply area	Future augmentation options
Impendle Town & Enguga Water Supply Scheme	▪ Implement WC/WDM programme ▪ Groundwater development ▪ Upgrading of the water supply infrastructure ▪ Augmentation of water supplies from the Nzinga River (dam or weir)
Embuthweni & Ogagwini Water Supply Area	▪ Implement WC/WDM programme ▪ Groundwater development ▪ Upgrading of the water supply infrastructure ▪ Augmentation of water supplies from the Lovu River (development of storage capacity)
KwaLembe Water Supply Area	▪ Implement WC/WDM programme ▪ Extend the water supply infrastructure
Mgeni Water Supply Area	▪ No information available ▪ Assumed increased supply from integrated Mgeni River system
eThekwini MM Water Supply Area	▪ No information available ▪ Assumed increased supply from integrated Mgeni River system
Other water supply areas	▪ No information available ▪ Assumed increased supply from integrated Mgeni River system

2.3 INDUSTRIAL (SAPPI-SAICCOR)

The SAPPI-SAICCOR mill near the coastal town of Umkomaas is a major producer of chemical cellulose (dissolving wood pulp) and the largest single water user within the uMkhomazi River catchment. The mill is licensed to abstract a total of 145.2 Mℓ/d (53.0 million m^3/a) from the uMkhomazi River directly upstream of the estuary (Daniel, 2012), (Ward, Personal Communication, 2012).

However, the water requirements of the mill currently significantly exceed the reliable supply of water from SAPPI-SAICCOR's diversion works on the uMkhomazi River, particularly during low flow periods. In order to augment water supply shortfalls SAPPI has recently requested an off-take from Mgeni Water's South Coast Pipeline Phase 1 (SCP-1) to be used as an interim measure. The SCP-1 off-take was agreed to by Mgeni Water based on a number of conditions, including that they could only draw the balance of water in the pipeline after the requirements of eThekwini and Ugu municipalities had been satisfied, and that this balance would decrease over time as new off-takes were added to the SCP-1 and the associated requirements increased. The off-take to SAPPI-SAICCOR was installed a short distance upstream of the Quarry Reservoir and the mill began drawing water from the SCP-1 in September 2010 (Umgeni Water, 2011).

Return flows from the mill are discharged via a pipeline extending 6.5 km out to sea off the Umkomaas coastline. However, a small volume of back wash water is discharged directly into the uMkhomazi estuary, estimated by SAPPI to be in the order of 5 % of the mill's total water requirement, or 7.3 Mℓ/d (2.6 million m^3/a) at current production levels (Daniel, 2012).

According to SAPPI (Oxley, 2012) the organisation aims to increase annual production from the mill from the current 775 000 tons to 1 000 000 tons. With an estimated water consumption of approximately 70 m^3/ton this will result in a total increase in the mill's water requirement by 30% from 145.2 Mℓ/d (53.0 million m^3/a) to 187.4 Mℓ/d (68.4 million m^3/a). In order to provide for this anticipated growth in water requirements SAPPI recently considered the further development of water resources, in particular the construction of an off-channel storage dam on a tributary of the uMkhomazi River at Ngwadini. However, preliminary assessments undertaken as part of this study indicated that the reliable supply from the proposed Ngwadini Dam is little more than the mill's current water requirement of 53.0 million m^3/a. Based on these findings and the significant costs involved with developing the scheme, SAPPI has indicated that they would probably not consider further pursuing this option. More information in this regard is provided in the *Water Resources Yield Assessment Report* of this study (AECOM, et al., 2014).

Within the above context, it was assumed for the purposes of this study that the direct water supply to the SAPPI-SAICCOR Mill from the uMkhomazi River would remain at the currently licensed level of 53.0 million m^3/a and that water supply for any future expansion would be sourced from elsewhere – probably from Mgeni Water's SCP-1 as is currently the case.

Table 2.15 provides a summary of the water requirements, return flows and water sources of the SAPPI-SAICCOR Mill.

Table 2.15: SAPPI-SAICCOR water requirements and return flows

Description	Note	Water volume (million m^3/a)	
		2012	2020 – 2050
Water requirements			
uMkhomazi River abstraction	Currently licensed	53.0	53.0
Return flows			
Back wash to uMkhomazi River estuary	5 % of water use	2.6	2.6
Sea outfall	-	Not known	Not known

2.4 IRRIGATION

2.4.1 Overview

Irrigation developments in the uMkhomazi River catchment are fairly small, with a total estimated irrigated crop area of only 60 km^2. The annual irrigation water requirement is around 104 Mℓ/d (38 million m^3) which accounts for 23% of all current in-catchment water use. Approximately 60% of irrigation is supplied from run-of-river schemes while the remainder is supplied from small storage dams. Irrigation from groundwater sources is negligible. The predominant irrigated crops in the catchment are pastures and rye grass for the dairy industry, while small areas of sugarcane and vegetables are irrigated particularly in the lower portion of the catchment.

Irrigation is fairly extensive in the upper uMlaza catchment, with a total crop area of almost 40 km^2 and an estimated annual water use of 104 Mℓ/d (23 million m^3) – the majority of which is supplied from run-of-river schemes. Irrigated crops include primarily sugarcane and vegetables.

Historical and current irrigation water requirements and return flows were estimated based on irrigated crop areas, crop type and irrigation system information, combined with site-specific crop evapotranspiration data from the SAPWAT 3 model. This information was used to model historical water requirements and return flows as part of the hydrological analysis (1925 to 2008, hydrological years) and also as a basis for developing future irrigation water requirement projections for yield analysis and planning purposes (as discussed later in **Section 3.3.3**). The modelling was undertaken using the "Type 2" (SAPWAT-based) Irrigation Block sub-model, which is available as a feature within the WRSM2000 rainfall-runoff model, as well as the WRYM and WRPM systems models. More information in this regard is provided in the following sub-sections.

2.4.2 Historical and current (1925 – 2012)

a) Areas under irrigation

Information on irrigated areas in the uMkhomazi and upper uMlaza river catchments was obtained from a wide variety of sources which were assessed, compared and evaluated in order to obtain the most reliable available data set that covers a historical period of 88 years from 1925 to

2012. A summary of available historical irrigation area data is presented in **Table 2.16** and also in **Figure 2.7** (the latter for the uMkhomazi catchment only) and more information on the various data sources is provided thereafter.

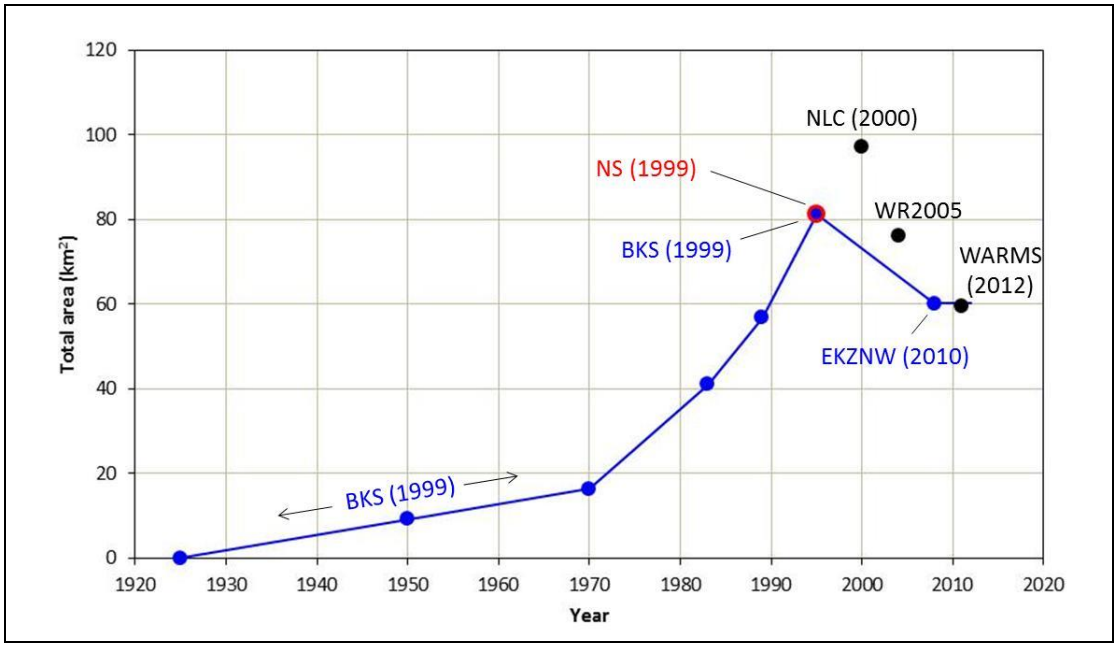

Figure 2.7: Available historical irrigation area data from various information sources

Table 2.16: Available historical irrigation area data from various information sources

Quaternary catchment	Total irrigated area (km^2), for indicated information source and level of development									
	BKS (1999)[1]					BKS (1999) & NS (1999)[2]	NLC (2000)[3]	WR-2005[4]	EKZNW (2010)[5]	WARMS (2012)[6]
	1925	1950	1970	1983	1989	1995	2000	2004	2008	2011
uMkhomazi River catchment										
U10A	0.00	0.73	1.31	3.27	4.53	6.50	0.00	5.20	0.00	0.00
U10B	0.00	0.68	1.23	3.07	4.25	6.10	0.00	5.03	0.00	0.00
U10C	0.00	0.46	0.83	2.09	2.89	4.15	3.22	3.63	2.70	2.36
U10D	0.00	0.59	1.05	2.63	3.65	5.23	0.15	4.58	1.80	1.72
U10E	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.25	0.00
U10F	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	1.35	1.58
U10G	0.00	1.18	2.13	5.33	7.39	10.58	21.06	8.93	10.07	11.58
U10H	0.00	1.53	2.75	6.88	9.55	13.67	29.17	13.67	19.83	14.32
U10J	0.00	1.69	3.04	7.60	10.54	15.09	16.70	15.09	11.80	10.71
U10K	0.00	1.21	2.19	5.47	7.59	10.87	26.07	10.87	11.41	15.38
U10L	0.00	1.03	1.85	4.63	6.42	9.20	0.00	9.20	0.92	0.52
U10M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.47
Sub-total:	**0.00**	**9.10**	**16.37**	**40.98**	**56.82**	**81.39**	**97.34**	**76.20**	**60.14**	**59.64**
Upper uMlaza River catchment										
U60A	0.08	0.46	0.64	0.85	0.94	0.94	1.41	4.10	1.28	1.81
U60B	2.26	13.60	18.84	24.98	27.54	27.54	15.43	19.20	37.63	52.74
Sub-total:	**2.34**	**14.06**	**19.48**	**25.83**	**28.48**	**28.48**	**16.84**	**23.30**	**38.91**	**54.55**
Total:	**2.34**	**23.16**	**35.85**	**66.81**	**85.30**	**109.87**	**114.18**	**99.50**	**99.06**	**114.18**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) for defined sub-catchments, distributed across quaternary catchments in the uMkhomazi River catchment based on Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999) and in the upper uMlaza based on Ezemvelo-KZN Wildlife (EKZNW, 2010).

(2) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) and subsequently used by Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999).

(3) From the South African National Land Cover 2000 project.

(4) From WR2005 (WRC, 2009).

(5) From Ezemvelo-KZN Wildlife (EKZNW, 2010).

(6) From the WARMS database (Tylcoat, 2011).

BKS (1999)

Historical irrigation areas in the study area were determined for the earlier *Mkomazi/Mgeni/Mooi River Hydrology Update* study (BKS, 1999) from 1:30 000 aerial photography and 1:50 000 maps. Results from that study are provided for four defined incremental sub-catchment within the uMkhomazi, namely “Impendle Dam” (I-06), “Smithfield Dam” (I-22), “Ngwadini Dam” (I-19) and “Mkomazi Mouth” (I-15). The uMlaza catchment was divided into three sub-catchments, with the upper catchment represented by “Umlaas” (I-21H), representing the area upstream of flow gauging station U6H003 and comprising of quaternary catchments U60A and U60B.

The irrigated areas shown in the table above for the 1925- to 1995-development levels are based on those from the BKS study but disaggregated across quaternary catchments based on the distribution adopted for the later Ninham Shand *Pre-feasibility Study* (see below). However, since the *Pre-feasibility Study* was limited to the uMkhomazi River catchment, the areas shown for the upper uMlaza River catchment were distributed across quaternaries based on information from the Ezemvelo-KZN Wildlife (EKZNW, 2010) database (discussed later).

Ninham Shand (1999)

Shortly after the BKS study, the *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999) was undertaken for the proposed *uMkhomazi Water Project* (uMWP). The study was based on the hydrological database developed earlier by BKS, but analyses were undertaken at a quaternary catchment-level and for this purpose irrigation areas were *disaggregated* from defined incremental sub-catchments (as described earlier) into quaternary catchments. The disaggregation was based on considerations such as the topography and precipitation characteristics of the catchments in question. The results of this analysis are shown in **Table 2.16** for the 1995-development level and correspond to those of BKS for the same year. Note however that, as mentioned above, the *Pre-feasibility Study* did not include the uMlaza River catchment.

NLC (2000)

The *South African National Land Cover 2000* (NLC 2000) project database was developed by the Agricultural Research Council (ARC) Institute for Soil, Climate and Water and the CSIR, based on multi-temporal Landsat 7

Enhanced Thematic Mapper (ETM+) imagery captured during the period 2000 to 2003. Irrigation areas shown in **Table 2.16** were derived from the NLC based on areas classified in the database as "agricultural land" and assumed to be representative of the 2000-development level. It should be noted that, while areas classified as "dry-land agriculture" were not included, the NLC areas are still clearly significantly higher than those from other sources. It was assumed that that this can probably be attributed to the fact that all areas classified in the NLC as "agricultural land" are necessarily under irrigation.

WR2005

The source of the irrigation areas used in the *Water Resources of South Africa 2005 (WR2005)* study (WRC, 2009) is unknown, but appears to be largely based on data from the earlier BKS study (compare, in particular, values for quaternary catchments U10H to M).

Ezemvelo-KZN Wildlife (2010)

A detailed land cover database was developed by remote-sensing specialists GeoterraImage for Ezemvelo-KZN Wildlife (Biodiversity Research) covering the entire KwaZulu-Natal province, based on high-resolution SPOT5 Satellite multispectral imagery dated 2008 (EKZNW, 2010). The values are shown in **Table 2.16** and were derived from the EKZNW data set based on areas classified as "annual commercial crops irrigated". The EKZNW is generally considered to be reliable source of land cover information for the KZN province and is currently used by bulk water supplier Mgeni Water for planning purposes (Sithole, 2012).

WARMS (2011)

Registered irrigation areas were obtained from the DWA *Water Authorisation and Registration Management System (WARMS)* dated 2 March 2011 (Tylcoat, 2011). The values were found to compare well with those mapped for the EKZNW land cover database (discussed above) and also suggest that no growth in irrigation development has taken place within the catchment over the last few years.

Based on a comparison and evaluation of the above information, a final data set of historical irrigated areas was adopted for this study and a summary is provided in **Table 2.17** below. For referencing purposes, these values are all

shown in blue on **Figure 2.7** of **Appendix A**. Also, the spatial coverage of irrigated areas at the 2008-development level is shown in **Figure A.6** of **Appendix A**, based on *EKZNW* (2008 KZN PROVINCE LAND-COVER MAPPING (from SPOT5 Satellite imagery circa 2008), 2010).

Table 2.17: Historical irrigated areas, adopted for this study

Quaternary catchment	Total irrigated area (km^2), for indicated information source and level of development						
	BKS (1999)[1]					BKS (1999) & NS (1999)[2]	EKZNW (2010)[3]
	1925	1950	1970	1983	1989	1995	2008 to 2012
uMkhomazi River catchment							
U10A	0.00	0.73	1.31	3.27	4.53	6.50	0.00
U10B	0.00	0.68	1.23	3.07	4.25	6.10	0.00
U10C	0.00	0.46	0.83	2.09	2.89	4.15	2.70
U10D	0.00	0.59	1.05	2.63	3.65	5.23	1.80
U10E	0.00	0.00	0.00	0.00	0.00	0.00	0.25
U10F	0.00	0.00	0.00	0.00	0.00	0.00	1.35
U10G	0.00	1.18	2.13	5.33	7.39	10.58	10.07
U10H	0.00	1.53	2.75	6.88	9.55	13.67	19.83
U10J	0.00	1.69	3.04	7.60	10.54	15.09	11.80
U10K	0.00	1.21	2.19	5.47	7.59	10.87	11.41
U10L	0.00	1.03	1.85	4.63	6.42	9.20	0.92
U10M	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Sub-total:	**0.00**	**9.10**	**16.37**	**40.98**	**56.82**	**81.39**	**60.14**
Upper uMlaza River catchment							
U60A	0.08	0.46	0.64	0.85	0.94	0.94	1.28
U60B	2.26	13.60	18.84	24.98	27.54	27.54	37.63
Sub-total:	**2.34**	**14.06**	**19.48**	**25.83**	**28.48**	**28.48**	**38.91**
Total:	**2.34**	**23.16**	**35.85**	**66.81**	**85.30**	**109.87**	**99.06**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) for defined sub-catchments, distributed across quaternary catchments in the uMkhomazi River catchment based on Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999) and in the upper uMlaza based on Ezemvelo-KZN Wildlife (EKZNW, 2010).

(2) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) and subsequently used by Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999).

(3) From Ezemvelo-KZN Wildlife (EKZNW, 2010), based on indications that no growth in irrigation occurred over the 2008 to 2012 period.

b) Water sources for irrigation

As discussed in **Sub-section (a)** above, registered irrigation areas from the DWA WARMS database (Tylcoat, 2011) compared very well with those from the detailed land cover database developed for Ezemvelo-KZN Wildlife (EKZNW, 2010) and on this basis it was decided that information in WARMS on the water sources for irrigation would be used in this study for modelling purposes. The water source classification in WARMS includes "river/stream", "spring/eye", "borehole", "dam", "estuary", "wetland", "lake", "scheme", as well as "boreholes and windmills on government land".

Based on the above information and the adopted irrigation areas discussed earlier, irrigation in the uMkhomazi and upper uMlaza river catchments was classified as being either from (i) dams; (ii) run-of-river schemes; or (iii) groundwater. The results are presented in **Tables D.1** to **D.3** of **Appendix D** and a summary is provided in **Table 2.18**. Note that irrigation from groundwater (shown in grey font) constitutes a very small area and percentage of all irrigation in the study area, and was therefore not accounted for in any of the water resources modelling undertaken as part of this study.

Table 2.18: Summary of water sources used for irrigation

Total area irrigated from indicated water source(1) (km^2) (% of total in catchment)			
Dams	**Run-of-river schemes**	**Groundwater(2)**	**Total**
uMkhomazi River catchment			
23.25 (39%)	36.40 (60%)	0.50 (1%)	**60.14 (100%)**
Upper uMlaza River catchment(3)			
10.23 (26%)	26.96 (70%)	1.73 (4%)	**38.91 (100%)**
Total			
33.47 (34%)	**63.36 (64%)**	**2.23 (2%)**	**99.06 (100%)**

*Notes: (1) Based on water source classification in WARMS (Tylcoat, 2011). Values as adopted for the 2008 to 2012 period (see **Table 2.17**).*

(2) Irrigation from groundwater not accounted for in the hydrological or systems modelling undertaken in this study.

(3) Comprising of quaternary catchments U60A and U60B.

c) *Irrigated crops*

As with the sources of water for irrigation discussed above, crop information from the DWA WARMS database (Tylcoat, 2011) were used in this study for modelling purposes. These are summarised in **Table 2.19**.

Table 2.19: Irrigated crop types

Quaternary catchment	Total irrigated area under indicated crop type[(1)] (as % of total in catchment)												
	Avocados	Cabbage	Citrus	Lucerne	Macadamias	Maize	Pastures (perennial)	Potatoes	Ryegrass	Sugarcane	Vegetables (summer)	Vegetables (winter)	Totals
uMkhomazi River catchment													
U10A				5%			38%		57%				**100%**
U10B				5%			38%		57%				**100%**
U10C				5%			38%		57%				**100%**
U10D							64%		36%				**100%**
U10E								44%	56%				**100%**
U10F								44%	56%				**100%**
U10G						4%	27%		69%				**100%**
U10H							50%		50%				**100%**
U10J			4%				10%		34%	42%	5%	5%	**100%**
U10K		5%					41%		17%	13%	12%	12%	**100%**
U10L			21%			27%		52%					**100%**
U10M					17%						42%	41%	**100%**
Upper uMlaza River catchment													
U60A	50%					12%	8%				12%	18%	**100%**
U60B			7%				8%			32%	27%	26%	**100%**

Note: (1) Based on crop information from WARMS (Tylcoat, 2011).

d) *Irrigation systems and efficiencies*

The irrigation system used impacts significantly upon the irrigation application efficiency achieved and, therefore, the gross irrigation requirement for a particular irrigated field. Typical irrigation system application efficiencies from the SAPWAT model (WRC, 2009) are shown in **Table 2.20**.

Table 2.20: Typical irrigation system application efficiencies

Irrigation system	Typical application efficiency (1) (as a %)
Centre pivot	80%
Drip	95%
Flood: basin	75%
Flood: border	50%
Flood: furrow	55%
Linear	85%
Micro spray	90%
Micro sprinkler	85%
Sprinkler: big gun	70%
Sprinkler: boom	75%
Sprinkler: dragline	75%
Sprinkler: hop-along	75%
Sprinkler: permanent	85%
Sprinkler: quick-coupling	75%
Sprinkler: side roll	75%
Sprinkler: travelling boom	80%
Sprinkler: travelling gun	75%
Sprinkler: permanent (floppy)	85%
Subsurface	95%

Note: (1) From SAPWAT.

Information on the actual irrigation systems used in the uMkhomazi and upper uMlaza river catchments was obtained from the DWA WARMS database (Tylcoat, 2011) and these are summarised in **Table 2.21**. Also, the table shows combined application efficiency for each quaternary catchment (in red font), calculated based on the typical system efficiencies shown above, weighted based on the actual irrigation systems used within the catchment in question.

Table 2.21: Irrigation systems and combined catchment application efficiencies

Quaternary catchment	Total irrigated area using indicated irrigation system[1] (as % of total in catchment)													
	Centre pivot	Drip	Flood: Furrow	Micro spray	Micro sprinkler	Sprinkler: Big gun	Sprinkler: Dragline	Sprinkler: Hop-along	Sprinkler: Permanent	Sprinkler: Quick-coupling	Sprinkler: Travelling boom	Sprinkler: Travelling gun	Totals	Combined catchment application efficiency[2]
uMkhomazi River catchment														
U10A	16%						30%		55%				**100%**	**81%**
U10B	16%						30%		55%				**100%**	**81%**
U10C	16%						30%		55%				**100%**	**81%**
U10D							100%						**100%**	**75%**
U10E				1%			99%						**100%**	**75%**
U10F				1%			99%						**100%**	**75%**
U10G	4%						92%			1%		3%	**100%**	**75%**
U10H	2%			2%			91%					4%	**100%**	**75%**
U10J	4%	2%		2%		27%	51%			14%			**100%**	**75%**
U10K		1%		1%		24%	73%						**100%**	**74%**
U10L		19%	7%				25%	48%					**100%**	**77%**
U10M					17%		83%						**100%**	**77%**
Upper uMlaza River catchment														
U60A				11%	35%	9%	31%			14%			**100%**	**80%**
U60B	1%	3%			1%	2%	75%	1%	1%	17%			**100%**	**76%**

Notes: (1) Based on irrigation system information from WARMS (Tylcoat, 2011).

*(2) Representative application efficiency for the catchment, calculated based on the typical system efficiencies shown in **Table 2.20**, weighted based on the actual areas irrigated within the catchment using the systems in question.*

e) Modelled irrigation requirements

Crop evapotranspiration

Monthly crop evapotranspiration data were obtained from the SAPWAT 3 model which calculates crop evapotranspiration (or ET_C) based on selected "short grass" (Penman-Monteith) reference evaporation (or ET_0) and crop factors from the SAPWAT database.

Due to the range in planting dates and crop options that can occur for each crop, assumptions were made with regard to the settings selected in SAPWAT for modelling purposes. These assumptions are summarised in **Table 2.22**.

Table 2.22: Crop types, crop options and planting dates for SAPWAT modelling

Crop type[(1)]	Parameters adopted for SAPWAT modelling		
	Crop type	Crop option	Planting date
Avocado	Avocado	-	1 April
Cabbage	Cabbage_early	Summer plant	15 December
Citrus	Citrus	Average	1 May
Lucerne	Lucerne	Non-dormant	1 June
Macadamia	Macadamia	-	1 May
Maize	Maize-late-plant	Med variety	15 December
Pastures (perennial)	Pastures: perennial	-	1 June
Potatoes	Potato	-	1 October
Ryegrass	Ryegrass	-	15 March
Sugarcane	Sugar-annual	-	1 August
Vegetables (summer)	Vegetables-summer	-	15 October
Vegetables (winter)	Vegetables-winter	-	15 March

*Note: (1) Based on information obtained from WARMS (as shown in **Table 2.19**).*

Based on the above assumptions, monthly crop evapotranspiration values were obtained for all irrigated crop types within the uMkhomazi and upper uMlaza river catchments and the results are presented in **Tables D.4** and **D.5** of **Appendix D**.

Representative crop evapotranspiration for quaternary catchments

Evapotranspiration for individual crops were used to calculate a preliminary set of combined monthly crop evapotranspiration values for each quaternary catchment, weighted based on the irrigated area under each crop for the catchment in question. The results are summarised in **Table 2.23**.

Before the above combined monthly crop evapotranspiration data values could be used for modelling purposes, some adjustments were required in order to ensure that the Irrigation Block sub-model produced the same results as those obtained from SAPWAT. The differences in results can be attributed to a number of factors, such as the modelling time-step, rainfall data used and the fact that SAPWAT accounts for certain practical irrigation practices which relate, amongst others, to daily irrigation scheduling.

Table 2.23: Preliminary combined monthly crop evapotranspiration for quaternary catchments

Quaternary catchment	Combined crop evapotranspiration, ET_C (mm), for indicated quaternary catchment(1)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
uMkhomazi River catchment													
U10A	108	95	46	45	38	54	68	62	51	59	78	98	**803**
U10B	108	95	46	45	38	54	68	62	51	59	78	98	**803**
U10C	108	95	46	45	38	54	68	62	51	59	78	98	**803**
U10D	102	97	68	67	56	63	65	57	47	55	72	92	**842**
U10E	93	102	64	59	0	20	41	40	34	39	50	62	**604**
U10F	93	102	64	59	0	20	41	40	34	39	50	62	**604**
U10G	107	89	30	31	28	50	69	63	52	61	79	98	**758**
U10H	94	92	49	47	44	58	68	64	65	78	90	101	**847**
U10J	86	94	71	73	69	76	77	72	70	80	87	94	**950**
U10K	66	77	71	74	68	62	57	54	53	62	68	71	**783**
U10L	47	80	98	101	50	52	25	14	14	17	19	20	**537**
U10M	30	49	70	71	57	37	29	35	38	42	38	27	**522**
Upper uMlaza River catchment													
U60A	61	77	95	102	91	76	53	41	33	41	53	54	**777**
U60B	49	64	82	88	76	62	47	43	34	38	48	44	**674**

*Notes: (1) Calculated based on crop evapotranspiration data from SAPWAT (see **Tables D.4** and **D.5** of **Appendix D**), weighted based on the actual irrigated area under each crop for the catchment in question (see **Table 2.19**).*

The preliminary monthly crop evapotranspiration data values shown earlier in **Table 2.23** were adjusted by means of an iterative process. This involved modelling an irrigated field of unit area in both SAPWAT and the Irrigation Block, comparing the resulting average monthly net irrigation requirements and adjusting the evapotranspiration values in the Irrigation Blocks until the modelled monthly requirements corresponded. The final values are presented in **Table 2.24**.

Table 2.24: Final adjusted combined monthly crop evapotranspiration for quaternary catchments, as applied in the Irrigation Block sub-model

Quaternary catchment	Combined crop evapotranspiration, ET_C (mm), for indicated quaternary catchment												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
uMkhomazi River catchment													
U10A	128	123	46	45	38	54	93	86	64	76	97	121	**974**
U10B	123	117	46	45	38	54	90	85	64	76	96	118	**952**
U10C	119	113	46	45	38	54	87	84	64	76	95	117	**939**
U10D	109	107	66	58	48	39	84	79	59	69	87	107	**913**
U10E	101	119	107	94	0	20	69	60	46	53	69	86	**825**
U10F	101	117	99	87	0	19	68	60	46	54	69	87	**806**
U10G	122	110	30	31	28	50	88	86	68	80	99	122	**914**
U10H	83	85	44	77	39	73	82	77	74	92	105	115	**946**
U10J	79	86	76	99	72	96	93	87	82	95	103	108	**1 078**
U10K	63	69	57	82	53	73	70	66	63	75	82	86	**839**
U10L	42	75	79	90	53	80	48	25	22	26	32	41	**611**
U10M	54	61	68	87	42	40	43	53	50	58	55	53	**664**
Upper uMlaza River catchment													
U60A	89	123	136	150	124	106	78	62	46	58	79	84	**1 134**
U60B	68	94	112	128	101	87	69	61	44	54	70	69	**956**

Results

A summary of the modelled irrigation requirements in the uMkhomazi and upper uMlaza river catchments is presented in **Table 2.25** for current development levels. Current-development levels are representative of the period 2008 to 2012, based on indications that little growth in irrigation has occurred over that period (see **Section 3.3.2**).

Distinction is made between irrigation supplied from dams, run-of-river schemes and groundwater. However, as mentioned earlier, irrigation from groundwater (shown in grey font) constitutes a very small portion of all irrigation in the study area and was therefore not accounted for in the hydrological or systems modelling undertaken in this study. Furthermore, in cases where the total irrigated area in a quaternary catchment supplied from a specific source is less than 0.25 km^2, the associated requirement was not modelled and is not shown in the table below.

Table 2.25: Summary of modelled irrigation requirements at 2012-development levels

Quaternary catchment	Modelled irrigation requirement(1), from indicated water source							
	million m^3/a				mm/a			
	Dams	Rivers	Ground water(2)	Total	Dams	Rivers	Ground water(2)	Total
uMkhomazi River catchment								
U10A	0.00	0.00	0.00	**0.00**	-	-	-	**-**
U10B	0.00	0.00	0.00	**0.00**	-	-	-	**-**
U10C	0.47	1.23	0.00	**1.70**	628	630	-	**630**
U10D	1.12	0.00	0.00	**1.12**	621	-	-	**621**
U10E	0.00	0.00(3)	0.00	**0.00**	-	-	-	**-**
U10F	0.00(3)	0.59	0.00	**0.59**	-	499	-	**499**
U10G	2.96	3.91	0.00	**6.87**	683	682	-	**682**
U10H	5.70	6.92	0.00	**12.62**	636	637	-	**636**
U10J	1.83	6.88	0.02	**8.73**	741	740	741	**740**
U10K	2.52	3.40	0.13	**6.05**	530	531	530	**530**
U10L	0.00	0.17	0.06	**0.23**	-	246	246	**246**
U10M	0.00	0.00(3)	0.00	**0.00**	-	-	-	**-**
Sub-total:	**14.60**	**23.10**	**0.20**	**37.90**	**628**	**635**	**407**	**630**
Upper uMlaza River catchment								
U60A	0.00(3)	0.69	0.00	0.69	-	667	-	538
U60B	5.93	15.41	1.03	22.37	594	594	594	594
Sub-total:	**5.93**	**16.10**	**1.03**	**23.06**	**580**	**597**	**594**	**592**
Total:	**20.53**	**39.20**	**1.23**	**60.96**	**613**	**619**	**552**	**615**

Notes: (1) Current-development levels are representative of the period 2008 to 2012, based on indications that no growth in irrigation occurred over that period. Average based on an analysis over the 1925 to 2008 period (hydrological), at a constant development level, as described above.

(2) Irrigation from groundwater not accounted for in the hydrological or systems modelling undertaken in this study.

(3) Irrigation requirement not modelled because total irrigated area in quaternary catchment supplied from specific source is less than 0.25 km^2.

Finally, **Table 2.26** provides a comparison of the modelled irrigation requirements from this study, with those from the earlier *Mgeni River System Analysis Study* (BKS, 1999) and *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999) studies. The comparison is made based on unit water requirements (in mm), because of differences in modelled irrigation areas in the various studies. The table does indicate significant variations, but this can be attributed mainly to differences in the crop combinations, irrigation systems and modelling methodologies applied. As discussed earlier, irrigation requirements were modelled in this study using the Irrigation Block sub-model and crop

evapotranspiration based on Penman-Monteith reference evaporation (or ET_0), while the earlier studies used A-pan evaporation-based analyses.

Table 2.26: Comparison of modelled unit irrigation requirements from this and earlier studies

Quaternary catchment	Modelled irrigation requirement (mm/a)	
	BKS (1999) & NS (1999)(1)	This study(2)
uMkomazi River catchment		
U10A	631	-
U10B	631	-
U10C	629	630
U10D	629	621
U10E	-(3)	-
U10F	-	499
U10G	603	682
U10H	603	636
U10J	604	740
U10K	603	530
U10L	604	246
U10M	-	-
Sub-total:	**611**	**637**
Upper uMlaza River catchment		
U60A	608	667
U60B	608	594
Sub-total:	**608**	**596**
Total:	**610**	**621**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) and subsequently used by Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999).

(2) Average based on an analysis over the 1925 to 2008 period (hydrological), at a constant development level, as described earlier.

(3) Catchments with no modelled irrigation for the study in question.

2.4.3 Projected future (2012 – 2050) scenarios

As part of the earlier *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999) scenarios were developed of possible future irrigation in the uMkhomazi catchment. These were based on an earlier assessment undertaken in *Mgeni River System Analysis Study* (BKS, 1999) to estimate irrigation potential in the Mooi River catchment and applied by Ninham Shand in the uMkhomazi River catchment by comparing the actual location of irrigated areas, topography, MAP and the then level of irrigation development within the

catchment in question. Three alternative scenarios were developed in the *Pre-feasibility Study*, at quaternary catchment-level, namely a "High", "Medium" and "Low" scenario.

For this purpose of this study new irrigation development scenarios were developed based on the assumption that the "High"-scenario from the *Pre-feasibility Study* represents the maximum ultimate irrigation potential in the uMkhomazi River catchment. The growth rate of the old "High"-scenario was therefore adopted for the new High-scenario, but starting from a lower base equal to the actual extent of irrigation within the catchment at the 2012-development level (as discussed earlier in **Section 3.4.2 (a)**). Two further scenarios were developed, namely a Low-scenario, assuming no further growth in irrigation, and a Medium-scenario, which represents the average of the High- and Low-scenarios. In all cases, growth was assumed to occur linearly and the respective annual rates are 2.9%, 1.4% and 0.0%.

The results are summarised in **Table 2.27**, **Table 2.28** and **Table 2.29** for the High-, Medium- and Low-scenarios, respectively, and also shown in **Figure 2.8**. It should be noted that projections were not developed for future irrigation requirements in the upper uMlaza River catchment and these are therefore not shown in the tables below. More information in this regard is provided earlier in **Section 2.1**.

Table 2.27: Projected future irrigated areas (High-scenario) adopted for this study

Quaternary catchment	Total irrigated area (km^2) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.00	1.71	3.85	5.99	8.13
U10B	0.00	1.61	3.62	5.62	7.63
U10C	2.70	3.35	4.17	4.99	5.81
U10D	1.81	3.19	4.92	6.64	8.37
U10E	0.25	1.04	2.02	3.01	4.00
U10F	1.35	1.91	2.61	3.30	4.00
U10G	10.07	11.29	12.82	14.34	15.87
U10H	19.83	19.97	20.15	20.33	20.51
U10J	11.80	14.08	16.93	19.79	22.64
U10K	11.41	12.21	13.21	14.22	15.22
U10L	0.92	3.15	5.93	8.72	11.50
U10M	0.02	0.43	0.96	1.48	2.00
Total:	**60.15**	**73.94**	**91.19**	**108.43**	**125.68**

Table 2.28: Projected future irrigated areas (Medium-scenario) adopted for this study

Quaternary catchment	Total irrigated area (km^2) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.00	0.86	1.93	3.00	4.07
U10B	0.00	0.80	1.81	2.81	3.82
U10C	2.70	3.03	3.44	3.85	4.25
U10D	1.81	2.50	3.36	4.22	5.09
U10E	0.25	0.64	1.13	1.63	2.12
U10F	1.35	1.63	1.98	2.33	2.68
U10G	10.07	10.68	11.44	12.21	12.97
U10H	19.83	19.90	19.99	20.08	20.17
U10J	11.80	12.94	14.36	15.79	17.22
U10K	11.41	11.81	12.31	12.81	13.32
U10L	0.92	2.04	3.43	4.82	6.21
U10M	0.02	0.22	0.49	0.75	1.01
Total:	**60.15**	**67.05**	**75.67**	**84.29**	**92.91**

Table 2.29: Projected future irrigated areas (Low-scenario) adopted for this study

Quaternary catchment	Total irrigated area (km^2) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.00	0.00	0.00	0.00	0.00
U10B	0.00	0.00	0.00	0.00	0.00
U10C	2.70	2.70	2.70	2.70	2.70
U10D	1.81	1.81	1.81	1.81	1.81
U10E	0.25	0.25	0.25	0.25	0.25
U10F	1.35	1.35	1.35	1.35	1.35
U10G	10.07	10.07	10.07	10.07	10.07
U10H	19.83	19.83	19.83	19.83	19.83
U10J	11.80	11.80	11.80	11.80	11.80
U10K	11.41	11.41	11.41	11.41	11.41
U10L	0.92	0.92	0.92	0.92	0.92
U10M	0.02	0.02	0.02	0.02	0.02
Total:	**60.15**	**60.15**	**60.15**	**60.15**	**60.15**

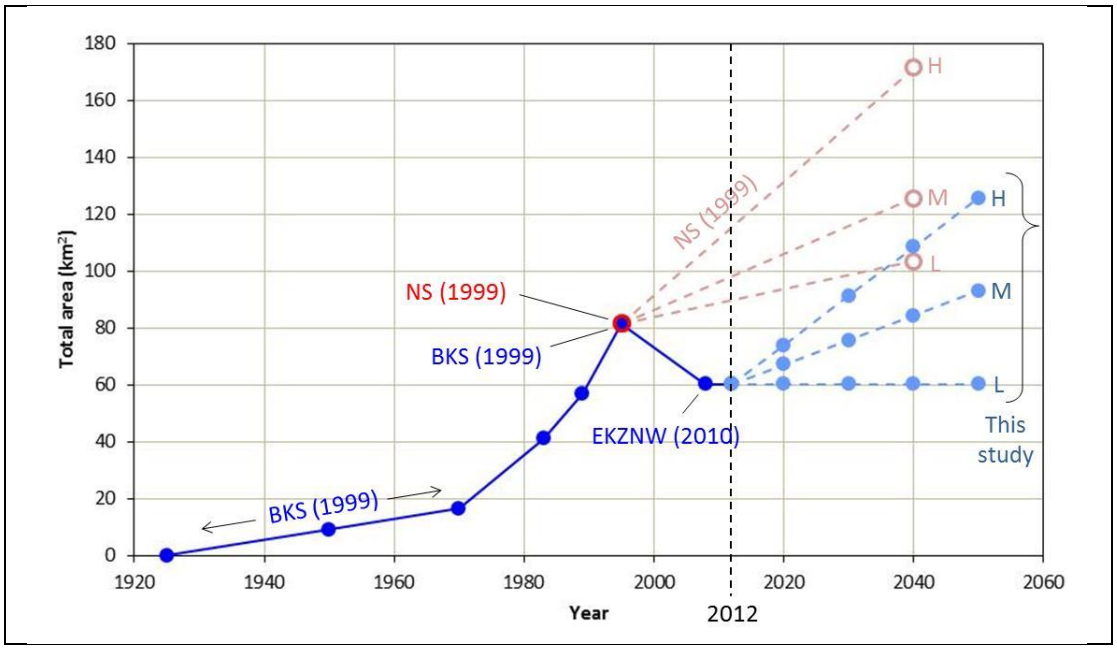

Figure 2.8: Projected future irrigated areas

Ultimately, the Medium-scenario described above was adopted as the most representative of the probable future situation and used in this study for planning purposes. This was based on a number of considerations including the following:

- The High-scenario assumes significant growth in irrigation in the upper four quaternary catchments in the uMkhomazi – a situation which will probably not

be allowed by DWA subsequent to the commissioning of the proposed downstream Smithfield Dam. Furthermore, the upper catchments are relatively remote and inaccessible, further suggesting that significant irrigation development in these areas is unlikely.

- **Figure 2.8** shows that the extent of irrigation development within the catchment has decreased significantly over the past 15 years, a phenomenon which can be attributed to factors such as the impact of economically unfavourable conditions and continuing land claims processes (Dlamini, 2012). The new High-scenario is clearly not in line with these recent developments suggesting that the Medium- (or even the Low-) scenario may be more representative of the long-term trend.

The modelled future irrigation requirements in the uMkhomazi River catchment for the Medium-scenario are presented in **Table 2.30**. It should be noted that, for all quaternary catchments, it was assumed that the current proportion of irrigated areas supplied from various sources (i.e. from dams, run-of-river schemes or groundwater), irrigated crops and irrigation systems (as discussed in earlier sub-sections) would remain unchanged over the projection period. Furthermore, as mentioned earlier, projections were not developed for the upper uMlaza River catchment and these are therefore not shown in the table below.

Table 2.30: Modelled future irrigated requirements (Medium-scenario)

Quaternary catchment	Modelled irrigation requirement (million m^3/a), for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.00	0.53	1.19	1.85	2.52
U10B	0.00	0.50	1.13	1.75	2.38
U10C	1.70	1.91	2.16	2.42	2.68
U10D	1.12	1.54	2.07	2.61	3.14
U10E	0.00	0.35	0.62	0.88	1.15
U10F	0.59	0.72	1.00	1.18	1.36
U10G	6.87	7.29	7.81	8.34	8.86
U10H	12.62	12.67	12.73	12.78	12.84
U10J	8.73	9.57	10.63	11.69	12.74
U10K	6.05	6.26	6.52	6.79	7.05
U10L	0.23	0.49	0.83	1.17	1.51
U10M	0.00	0.07	0.15	0.23	0.31
Total:	**37.90**	**41.90**	**46.85**	**51.69**	**56.54**

Finally, during the course of this study the possibility was proposed of providing water directly from the proposed Smithfield Dam for new irrigation developments in the vicinity of the dam basin. However, no formal investigation into the irrigation potential in this area or the financial viability of the proposed developments was undertaken as part of in this study. Instead, it was assumed that the projected irrigation growth in the associated quaternary catchment, U10F, from 1.35 to 2.68 km^2 (i.e. growth of 133 ha as shown earlier in **Table 2.28** for the Medium-scenario) is adequate to account for these proposed developments.

2.5 STOCK WATERING

2.5.1 Overview

Livestock farming has been one of the most important agricultural activities in the southern and central KwaZulu-Natal region for over 100 years and it is estimated that currently almost 3 million m^3 is used annually for stock watering in the uMkhomazi and upper uMlaza river catchments. More information in this regard is provided in the following sub-sections.

2.5.2 Historical and current (1925 – 2012)

a) Stock units

Livestock numbers in the uMkhomazi and upper uMlaza river catchments were estimated based on information from a livestock census undertaken by the then *National Department of Agriculture, Directorate: Veterinary Services, dated December 2004*. The census was undertaken on a district-basis and equivalent catchment-based numbers were derived by correlating district and catchment boundaries and allocating livestock numbers to the catchments in question. This approach was considered to be acceptable since, although extensive livestock farming is practised particularly in the uMkhomazi catchment, the overall impact on the water resources of the study area is fairly small. The results are presented in **Table 2.31** and include both the "commercial" and "communal" livestock classifications reported on in the census publication (NDA, 2004).

Table 2.31: Livestock numbers based on the 2004-livestock census

Quaternary catchment	Associated census district/s	Total estimated number of livestock in 2004							
		Cattle	Horses	Donkey	Mules	Goats	Sheep	Pigs	Total
uMkhomazi River catchment									
U10A	Mpendle	13 211	389	16	4	2 836	1 943	194	**18 592**
U10B	Mpendle	3 717	109	4	1	798	547	55	**5 231**
U10C	Mpendle	844	25	1	0	181	124	12	**1 188**
U10D	Mpendle	10 651	313	13	3	2 287	1 566	157	**14 989**
U10E	Polela	7 718	332	91	8	3 568	830	116	**12 664**
U10F	Polela	8 945	385	106	10	4 136	962	135	**14 678**
U10G	Mpendle, Polela	9 744	343	56	6	3 124	1 268	145	**14 686**
U10H	Polela, Richmond	7 389	306	89	7	3 154	768	378	**12 092**
U10J	Polela, Ixopo, Richmond	11 092	258	64	6	2 569	789	438	**15 216**
U10K	Ixopo	15 666	179	18	4	1 790	783	179	**18 620**
U10L	Ixopo, Richmond	7 364	98	18	2	885	390	311	**9 067**
U10M	-	0	0	0	0	0	0	0	**0**
Sub-total:		**96 340**	**2 737**	**475**	**51**	**25 329**	**9 970**	**2 120**	**137 021**
Upper uMlaza River catchment									
U60A	Richmond	518	15	7	0	89	41	161	**831**
U60B	Richmond	935	28	13	0	160	74	291	**1 501**
Sub-total:		**1 453**	**43**	**20**	**0**	**249**	**114**	**451**	**2 332**
Total:		**97 793**	**2 780**	**495**	**51**	**25 578**	**10 084**	**2 571**	**139 353**

Note: Based on district-based livestock census by the NDA (Livestock Figures for South Africa as Supplied by the State Veterinarians of the Directorate of Veterinary Services, 2004).

Table 2.32 provides a summary of the above census data in terms of *stock units*. Stock units are used as a basis of estimating typical livestock water consumption by differentiating between *large stock units* (LSUs), which include predominantly cattle, and *small stock units* (SSUs), which include mainly goats and sheep.

Table 2.32: Stock unit numbers adopted for this study

Quaternary catchment	Total estimated number of stock units in 2004[1]		
	LSUs[2]	SSUs[3]	Totals
uMkhomazi River catchment			
U10A	13 619	4 973	**18 592**
U10B	3 831	1 399	**5 231**
U10C	870	318	**1 188**
U10D	10 980	4 010	**14 989**
U10E	8 149	4 514	**12 664**
U10F	9 445	5 232	**14 678**
U10G	10 149	4 537	**14 686**
U10H	7 792	4 301	**12 092**
U10J	11 420	3 796	**15 216**
U10K	15 867	2 753	**18 620**
U10L	7 482	1 585	**9 067**
U10M	0	0	**0**
Sub-total:	**99 603**	**37 418**	**137 021**
Upper uMlaza River catchment			
U60A	541	290	**831**
U60B	976	524	**1 501**
Sub-total:	**1 517**	**815**	**2 332**
Total:	**101 120**	**38 233**	**139 353**

Notes: (1) Based on livestock census by NDA (Livestock Figures for South Africa as Supplied by the State Veterinarians of the Directorate of Veterinary Services, 2004).

(2) Large stock units, which includes predominantly cattle.

(3) Small stock units, which includes mainly goats and sheep.

b) Historical growth

Little information is available on the historical growth in livestock farming in the study area. For this purpose, therefore, it was assumed that growth in the number of livestock units was similar to the pattern assumed for the adjacent Mzimkhulu River catchment in the earlier *Southern KwaZulu-Natal Water Resources Pre-feasibility Study (SKZN-WRPFS)* (WRP and GMA, 2011). This pattern was based on information from the then Department of Agriculture and Environmental Affairs at Cedara (Dugmore, 2000) and a summary is provided in **Table 2.33**. The table shows the assumed number of livestock units as a portion of the total number in 1999 and it is interesting to note that, according to these numbers, there had been no increase over the 40-year period from 1960 to 1999. Furthermore, considering the fact that there has been very little growth in irrigation in the uMkhomazi and upper uMlaza river catchments over the last 15 years, and also that the majority of irrigation is

used for watering pastures, it was assumed that this trend has persisted to the current day.

Table 2.33: Assumed historical growth pattern for stock unit numbers

Number of stock units (as a % of the number in 1999)			
1925	**1960**	**1999**	**2012**
65%	100%	100%	100%

Note: Based on information from (WRP & GMA, Southern KwaZulu-Natal Water Resources Pre-feasibility Study. Supporting Report No. 1 – Abstractions, 2011).

c) *Water use by livestock*

An estimate of the daily water consumption by livestock was based on information applied in the earlier *SKZN-WRPFS study* based on the recommendation by the then Department of Agriculture and Environmental Affairs at Cedara. These are provided in **Table 2.34**.

Table 2.34: Daily water consumption by stock units adopted for this study

Season	Water consumption (ℓ/d) per indicated stock unit(1)	
	LSUs	**SSUs**
Summer	90	20
Winter	45	10

Note: Based on information from WRP and GMA (Southern KwaZulu-Natal Water Resources Pre-feasibility Study. Supporting Report No. 1 – Abstractions, 2011).

Finally, the water use by livestock in the uMkhomazi and upper uMlaza river catchments was calculated based on the above information and assumptions and the results are presented in **Table 2.35** for current (2012) development levels.

Table 2.35: Summary of water use by livestock at 2012-development levels

Quaternary catchment	Total water use[1] (million m^3/a)		
	LSUs[2]	SSUs[3]	Totals
uMkhomazi River catchment			
U10A	0.34	0.03	**0.36**
U10B	0.09	0.01	**0.10**
U10C	0.02	0.00	**0.02**
U10D	0.27	0.02	**0.29**
U10E	0.20	0.02	**0.23**
U10F	0.23	0.03	**0.26**
U10G	0.25	0.02	**0.27**
U10H	0.19	0.02	**0.22**
U10J	0.28	0.02	**0.30**
U10K	0.39	0.02	**0.41**
U10L	0.18	0.01	**0.19**
U10M	0.00	0.00	**0.00**
Sub-total:	**2.45**	**0.20**	**2.66**
Upper uMlaza River catchment			
U60A	0.01	0.00	0.01
U60B	0.02	0.00	0.03
Sub-total:	**0.04**	**0.00**	**0.04**
Total:	**2.49**	**0.21**	**2.70**

Notes: (1) Based on the 2004-livestock census (NDA, 2004).
(2) Large stock units, which includes predominantly cattle.
(3) Small stock units, which includes mainly goats and sheep.

2.5.3 Projected future (2012 – 2050) scenarios

As the majority of irrigation areas in the uMkhomazi catchment is linked to the dairy industry (the two predominant irrigated crops are pasture and rye grass), it was assumed that the growth in livestock would follow that of irrigation (as discussed earlier in **Section 3.4.3**). Based on this assumption, two scenarios were developed namely a High- and Low-scenario and the results are presented in **Figure 2.9**. The figure also shows an initial Medium-scenario (shown in grey), which was calculated as the average of the High- and Low-scenarios. However, a Revised Medium-scenario was later developed (shown in blue) based on the historical trend in livestock growth over the period 1920 to 1999, since the historical trend clearly suggested that the initial scenario was too high.

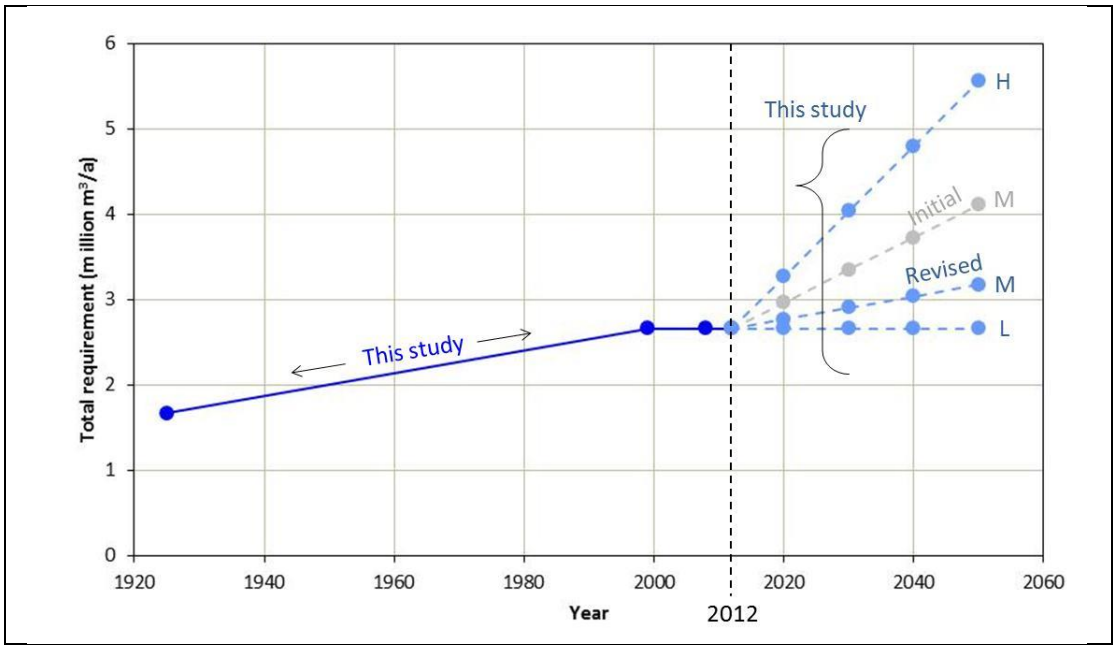

Figure 2.9: Projected future livestock water requirements

Results for the High-, Revised Medium- and Low-scenarios are summarised in **Table 2.36**, **Table 2.37** and **Table 2.38**, respectively. The Revised Medium-scenario was ultimately adopted as the most representative of the probable future situation and used in this study for planning purposes. Linear growth was assumed in all cases. It should be noted that projections were not developed for the future water use by livestock in the upper uMlaza River catchment and these are therefore not shown in the tables below. More information in this regard is provided earlier in **Section 2.1**.

Table 2.36: Projected future livestock water requirements (High-scenario)

Quaternary catchment	Total water requirement (million m^3/a) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.36	0.45	0.55	0.65	0.76
U10B	0.10	0.13	0.15	0.18	0.21
U10C	0.02	0.03	0.04	0.04	0.05
U10D	0.29	0.36	0.44	0.53	0.61
U10E	0.23	0.28	0.34	0.41	0.47
U10F	0.26	0.32	0.40	0.47	0.55
U10G	0.27	0.34	0.42	0.50	0.57
U10H	0.22	0.26	0.33	0.39	0.45
U10J	0.30	0.37	0.46	0.54	0.63
U10K	0.41	0.50	0.62	0.73	0.85
U10L	0.19	0.24	0.29	0.35	0.40
U10M	0.00	0.00	0.00	0.00	0.00
Total:	2.66	3.27	4.03	4.79	5.56

Table 2.37: Projected future livestock water requirements (Revised Medium-scenario)

Quaternary catchment	Total water requirement (million m^3/a) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.36	0.38	0.40	0.41	0.43
U10B	0.10	0.11	0.11	0.12	0.12
U10C	0.02	0.02	0.03	0.03	0.03
U10D	0.29	0.30	0.32	0.33	0.35
U10E	0.23	0.23	0.25	0.26	0.27
U10F	0.26	0.27	0.29	0.30	0.31
U10G	0.27	0.29	0.30	0.31	0.33
U10H	0.22	0.22	0.24	0.25	0.26
U10J	0.30	0.31	0.33	0.34	0.36
U10K	0.41	0.42	0.44	0.46	0.48
U10L	0.19	0.20	0.21	0.22	0.23
U10M	0.00	0.00	0.00	0.00	0.00
Total:	2.66	2.77	2.90	3.04	3.17

Note: Revised Medium-scenario based on the historical trend in livestock growth over the period 1920 to 1999.

Table 2.38: Projected future livestock water requirements (Low-scenario)

Quaternary catchment	Total water requirement (million m^3/a) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.36	0.36	0.36	0.36	0.36
U10B	0.10	0.10	0.10	0.10	0.10
U10C	0.02	0.02	0.02	0.02	0.02
U10D	0.29	0.29	0.29	0.29	0.29
U10E	0.23	0.23	0.23	0.23	0.23
U10F	0.26	0.26	0.26	0.26	0.26
U10G	0.27	0.27	0.27	0.27	0.27
U10H	0.22	0.22	0.22	0.22	0.22
U10J	0.30	0.30	0.30	0.30	0.30
U10K	0.41	0.41	0.41	0.41	0.41
U10L	0.19	0.19	0.19	0.19	0.19
U10M	0.00	0.00	0.00	0.00	0.00
Total:	2.66	2.66	2.66	2.66	2.66

2.6 STREAM FLOW REDUCTIONS

2.6.1 Commercial forestry

a) Overview

Commercial forestry is currently the largest water user sector in the study area. Plantations, including pine, eucalyptus and wattle species, occur mainly in the central areas of the uMkhomazi River catchment, particularly in quaternary catchments U10E to U10K around the towns of Richmond, Ixopo, Bulwer and Impendle. The total area under commercial forestry in the uMkhomazi and upper uMlaza river catchments is estimated at almost 700 km^2, with an associated water use of almost 70 million m^3/a – 35% of all current in-catchment water use.

The historical and current reduction in runoff due to commercial forestry was estimated based on afforested areas, species and location and modelled using the Stream Flow Reduction (SFR) sub-model feature in the WRSM2000 rainfall-runoff model. More information in this regard is provided in the following sub-sections.

b) *Historical and current (1925 – 2012)*

Areas under commercial forestry

Information on the areas under commercial forestry in the uMkhomazi and upper uMlaza river catchments was obtained from a wide variety of sources which were assessed, compared and evaluated in order to obtain the most reliable available data set which covers a historical period of 88 years from 1925 to 2012. A summary of available historical data is presented in **Table 2.39** and also in **Figure 2.10** (the latter for the uMkhomazi catchment only). More information on the various data sources is provided thereafter.

Table 2.39: Available historical data on commercial forestry, based on various sources

Quaternary catchment	Total area under commercial forestry (km^2), for indicated data source and level of development											
	BKS (1999)[1]						UW (1999) [2]	NS (1999) [3]	NLC (2000) [4]	WR-2005 [5]	EKZNW (2010) [6]	WARMS (2012) [7]
	1925	1960	1970	1980	1989	1995			2000	2004	2008	2011
uMkhomazi River catchment												
U10A	0.00	0.05	0.92	2.33	6.31	6.31	2.35	2.35	1.84	0.00	4.73	2.46
U10B	0.00	0.22	4.43	11.26	30.55	30.55	8.74	8.68	9.97	0.00	22.89	15.33
U10C	0.00	0.20	4.04	10.25	27.82	27.82	38.86	39.02	11.28	0.00	20.84	19.40
U10D	0.00	0.03	0.61	1.55	4.22	4.22	15.53	15.26	5.19	0.80	3.16	1.25
U10E	0.00	0.28	6.10	15.70	41.89	42.45	40.76	41.59	34.02	26.00	35.79	27.82
U10F	0.00	0.42	9.30	23.90	63.81	64.65	69.31	71.42	42.28	24.20	54.51	44.96
U10G	4.42	6.77	9.37	20.88	50.49	53.58	62.87	80.71	61.80	26.20	56.69	51.43
U10H	11.72	17.97	24.86	55.38	133.95	142.14	138.25	155.63	139.12	112.50	150.38	131.96
U10J	11.14	17.09	23.64	52.67	127.39	135.18	134.37	153.07	131.77	99.60	143.01	120.46
U10K	7.23	11.08	15.33	34.15	82.60	87.65	76.90	97.21	79.38	62.80	92.73	70.74
U10L	1.42	2.18	3.02	6.72	16.27	17.26	9.82	27.79	15.85	12.50	18.26	14.90
U10M	0.11	0.17	0.24	0.54	1.30	1.38	0.24	18.92	0.62	0.00	1.46	0.53
Sub-total:	**36.04**	**56.46**	**101.87**	**235.33**	**586.60**	**613.18**	**598.00**	**711.65**	**533.12**	**364.60**	**604.44**	**501.24**
Upper uMlaza River catchment												
U60A	14.40	21.40	22.73	29.84	34.63	34.63	-[8]	-[8]	35.04	47.50	43.32	41.78
U60B	17.10	25.41	26.99	35.43	41.12	41.12	-[8]	-[8]	33.05	48.30	51.44	56.85
Sub-total:	**31.50**	**46.80**	**49.72**	**65.27**	**75.75**	**75.75**	-[8]	-[8]	**68.09**	**95.80**	**94.76**	**98.63**
Total:	**67.54**	**103.26**	**151.58**	**300.61**	**662.35**	**688.93**	-	-	**601.21**	**460.40**	**699.20**	**599.87**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) for defined sub-catchments, distributed across quaternary catchments based on Ezemvelo-KZN Wildlife (EKZNW, 2010).
(2) From Mgeni Water, as reported in Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999).
(3) From Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999) and includes both commercial forestry and dry-land sugarcane.
(4) From the South African National Land Cover 2000 (NLC 2000) project.

(5) From WR2005 (WRC, 2009).
(6) From Ezemvelo-KZN Wildlife (EKZNW, 2010).
(7) From the WARMS database (Tylcoat, 2011).
(8) Area not included in the Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999) study.

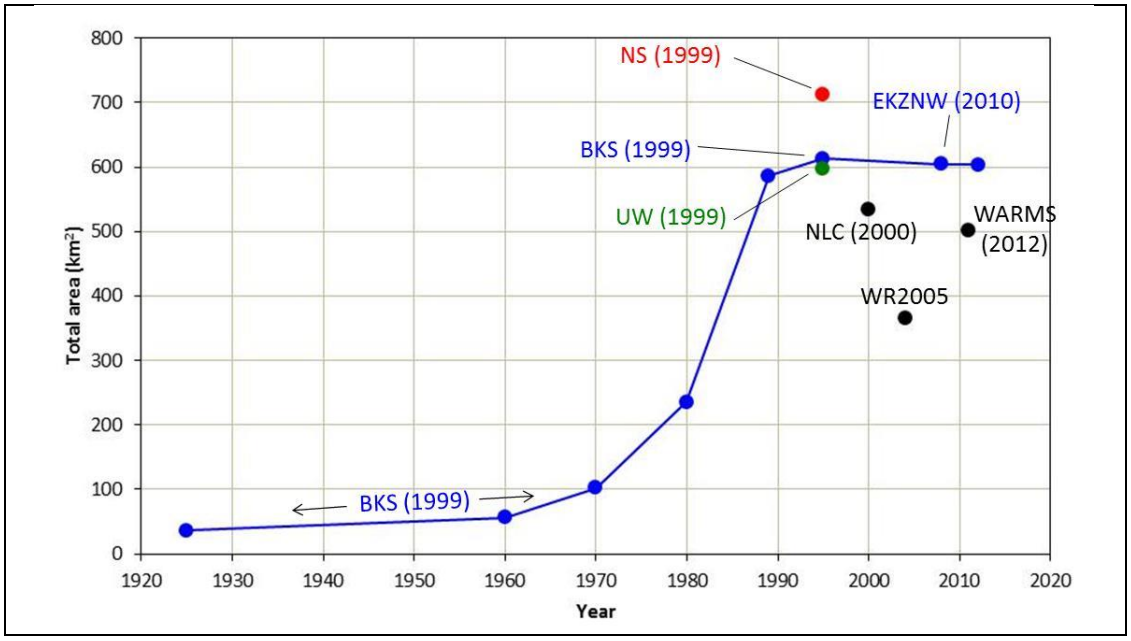

Figure 2.10: Available historical data on commercial forestry, based on various sources

BKS (1999)

Historical commercial forestry areas in the study area were determined for the earlier *Mkomazi/Mgeni/Mooi River Hydrology Update study* (BKS, 1999) from 1:30 000 aerial photography and 1:50 000 maps. Results from that study are provided for four defined incremental sub-catchments within the uMkhomazi River catchment, namely “Impendle Dam” (I-06), “Smithfield Dam” (I-22), “Ngwadini Dam” (I-19) and “Mkomazi Mouth” (I-15). The uMlaza catchment was divided into three sub-catchments, with the upper catchment represented by “Umlaas” (I-21H), representing the area upstream of flow gauging station U6H003 and comprising of quaternary catchments U60A and U60B. The areas shown in the table above for the 1925- to 1995-development levels are based on those from the BKS study but disaggregated into quaternary catchments based on the percentage distribution of the *Ezemvelo-KZN Wildlife* (EKZNW, 2010) database (discussed later).

Mgeni Water (1999)

As part of a later *Pre-feasibility Study* (discussed below), Ninham Shand listed areas under commercial forestry in the uMkhomazi River catchment that had been obtained from Mgeni Water and which was mapped using aerial photographs. The Mgeni Water areas compare well with those from the *Mgeni River System Analysis Study (*BKS, 1999).

Ninham Shand (1999)

Shortly after the BKS study the *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999) was undertaken which was based, largely, on the hydrological and land use databases developed by BKS for the uMkhomazi River catchment. As such, the study adopted areas under commercial forestry from the BKS study, but combined these with dry-land sugarcane areas for modelling purposes. The result is that the *Pre-feasibility Study* values shown in **Table 2.39** are much higher than those from other sources, However, if the dry-land sugarcane areas from the BKS study (as discussed later in **Section 3.6.2**) are subtracted from the *Pre-feasibility Study* values shown in **Table 2.39** the resulting area under commercial forestry for the uMkhomazi River catchment is 613 km^2, which corresponds exactly with the BKS value for the 1995 development level.

NLC (2000)

The *South African National Land Cover 2000* (NLC 2000) project is an update of the NLC '94 mentioned above and areas under commercial forestry were estimated based on multi-temporal Landsat 7 Enhanced Thematic Mapper (ETM+) imagery captured during the period 2000 to 2003. The results are significantly lower than those from the *Mgeni River System Analysis Study (*BKS, 1999), Mgeni Water and the *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999).

WR2005

The source of the commercial forestry areas used in the *Water Resources of South Africa 2005 (WR2005) study* (WRC, 2009) is unknown. The values do not correspond well to those from any other sources over the 1995 to 2011 period and are significantly lower in all quaternary catchments.

Ezemvelo-KZN Wildlife (2010)

A detailed land cover database was developed by remote-sensing specialists GeoterraImage for Ezemvelo-KZN Wildlife (Biodiversity Research) covering the entire KwaZulu-Natal province, based on high-resolution SPOT5 Satellite multispectral imagery dated 2008 (EKZNW, 2010). The values shown in **Table 2.39** were derived by combining areas classified as "plantation" and "plantation clear-felled". The EKZNW database is generally considered to be a reliable source of land cover information and is currently used by bulk water supplier Mgeni Water for planning purposes (Sithole, 2012). The total area of 604 km^2 for the uMkhomazi River catchment also compares well with those from the BKS, Mgeni Water and Ninham Shand studies, suggesting that little or no growth in forestry development has taken place within the catchment over the last 15 years. Results for the upper uMlaza River catchment, however, suggest that some growth in commercial forestry has occurred in that catchment.

WARMS (2011)

Registered commercial forestry areas were obtained from the DWA *Water Authorisation and Registration Management System* (WARMS) dated 2 March 2011 (Tylcoat, 2011). The values were found to be somewhat lower than those from other sources and this may indicate that some of the afforested areas in the catchment are not registered.

Based on a comparison and evaluation of the above information, a final data set of historical areas under commercial forestry was adopted for this study and a summary is provided in **Table 2.40** below. For referencing purposes, these values are all shown in blue on **Figure 2.10**. Also, the spatial coverage of afforested areas at the 2008-development level is shown in **Figure A.7** of **Appendix A**, from *EKZNW* (2008 KZN PROVINCE LAND-COVER MAPPING (from SPOT5 Satellite imagery circa 2008), 2010).

Table 2.40: Historical areas under commercial forestry adopted for this study

Quaternary catchment	Total afforested area (km^2), for indicated data source and level of development						
	BKS (1999)(1)						EKZNW (2010)(2)
	1925	1960	1970	1980	1989	1995	2008 to 2012
uMkhomazi River catchment							
U10A	0.00	0.05	0.92	2.33	6.31	6.31	4.73
U10B	0.00	0.22	4.43	11.26	30.55	30.55	22.89
U10C	0.00	0.20	4.04	10.25	27.82	27.82	20.84
U10D	0.00	0.03	0.61	1.55	4.22	4.22	3.16
U10E	0.00	0.28	6.10	15.70	41.89	42.45	35.79
U10F	0.00	0.42	9.30	23.90	63.81	64.65	54.51
U10G	4.42	6.77	9.37	20.88	50.49	53.58	56.69
U10H	11.72	17.97	24.86	55.38	133.95	142.14	150.38
U10J	11.14	17.09	23.64	52.67	127.39	135.18	143.01
U10K	7.23	11.08	15.33	34.15	82.60	87.65	92.73
U10L	1.42	2.18	3.02	6.72	16.27	17.26	18.26
U10M	0.11	0.17	0.24	0.54	1.30	1.38	1.46
Sub-total:	**36.04**	**56.46**	**101.87**	**235.33**	**586.60**	**613.18**	**604.44**
Upper uMlaza River catchment							
U60A	14.40	21.40	22.73	29.84	34.63	34.63	43.32
U60B	17.10	25.41	26.99	35.43	41.12	41.12	51.44
Sub-total:	**31.50**	**46.80**	**49.72**	**65.27**	**75.75**	**75.75**	**94.76**
Total:	**67.54**	**103.26**	**151.58**	**300.61**	**662.35**	**688.93**	**699.20**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) for defined sub-catchments, distributed across quaternary catchments based on Ezemvelo-KZN Wildlife (EKZNW, 2010).

(2) From Ezemvelo-KZN Wildlife (EKZNW, 2010), based on indications that little growth in commercial forestry occurred in the study area over the 2008 to 2012 period.

Species of commercial forestry

Information on the cultivated species of commercial forestry in the uMkhomazi and upper uMlaza river catchments was obtained from the *NLC 2000 database*. These are summarised in **Table 2.41**.

Table 2.41: Species of commercial forestry

Quaternary catchment	Total afforested area for indicated species[1] (as % of total in catchment)			
	Eucalyptus	Pine	Wattle	Total
uMkhomazi River catchment				
U10A	97%	0%	3%	**100%**
U10B	94%	6%	0%	**100%**
U10C	56%	8%	37%	**100%**
U10D	17%	4%	80%	**100%**
U10E	25%	51%	24%	**100%**
U10F	28%	64%	9%	**100%**
U10G	45%	35%	20%	**100%**
U10H	42%	38%	19%	**100%**
U10J	70%	11%	18%	**100%**
U10K	66%	13%	20%	**100%**
U10L	88%	0%	12%	**100%**
U10M	44%	0%	56%	**100%**
Sub-total:	**55%**	**27%**	**19%**	**100%**
Upper uMlaza River catchment				
U60A	57%	4%	39%	**100%**
U60B	63%	0%	37%	**100%**
Sub-total:	**60%**	**2%**	**38%**	**100%**
Total:	**55%**	**23%**	**21%**	**100%**

Note: (1) From the South African National Land Cover 2000 (NLC 2000) project.

Modelled water use by commercial forestry

The impact of commercial forestry on runoff was modelled using the *Smoothed Gush/Pitman*-option in the WRSM2000 Stream Flow Reduction (SFR) sub-model. This modelling approach is commonly used for detailed water resources and hydrological assessments and is based on runoff reduction estimates made using the ACRU model as part of a research project undertaken by Gush et. al. (2002). The Gush estimates are generally accepted to be an improvement on those from earlier studies such as those undertaken by the CSIR and others, based on the following considerations:

- The aim of the Gush Study was to improve upon the CSIR estimates, particularly with respect to catchments with “lower” rainfall areas.
- The results from the Gush Study have been extensively discussed with the forestry industry and representatives of the industry were involved in the definition of the parameters used in the ACRU modelling.

A summary of the modelled water use by commercial forestry in the uMkhomazi and upper uMlaza river catchments is shown in **Table 2.42**, representative of current development levels. Current development levels are representative of the period 2008 to 2012, based on indications that little growth in forestry has occurred over that period, as discussed earlier.

Table 2.42: Summary of modelled water use by commercial forestry at 2012-development levels

Quaternary catchment	Total afforested area (km^2)	Modelled water use by commercial forestry[(1);(2)]	
		million m^3/a	mm/a
uMkhomazi River catchment			
U10A	4.73	0.88	186
U10B	22.89	4.26	186
U10C	20.84	3.29	158
U10D	3.16	0.42	132
U10E	35.79	4.82	135
U10F	54.51	4.70	86
U10G	56.69	5.55	98
U10H	150.38	14.35	95
U10J	143.01	13.35	93
U10K	92.73	6.74	73
U10L	18.26	1.24	68
U10M	1.46	0.12	81
Sub-total:	**604.44**	**59.71**	**99**
Upper uMlaza River catchment			
U60A	43.32	4.75	110
U60B	51.44	3.77	73
Sub-totals	**94.76**	**8.52**	**90**
Totals	**699.20**	**68.23**	**98**

Notes: (1) Current-development levels are representative of the period 2008 to 2012, based on indications that little growth in forestry occurred in the study area over that period.

(2) Average based on an analysis over the 1925 to 2008 period (hydrological), at a constant development level, as described above.

Finally, **Table 2.43** provides a comparison of the modelled water use by commercial forestry from this study, with those from the earlier *Mgeni River System Analysis Study* (BKS, 1999) and *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999) studies. The comparison is made based on unit water use (in mm), because of differences in modelled afforested areas in the various studies. The table does indicate some variation, but this can be attributed mainly to the fact that the Gush runoff

reduction estimates were used in this study (as discussed earlier), while the other studies applied estimates obtained from the earlier CSIR research.

Table 2.43: Comparison of modelled water use by commercial forestry from this study and earlier studies

Quaternary catchment	Modelled water use by commercial forestry (mm/a)		
	BKS (1999)[1]	NS (1999)[2]	This study[3]
uMkhomazi River catchment			
U10A	180	179	186
U10B	180	180	186
U10C	180	180	158
U10D	180	180	132
U10E	117	122	135
U10F	117	115	86
U10G	62	62	98
U10H	62	62	95
U10J	62	62	93
U10K	62	62	73
U10L	62	62	68
U10M	55	50	81
Sub-total:	**85**	**81**	**99**
Upper uMlaza River catchment[4]			
U60A	28	-	110
U60B	28	-	73
Sub-total:	**28**	**-**	**90**
Total:	**78**	-	**98**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) for defined sub-catchments, distributed across quaternary catchments based on Ezemvelo-KZN Wildlife (EKZNW, 2010).

(2) From Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999), includes dry-land sugarcane.

(3) Average based on an analysis over the 1925 to 2008 period (hydrological), at a constant development level, as described earlier.

(4) Area not included in the Ninham Shand (Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999) study.

c) Projected future (2012 – 2050) scenarios

Scenarios of projected future areas under commercial forestry in the uMkhomazi River catchment were developed based on a general guideline adopted by the DWA Regional Office in Durban which limits the extent to approximately 20% of the quaternary catchment in question (Ward, Forestry

Potential in the uMkhomazi River Catchment, 2013). This guideline is applied to ensure that the percentage reduction in base flow runoff from a catchment does not exceed a prescribed level. It was found, however, that based on the EKZNW coverage (discussed earlier in **Section 3.6.1 (a)**) the limit had already been exceeded in a number of catchments, most notably U10H, U10J and U10K.

Within the above context, a High-scenario was developed based on the assumption that areas would increase in all quaternary catchments up to the limit, or remain at the current level where the limit has already been exceeded. Furthermore, it was assumed that growth would occur at a similar rate to that of the "High"-scenario developed for the earlier *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999). The Medium-scenario is similar to the High-scenario, with the exception that it was assumed that (i) no further development would occur within the Ukhahlamba-Drakensberg National Park and that, therefore, growth up to the 20% limit would occur only within the portions of U10A, U10B, U10C and U10D that lie outside of protected areas; and (ii) no further growth would occur in U10M as species planted in the region are not well adapted to the semi-tropical coastal climate (SAPPI-SAICCOR, 2012). Finally, the Low-scenario was based on the assumption of no further growth in commercial forestry.

The resulting projections are summarised in **Table 2.44**, **Table 2.45** and **Table 2.46** for the High-, Medium- and Low-scenarios, respectively, and also shown in **Figure 2.11**. The latter also shows scenarios developed as part of the earlier study by the *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999) for comparative purposes. It should be noted that projections were not developed for future water use by commercial forestry in the upper uMlaza River catchment and these are therefore not shown in the tables below. More information in this regard is provided earlier in **Section 2.1**. Furthermore, it was assumed that the current proportion of areas under various species of trees (as discussed in earlier sub-sections) would remain unchanged over the projection period for all quaternary catchments in the uMkhomazi River catchment.

Table 2.44: Projected future afforested areas (High-scenario)

Quaternary catchment	Total afforested area (km^2) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	4.73	15.92	29.92	43.91	57.90
U10B	22.89	30.77	40.62	50.46	60.31
U10C	20.84	25.46	31.24	37.01	42.79
U10D	3.16	12.28	23.67	35.07	46.47
U10E	35.79	39.99	45.24	50.50	55.75
U10F	54.51	57.53	61.31	65.08	68.86
U10G	56.69	58.66	61.13	63.60	66.07
U10H	150.38	150.38	150.38	150.38	150.38
U10J	143.01	143.01	143.01	143.01	143.01
U10K	92.73	92.73	92.73	92.73	92.73
U10L	18.26	22.55	27.92	33.29	38.66
U10M	1.46	9.09	18.63	28.16	37.70
Total:	**604.44**	**658.37**	**725.79**	**793.21**	**860.63**

Table 2.45: Projected future afforested areas (Medium-scenario)

Quaternary catchment	Total afforested area (km^2) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	4.73	8.00	12.10	16.19	20.28
U10B	22.89	23.13	23.44	23.74	24.04
U10C	20.84	22.88	25.42	27.97	30.52
U10D	3.16	10.52	19.71	28.91	38.11
U10E	35.79	39.99	45.24	50.50	55.75
U10F	54.51	57.53	61.31	65.08	68.86
U10G	56.69	58.66	61.13	63.60	66.07
U10H	150.38	150.38	150.38	150.38	150.38
U10J	143.01	143.01	143.01	143.01	143.01
U10K	92.73	92.73	92.73	92.73	92.73
U10L	18.26	22.55	27.92	33.29	38.66
U10M	1.46	1.46	1.46	1.46	1.46
Total:	**604.44**	**630.85**	**663.85**	**696.86**	**729.87**

Table 2.46: Projected future afforested areas (Low-scenario)

Quaternary catchment	Total afforested area (km^2) for indicated level of development				
	2012	2020	2030	2040	2050
U10A	4.73	4.73	4.73	4.73	4.73
U10B	22.89	22.89	22.89	22.89	22.89
U10C	20.84	20.84	20.84	20.84	20.84
U10D	3.16	3.16	3.16	3.16	3.16
U10E	35.79	35.79	35.79	35.79	35.79
U10F	54.51	54.51	54.51	54.51	54.51
U10G	56.69	56.69	56.69	56.69	56.69
U10H	150.38	150.38	150.38	150.38	150.38
U10J	143.01	143.01	143.01	143.01	143.01
U10K	92.73	92.73	92.73	92.73	92.73
U10L	18.26	18.26	18.26	18.26	18.26
U10M	1.46	1.46	1.46	1.46	1.46
Total:	**604.44**	**604.44**	**604.44**	**604.44**	**604.44**

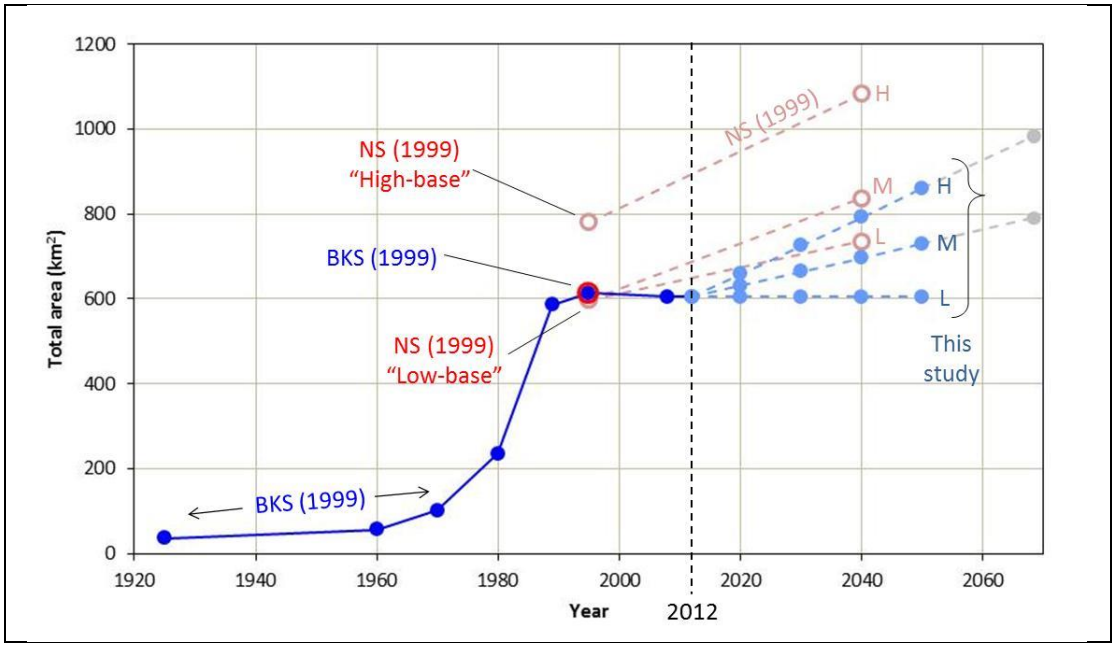

Figure 2.11: Projected future areas under commercial forestry

Ultimately, the Medium-scenario described above was adopted as the most representative of the probable future situation and used in this study for planning purposes. This was based on the fact that extensive further development of commercial forestry within the uMkhomazi catchment is unlikely due to a number of considerations, including the following:

- The central catchments are largely developed and already exceed the 20% limit guideline adopted by DWA (as discussed earlier).
- The headwater catchments lie largely within the protected area of the Ukhahlamba-Drakensberg National Park. This, together with the fact that these areas are relatively remote and inaccessible significantly limits the development potential within the upper portions of the catchment.
- In support of the above, it is important to note that the High-scenario assumes significant growth in the upper uMkhomazi River catchment – a situation which will probably not be allowed by DWA subsequent to the commissioning of the proposed downstream Smithfield Dam.
- According to the DWA Regional Office in Durban, the uMkhomazi is considered a "closed" catchment (Ward, Forestry Potential in the uMkhomazi River Catchment, 2013), which means that DWA does not currently consider water use license applications for commercial forestry. Although DWA may in future allow new developments on condition that the related impacts are mitigated (such as by the development of storage to release water and restore base flows in low flow periods), such measures will probably prove to be prohibitively expensive.
- The coverage of existing plantations are concentrated mostly within the high-rainfall areas near catchment boundaries, which means that future development may also be limited by lower rainfall in the river valleys (Ward, Forestry Potential in the uMkhomazi River Catchment, 2013).

In this regard it should be noted that, although the uMkhomazi is a closed catchment, the DWA Regional Office has recently made a concession allowing for the development of an additional 1 000 ha (10 km^2) of commercial forestry by previously disadvantaged individuals (HDIs) (Ward, Forestry Potential in the uMkhomazi River Catchment, 2013). Of this 10 km^2, a total of 4 km^2 have already been taken up, leaving only another 6 km^2 available for possible future development. This remaining area is clearly significantly smaller than the projected growth under the Medium-scenario (which is in excess of 100 km^2 over the planning horizon) and it is within this context that Mr Norman Ward of the Regional Office suggested the Medium-scenario may in fact be too high (Ward, Forestry Potential in the uMkhomazi River Catchment, 2013). However, despite this concern, it was decided that the Medium-scenario would be used for planning purposes since it may be conservative while not as high as those proposed in the earlier *Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand, 1999). The modelled future water use by commercial forestry in the

uMkhomazi River catchment for the Medium-scenario is presented in **Table 2.47**. It should be noted that, for all quaternary catchments, it was assumed that the current proportion of cultivated species would remain unchanged over the projection period. Furthermore, as mentioned earlier, projections were not developed for the upper uMlaza River catchment and these are therefore not shown in the table below.

Table 2.47: Modelled future water requirements for forestry (Medium-scenario)

Quaternary catchment	Modelled water use by commercial forestry (million m^3/a), for indicated level of development				
	2012	2020	2030	2040	2050
U10A	0.88	1.49	2.25	3.01	3.77
U10B	4.26	4.31	4.37	4.42	4.48
U10C	3.29	3.61	4.01	4.41	4.82
U10D	0.42	1.38	2.59	3.80	5.01
U10E	4.82	5.39	6.09	6.80	7.51
U10F	4.70	4.96	5.28	5.61	5.93
U10G	5.55	5.74	5.98	6.23	6.47
U10H	14.35	14.35	14.35	14.35	14.35
U10J	13.35	13.35	13.35	13.35	13.35
U10K	6.74	6.74	6.74	6.74	6.74
U10L	1.24	1.53	1.89	2.25	2.62
U10M	0.12	0.12	0.12	0.12	0.12
Total:	**59.71**	**62.96**	**67.03**	**71.10**	**75.17**

2.6.2 Dry-land sugarcane

a) Overview

Some dry-land sugarcane occurs in the lower portion of the uMkhomazi River catchment, particularly in quaternary catchments U10K and U10L. However, with a total estimated area of only 26 km^2 (compared to the 600 km^2 of commercial forestry) and an associated water use of under 2 million m^3/a, dry-land sugarcane is not a major water user in the uMkhomazi River catchment. However, the extent of dry-land sugarcane in the upper uMlaza River catchment is significant – particularly in quaternary catchment U60B, with a total area of 76 km^2 and estimated annual water use of almost 5 million m^3.

The historical and current reduction in runoff due to dry-land sugarcane was modelled using the Stream Flow Reduction (SFR) sub-model which is available as a feature in the WRSM2000 rainfall-runoff model, as well as the WRYM and WRPM systems models. More information in this regard is provided in the following sub-sections.

b) Historical and current (1925 – 2012)

Areas under dry-land sugarcane

Information on the areas under dry-land sugarcane in the uMkhomazi and upper uMlaza river catchments was obtained from three separate sources in order to obtain the most reliable available data set which covers a historical period of 88 years from 1925 to 2012. A summary of available historical data is presented in **Table 2.48** and also in **Figure 2.12** (the latter for the uMkhomazi River catchment only). More information on the various data sources is provided thereafter.

Table 2.48: Available historical data on dry-land sugarcane, based on various sources

Quaternary catchment	Total area under dry-land sugarcane (km²), for indicated data source and level of development							
	BKS (1999)[1]						NLC (2000)[2]	EKZNW (2010)[3]
	1925	1960	1970	1980	1989	1995	2000	2008
uMkhomazi River catchment								
U10A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10H	0.19	0.28	0.39	0.87	2.11	2.24	0.00	0.46
U10J	0.78	1.20	1.66	3.69	8.92	9.47	2.05	0.00
U10K	3.65	5.56	7.70	17.15	41.47	44.03	0.63	12.24
U10L	3.34	5.10	7.06	15.71	38.01	40.35	9.28	12.88
U10M	0.20	0.31	0.43	0.95	2.29	2.43	1.66	0.78
Sub-total:	**8.16**	**12.44**	**17.23**	**38.37**	**92.80**	**98.52**	**13.61**	**26.36**
Upper uMlaza River catchment								
U60A	2.59	3.85	4.09	5.37	6.23	6.23	0.00	2.68
U60B	88.13	130.93	139.08	182.61	211.63	211.63	69.67	76.30
Sub-total:	**90.72**	**134.78**	**143.18**	**187.98**	**217.85**	**217.85**	**69.67**	**78.98**
Total:	**98.88**	**147.22**	**160.41**	**226.35**	**310.65**	**316.37**	**83.28**	**105.33**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) for defined sub-catchments, distributed across quaternary catchments based on Ezemvelo-KZN Wildlife (EKZNW, 2010).

(2) From the South African National Land Cover 2000 (NLC 2000) project.

(3) From Ezemvelo-KZN Wildlife (EKZNW, 2010).

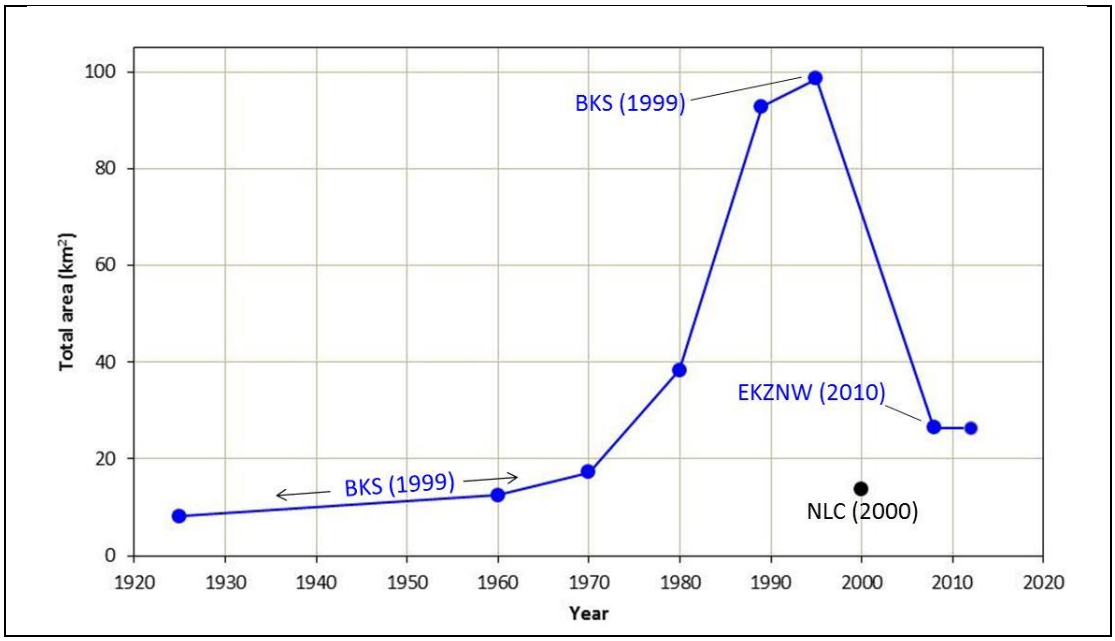

Figure 2.12: Available historical data on dry-land sugarcane, based on various sources

BKS (1999)

Historical irrigation areas in the study area were determined for the earlier *Mkomazi/Mgeni/Mooi River Hydrology Update study* (BKS, 1999) from 1:30 000 aerial photography and 1:50 000 maps. Results from that study are provided for four defined incremental sub-catchments within the uMkhomazi River catchment, namely "Impendle Dam" (I-06), "Smithfield Dam" (I-22), "Ngwadini Dam" (I-19) and "Mkomazi Mouth" (I-15). The uMlaza River catchment was divided into three sub-catchments, with the upper catchment represented by "Umlaas" (I-21H), representing the area upstream of flow gauging station U6H003 and comprising of quaternary catchments U60A and U60B.

The areas shown in the table above for the 1925- to 1995-development levels are based on those from the BKS study but disaggregated into quaternary catchments based on the percentage distribution of the Ezemvelo-KZN Wildlife database (discussed later).

NLC (2000)

Dry-land sugarcane areas were estimated in the *South African National Land Cover 2000* (NLC 2000) project based on multi-temporal Landsat 7 Enhanced Thematic Mapper (ETM+) imagery captured during the period 2000 to 2003.

Ezemvelo-KZN Wildlife (2010)

A detailed land cover database was developed by remote-sensing specialists GeoterraImage for Ezemvelo-KZN Wildlife (Biodiversity Research) covering the entire KwaZulu-Natal province, based on high-resolution SPOT5 Satellite multispectral imagery dated 2008 (EKZNW, 2010). The values shown in **Table 2.48** were derived by combining all areas classified as "sugarcane commercial" and "sugarcane subsistence" and then subtracting irrigated sugarcane areas obtained from the DWA *Water Authorisation and Registration Management System (WARMS)* dated 2 March 2011 (Tylcoat, 2011). The latter was included in this study as part of irrigation water use and more information in this regard is provided in **Section 3.2.2**.

It is interesting to note that both the later data sources, namely *NLC* (2000) *and Ezemvelo-KZN Wildlife* (2010) show significantly smaller areas of dry-land sugarcane compared to those from the earlier BKS study. According the South African Sugarcane Research Institute (SASRI), this apparent downward trend is not unexpected and can be attributed to factors such as the decreasing price of sugar and land reform initiatives (Jumman, 2012). It is also clearly reflected in the publication *Trends in the Agricultural Sector 2011* (DAFF, 2011), which shows a marked decrease in the hectares of sugarcane harvested nationally from 2006/7 to 2010/11.

Based on the above considerations, the final data set of historical areas under dry-land sugarcane adopted for this study are as summarised in **Table 2.49**. Also, the spatial coverage of areas under dry-land sugarcane at the 2008-development level is shown in **Figure A.8** of **Appendix A**, from *EKZNW* (2008 KZN PROVINCE LAND-COVER MAPPING (from SPOT5 Satellite imagery circa 2008), 2010).

Table 2.49: Historical areas under dry-land sugarcane adopted for this study

Quaternary catchment	Total area under dry-land sugarcane (km^2), for indicated data source and level of development						
	BKS (1999)(1)						EKZNW (2010)(2)
	1925	1960	1970	1980	1989	1995	2008 to 2012
uMkhomazi River catchment							
U10A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10B	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10D	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10E	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10F	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10G	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10H	0.19	0.28	0.39	0.87	2.11	2.24	0.46
U10J	0.78	1.20	1.66	3.69	8.92	9.47	0.00
U10K	3.65	5.56	7.70	17.15	41.47	44.03	12.24
U10L	3.34	5.10	7.06	15.71	38.01	40.35	12.88
U10M	0.20	0.31	0.43	0.95	2.29	2.43	0.78
Sub-total:	**8.16**	**12.44**	**17.23**	**38.37**	**92.80**	**98.52**	**26.36**
Upper uMlaza River catchment							
U60A	2.59	3.85	4.09	5.37	6.23	6.23	2.68
U60B	88.13	130.93	139.08	182.61	211.63	211.63	76.30
Sub-total:	**90.72**	**134.78**	**143.18**	**187.98**	**217.85**	**217.85**	**78.98**
Total:	**98.88**	**147.22**	**160.41**	**226.35**	**310.65**	**316.37**	**105.33**

Notes: (1) From BKS (Mgeni River System Analysis Study; Mooi and Mkomazi Rivers - Hydrology (PB U000/00/1092), 1999) for defined sub-catchments, distributed across quaternary catchments based on Ezemvelo-KZN Wildlife (EKZNW, 2010).

(2) From Ezemvelo-KZN Wildlife (EKZNW, 2010). It is assumed that no growth in dry-land sugarcane occurred over the 2008 to 2012 period.

Modelled water use by dry-land sugarcane

The impact of dry-land sugarcane on runoff was modelled using the WRSM2000 Stream Flow Reduction (SFR) sub-model, more information on which is provided earlier in **Section 3.5.1 (c)**. A summary of the results is provided in **Table 2.50** for current development levels. Current development levels are representative of the period 2008 to 2012, based on the assumption that no growth in sugarcane has occurred over that period, as discussed earlier.

Table 2.50: Summary of modelled water use by dry-land sugarcane at 2012-development levels

Quaternary catchment	Total area under dry-land sugarcane (km^2)	Modelled water use by dry-land sugarcane[(1);(2)]	
		million m^3/a	mm/a
uMkhomazi River catchment			
U10A	0.00	0.00	-
U10B	0.00	0.00	-
U10C	0.00	0.00	-
U10D	0.00	0.00	-
U10E	0.00	0.00	-
U10F	0.00	0.00	-
U10G	0.00	0.00	-
U10H	0.46	0.04	95
U10J	0.00	0.00	-
U10K	12.24	0.79	64
U10L	12.88	0.75	58
U10M	0.78	0.06	77
Sub-total:	**26.36**	**1.64**	**62**
Upper uMlaza River catchment			
U60A	2.68	0.25	95
U60B	76.30	4.87	64
Sub-total:	**78.98**	**5.13**	**65**
Total:	**105.33**	**6.77**	**64**

Notes: (1) Current-development levels are representative of the period 2008 to 2012. It is assumed that no growth in dry-land sugarcane occurred over this period.

(2) Average based on an analysis over the 1925 to 2008 period (hydrological), at a constant development level, as described above.

c) Projected future (2012 – 2050) scenarios

As mentioned earlier, the area under dry-land sugarcane in the uMkhomazi River catchment has declined significantly over the last decade, primary because of the decreasing price of sugar and land reform initiatives (Jumman, 2012). Furthermore, scope for expansion is small, primarily as a result of the fact that the catchment narrows down considerably towards the downstream end, leaving little area available within the sub-tropical coastal strip suited to this crop. In addition, despite the fact that this area is located in the proximity of coastal towns and transport routes (such as the N2-highway) it remains relatively inaccessible because of the mountainous topography and lack of local road infrastructure.

With consideration of the above, therefore, it was assumed that no growth in the development of dry-land sugarcane would occur over the planning horizon within the uMkhomazi River catchment.

2.6.3 Invasive alien plants (IAPs)

a) Overview

Alien plant infestation in the uMkhomazi and upper uMlaza river catchments is considerable, covering an area of 47 km^2 – almost half the extent of dry-land sugarcane discussed earlier. The impact of invasive alien plants (IAPs) on the water resources of the catchments is, however, small, with an associated annual water use of under 7 million m^3.

The historical and current reduction in runoff due to IAPs was modelled using the Stream Flow Reduction (SFR) sub-model which is available as a feature in the WRSM2000 rainfall-runoff model. More information in this regard is provided in the following sub-sections.

b) Historical and current (1925 – 2012)

Extent and characteristics of IAPs

Detailed information on the current extent of IAP infestation in the study area was obtained from the *Water Resources of South Africa 2005 (WR2005) study* (WRC, 2009). The dataset includes IAP areas at the 2004-development level, per quaternary catchment, as well as a distinction between vegetation located in the riparian zone and those located in upland areas. Furthermore, the dataset also classifies vegetation into three distinct biomass classes, namely *tall trees*, *medium trees* and *tall shrubs*.

A summary of the WR2005 information is provided in **Table 2.51**. It should be noted that IAPs can occur at various densities ranging from sparse cover to dense cover and the areas in **Table 2.51** are representative of the vegetation condensed to an equivalent cover of 100%, referred to as the *equivalent dense area*.

Table 2.51: Extent and characteristics of IAP infestation adopted in this study

Quaternary catchment	Total equivalent dense area, in 2004 (km^2)	Portion located in the riparian zone (as % of total)	Portion in biomass class (as % of total)		
			Tall trees	Medium trees	Tall shrubs
uMkhomazi River catchment					
U10A	1.41	0.7%	93%	4%	3%
U10B	6.49	3.0%	93%	5%	1%
U10C	4.08	1.2%	90%	10%	1%
U10D	4.46	0.9%	57%	13%	30%
U10E	3.71	0.5%	83%	13%	4%
U10F	3.04	1.6%	78%	10%	13%
U10G	2.91	0.6%	53%	15%	32%
U10H	3.66	0.8%	50%	14%	36%
U10J	4.21	1.3%	52%	12%	36%
U10K	4.42	1.4%	59%	8%	33%
U10L	2.67	0.4%	48%	12%	39%
U10M	2.70	0.7%	22%	23%	55%
Sub-total:	**43.76**	**1.3%**	**66%**	**11%**	**22%**
Upper uMlaza River catchment					
U60A	0.56	0.4%	49%	13%	38%
U60B	3.09	0.1%	57%	12%	31%
Sub-total:	**3.65**	**0.2%**	**55%**	**12%**	**32%**
Total:	**47.41**	**1.2%**	**66%**	**11%**	**23%**

Note: From WR2005 (WRC, 2009).

Historical growth of IAPs

Little information is available on the historical extent of IAP infestation. A scenario for the possible growth in IAPs within the study area was therefore developed based on the historical growth of commercial forestry (as discussed earlier in **Section 3.5.1 (b)**). This approach was considered to be acceptable based on the fact that the level of infestation, and therefore the impact on water resources is relatively small. Furthermore, it is likely that there is some causal link between the development of forestry plantation and IAP propagation and that, therefore, the assumption is not without merit.

The resulting growth scenario is summarised in **Table 2.52**.

Table 2.52: Adopted growth scenario for the historical extent of IAPs

Quaternary catchment	Total equivalent dense area of IAPs (km^2), at indicated level of development[(1)]				
	1925	1970	1980	1995	2004 to 2012
uMkhomazi River catchment					
U10A	0.08	0.24	0.55	1.43	1.41
U10B	0.39	1.09	2.53	6.58	6.49
U10C	0.24	0.69	1.59	4.14	4.08
U10D	0.27	0.75	1.74	4.52	4.46
U10E	0.22	0.63	1.44	3.76	3.71
U10F	0.18	0.51	1.18	3.08	3.04
U10G	0.17	0.49	1.13	2.95	2.91
U10H	0.22	0.62	1.42	3.71	3.66
U10J	0.25	0.71	1.64	4.27	4.21
U10K	0.26	0.74	1.72	4.48	4.42
U10L	0.16	0.45	1.04	2.71	2.67
U10M	0.16	0.46	1.05	2.74	2.70
Sub-total:	**2.61**	**7.37**	**17.04**	**44.39**	**43.76**
Upper uMlaza River catchment					
U60A	0.19	0.29	0.39	0.45	0.56
U60B	1.03	1.62	2.13	2.47	3.09
Sub-total:	**1.21**	**1.92**	**2.51**	**2.92**	**3.65**
Total:	**3.82**	**9.29**	**19.55**	**47.31**	**47.41**

Note: (1) Possible growth scenario developed based on the extent of IAPs in 2004, from WR2005 (WRC, 2009) and the historical growth of commercial forestry.

Modelled water use by IAPs

Based on the information provided above, the impact of IAPs on runoff was modelled using the WRSM2000 Stream Flow Reduction (SFR) sub-model (see **Section 3.5.1 (c)**). A summary of the results is provided in **Table 2.53** for current development levels. Current-development levels are representative of the period 2008 to 2012, based on the growth scenario discussed in the preceding sub-section.

Table 2.53: Summary of modelled water use by IAPs at 2012-development levels

Quaternary catchment	Total equivalent dense area of IAPs (km^2)	Modelled water use by IAPs[(1);(2)]	
		million m^3/a	mm/a
uMkhomazi River catchment			
U10A	1.41	0.38	266
U10B	6.49	1.46	225
U10C	4.08	0.81	199
U10D	4.46	0.87	195
U10E	3.71	0.66	177
U10F	3.04	0.32	107
U10G	2.91	0.36	125
U10H	3.66	0.41	112
U10J	4.21	0.42	100
U10K	4.42	0.35	78
U10L	2.67	0.15	58
U10M	2.70	0.18	65
Sub-total:	**43.76**	**6.37**	**146**
Upper uMlaza River catchment			
U60A	0.56	0.07	131
U60B	3.09	0.23	74
Sub-total:	**3.65**	**0.30**	**83**
Total:	**47.41**	**6.67**	**141**

Notes: (1) Current-development levels are representative of the period 2008 to 2012, based on the growth scenario discussed earlier.

(2) Average based on an analysis over the 1925 to 2008 period (hydrological), at a constant development level, as described above.

c) Projected future (2012 – 2050) scenarios

As mentioned earlier, little information is available on the historical growth of IAP infestation in the uMkhomazi River catchment and, for the purposes of this study, was based on the growth characteristics of commercial forestry. However, for planning purposes, it was assumed that there would be no further growth in IAP areas. This assumption is based on the fact that the DWA are likely to maintain infestation levels at least at current levels through their on-going Working for Water programme subsequent to the commissioning of the proposed Smithfield Dam.

2.7 SUMMARY

A summary of the water requirements and return flows in the uMkhomazi and uMlaza river catchments at 2012-development levels is provided in **Table 2.54**. It shows that currently the net in-catchment water requirements in the uMkhomazi River catchment totals 159 million^3/a, or 15% of the total natural MAR.

Table 2.54: Summary of water requirements and return flows in the uMkhomazi River catchment at 2012-development levels

Quaternary catchment	Water use[1] (million m^3/a)								
	Irrigation, supplied from all sources[2]	Commercial forestry	Dry-land sugarcane	Invasive alien plants	Stock watering	Domestic water use, supplied from all sources[4]	Industrial water use	Return flows	Totals
uMkhomazi River catchment									
U10A	-	0.88	-	0.38	0.36	0.06	-	-	**1.68**
U10B	-	4.26	-	1.46	0.10[3]	0.08	-	-	**5.91**
U10C	1.70	3.29	-	0.81	0.02[3]	0.08	-	0.17	**5.74**
U10D	1.12	0.42	-	0.87	0.29	0.26	-	0.11	**2.84**
U10E	-	4.82	-	0.66	0.23[3]	1.01	-	-	**6.71**
U10F	0.59	4.70	-	0.32	0.26	0.55	-	0.08	**6.35**
U10G	6.87	5.55	-	0.36	0.27	0.14	-	0.69	**12.51**
U10H	12.62	14.35	0.04	0.41	0.22[3]	0.38	-	1.26	**26.75**
U10J	8.73	13.35	-	0.42	0.30	0.31	-	1.08	**22.03**
U10K	6.05	6.74	0.79	0.35	0.41	0.69	-	0.60	**14.42**
U10L	0.23	1.24	0.75	0.15	0.19[3]	0.21	-	0.02	**2.75**
U10M	-	0.12	0.06	0.18	-	0.11	53.00[5]	2.65	**50.81**
Totals:	**37.90**	**59.71**	**1.64**	**6.37**	**2.66**	**3.89**	**53.00**	**6.66**	**158.51**
uMlaza River catchment									
U60A	0.69	4.75	0.25	0.07	0.01[3]	0.11	-	0.07	**5.82**
U60B	22.37	3.77	4.87	0.23	0.03[3]	0.94	-	2.24	**29.97**
Totals:	**23.06**	**8.52**	**5.13**	**0.30**	**0.04**	**1.05**	**-**	**2.31**	**35.79**

Notes: (1) Modelled average based on an analysis over the historical period 1925 to 2008 (hydrological years), at a constant development level as indicated.

(2) The impact on surface water of irrigation supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(3) Stock watering not modelled in quaternary catchments where the requirement is less than 0.25 million m^3/a.

(4) Urban and rural water use. The impact on surface water of users supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(5) Licenced water use by SAPPI-SAICCOR.

Finally, summaries are provided in **Table 2.55** and **Figure 2.13** of the projected in-catchment water requirements and return flows in the uMkhomazi River catchment over a planning period of approximately 40 years, from 2012 to 2050.

Table 2.55: Summary of projected water requirements and return flows in the uMkhomazi River catchment

Water user category	Water requirement[1] (million m^3/a), at indicated development level				
	2012	2020	2030	2040	2050
Irrigation, supplied from all sources[2]	37.90	41.90	46.85	51.69	56.54
Commercial forestry	59.71	62.96	67.03	71.10	75.17
Dry-land sugarcane	1.64	1.64	1.64	1.64	1.64
Invasive alien plants	6.37	6.37	6.37	6.37	6.37
Stock watering[3]	2.66	2.77	2.90	3.04	3.17
Domestic water use, supplied from all sources[4]	3.89	4.09	4.27	4.44	4.61
Industrial water use[5]	53.00	53.00	53.00	53.00	53.00
Total water use:	**165.17**	**172.74**	**182.06**	**191.28**	**200.50**
Return flows	6.66	7.06	7.55	8.03	8.51
Total net water use:	**158.51**	**165.68**	**174.52**	**183.25**	**191.99**

Notes: (1) Modelled average based on an analysis over the historical period 1925 to 2008 (hydrological years), at a constant development level as indicated.

(2) The impact on surface water of irrigation supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(3) Stock watering not modelled in quaternary catchments where the requirement is less than 0.25 million m^3/a.

(4) Urban and rural water use. The impact on surface water of users supplied from groundwater is insignificant and was not accounted for in the yield analysis.

(5) Licenced water use by SAPPI-SAICCOR.

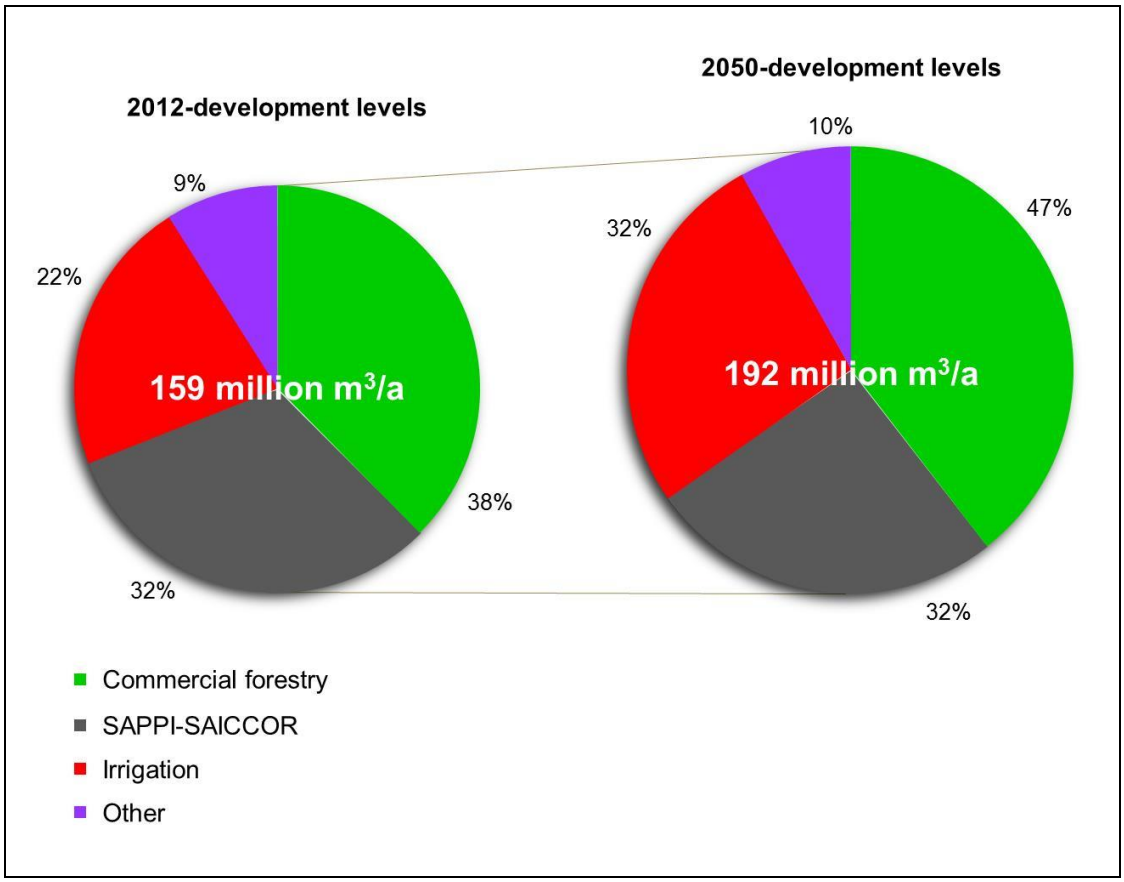

Figure 2.13: Summary of projected net water requirements in the uMkhomazi River catchment

3 MGENI WATER SUPPLY SYSTEM

3.1 BACKGROUND

As mentioned in **Section 1** of this report the integrated Mgeni Water Supply System (WSS) is the main water source that supplies about five million people and industries in the eThekwini Municipality, uMgungundlovu District Municipality and Msunduzi Local Municipality areas of jurisdiction, incorporating the greater Pietermaritzburg and Durban metropolitan areas.

The growing requirements of these areas require additional water resources to augment the current water availability. Transfers from the recently commissioned Spring Grove Dam in the upper Mooi River will increase the yield of the Integrated Mgeni WSS by 60 million m³/a. However, according to the DWA *Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas* (WRP, DMM, Golder, Kv3, & Zitholele, 2009), this will not be adequate to meet the long-term water requirements of the Mgeni WSS as shown in **Figure 3.1** (WRP, DMM, Golder, Kv3, & Zitholele, Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas; Executive Summary (PWMA 11/000/00/1107), 2009) and the uMWP-1 (Smithfield Dam) is proposed as a long-term solution.

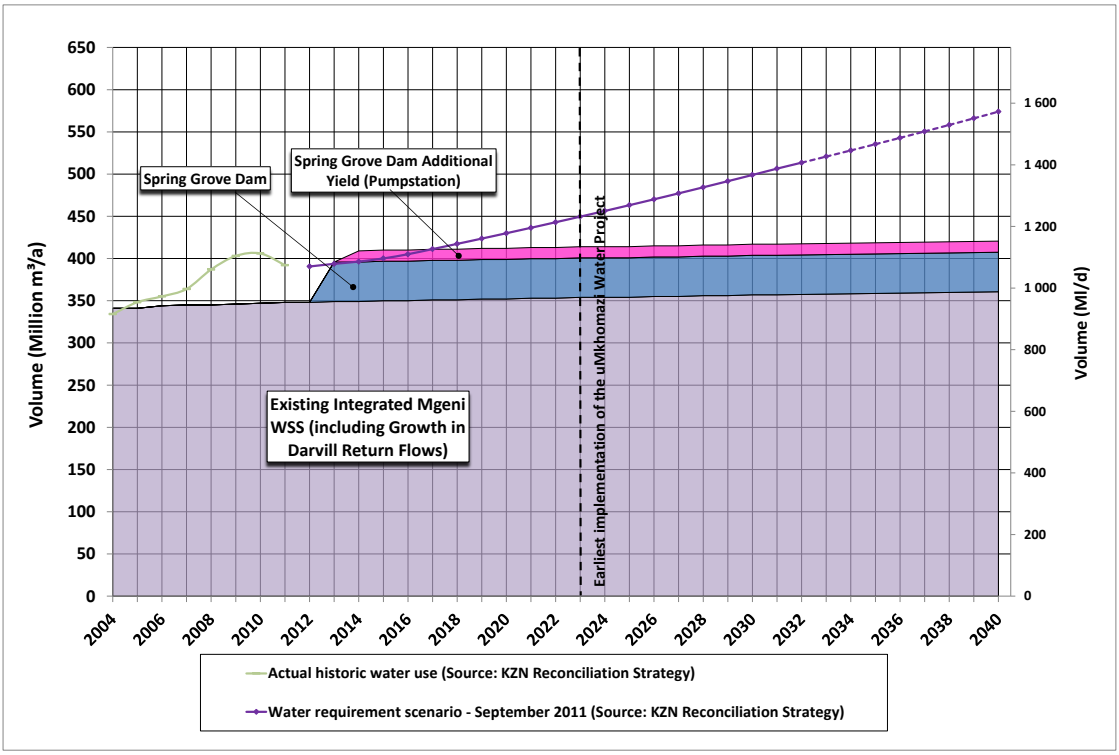

Figure 3.1: Long-term water requirement projection for the Mgeni WSS (2009)

The figures included in **Figure 3.1** are however outdated, and the supply area for the proposed uMWP-1 needed to be clearly defined and the associated water requirements determined. This was the scope of *Module 3* of this *Feasibility Study*, namely the *Potable Water* component conducted by Umgeni Water. Hence, the supply areas and associated water requirement projections planned to be met by the uMWP-1 are covered in detail in a *Module 3: Technical Feasibility Study: Potable Water* report, namely the *uMkhomazi Water Project Phase 1: Module 3: Bulk Water Study – Water Demand Projections and Phasing of Infrastructure Report*. The key information and findings of that report are summarised here, as well as how these water requirements fit into the Mgeni WSS.

3.2 WATER REQUIREMENT PROJECTIONS

3.2.1 uMWP supply area

The uMWP-1 will support water requirements in the Mgeni WSS by providing water to a selected portion of the supply area. The proposed ***uMWP-1 water supply area*** is shown in **Figure A.9** of **Appendix A** and comprises of:

- The portion of the Mgeni WSS downstream of Umlaas Road.

- The eThekwini Municipality on the North Coast currently linked to the Mdloti WSS (supplied from Hazelmere Dam).

These areas were selected for various reasons which include the ability to gravity feed from Umlaas Road, as well as consideration of anticipated areas of growth within the Mgeni WSS.

Water will be supplied from the proposed Smithfield Dam on the uMkhomazi River near Bulwer via a series of conveyance infrastructure into the recently constructed Western Aqueduct and the planned extension of the Northern Aqueduct (shown in **Figure A.10** of **Appendix A**). This planned Northern Aqueduct will connect to, and extend, the Western Aqueduct northwards into the Mdloti River catchment and will also connect to the existing Northern Aqueduct supplied from Durban Heights WTP. It should be noted that the renaming of the existing and proposed Northern Aqueduct supply lines is recommended to avoid confusion. For the purposes of this report, however, the term "Northern Aqueduct" is used to refer to the **proposed** Northern Aqueduct.

The *Module 3: Technical Feasibility Study: Potable Water* study team identified the areas to be serviced by the proposed uMWP-1 at a bulk reservoir level. The supply areas are summarised in **Table 3.1** and are sub-divided into three main areas as follows:

- ***Outer West Area:*** The outer west area which is currently supplied from Midmar Dam via Umlaas Road.
- ***Western Aqueduct Area:*** Areas that are currently supplied from Durban Heights WTP that will be moved (or "shed") onto the uMWP-1 when Durban Heights WTP reaches its operating capacity limit.
- ***Northern Aqueduct Area:*** Areas on the North Coast that are either currently supplied from Durban Heights WTP or Hazelmere Dam (which has limited yield) or requirements associated with new anticipated developments particularly around the King Shaka Airport and planned housing developments.

Table 3.1: Supply areas and reservoirs proposed to be supplied from the uMWP-1

Supply Area	Bulk reservoirs	
Outer West (“Point M” supply area)	Abelia Alverstone Nek Bothas Hill Cato Ridge Abbattoir Cato Ridge Emberton Georgedale & Et Hammersdale Hl Hammersdale_Ll_ Hoyer (Ex Ctholme) Knlesby Pk Kwanqetho	Molweni 1 & 2 Monteseel Ps & Et Mpumalanga 1, 2, 3, 4 & 6 Ofudu Pinkney Park Plateau Et Point M Salem Shongweni Summerhills Et Westriding Zwelibomvu 2
Pinetown, Wyebank-Bershire Downs System (Western Aqueduct shed zone)	Berkshire Downs Clermont 1, 2 & 4 Clermont 5 Kwadabeka 5 Clubhouse Place Haygarth Road	Hocking Place Methven Mountain Ridge Paradise Valley Pinetown System Wybank
KwaDabeka (Western Aqueduct shed zone)	Kwadabeka 1 Bpt1 & Bpt2 Kwadabeka 2, 3, & 4	
Tshelimnyama (Western Aqueduct)	Intake Road Kwadengezi	Tshelimnyama 1, 2 & 3 Washington Hts
Ntuzuma (Western Aqueduct)	Amaotana Etafuleni Kwasilwane Nr 5 Elevated Tank	Ntuzuma 3, 4, 5 & 7 Rural North West Sensokuhle
Mzinyathi (Western Aqueduct shed zone)	Nr5 To Mzinyathi Ogunjini Waterworks Partial Demand	
Northern Aqueduct (Northern Aqueduct)	Cornubia Mount View Phoenix 2, 4, and 5	Umhlanga 2 Umhlanga North Umhlanga South
iNyaninga (Northern Aqueduct shed zone)	Ksia & Dube Tradeport Inyaninga	
Waterloo (Northern Aqueduct shed zone)	Sibaya Nodes 1-5 Sibaya West Umdloti North	Mt Moreland Township Mt Moreland South Mt Moreland North
La Mercy (Northern Aqueduct)	La Mercy Beach Zimbali South Banks / Westbrook	

In order to provide a clearer picture of the uMWP-1 supply area, a schematic diagram is provided in **Figure 3.2**, showing the main sub-areas of the uMWP-1 and how these will relate to the supply area if the Mgeni WSS.

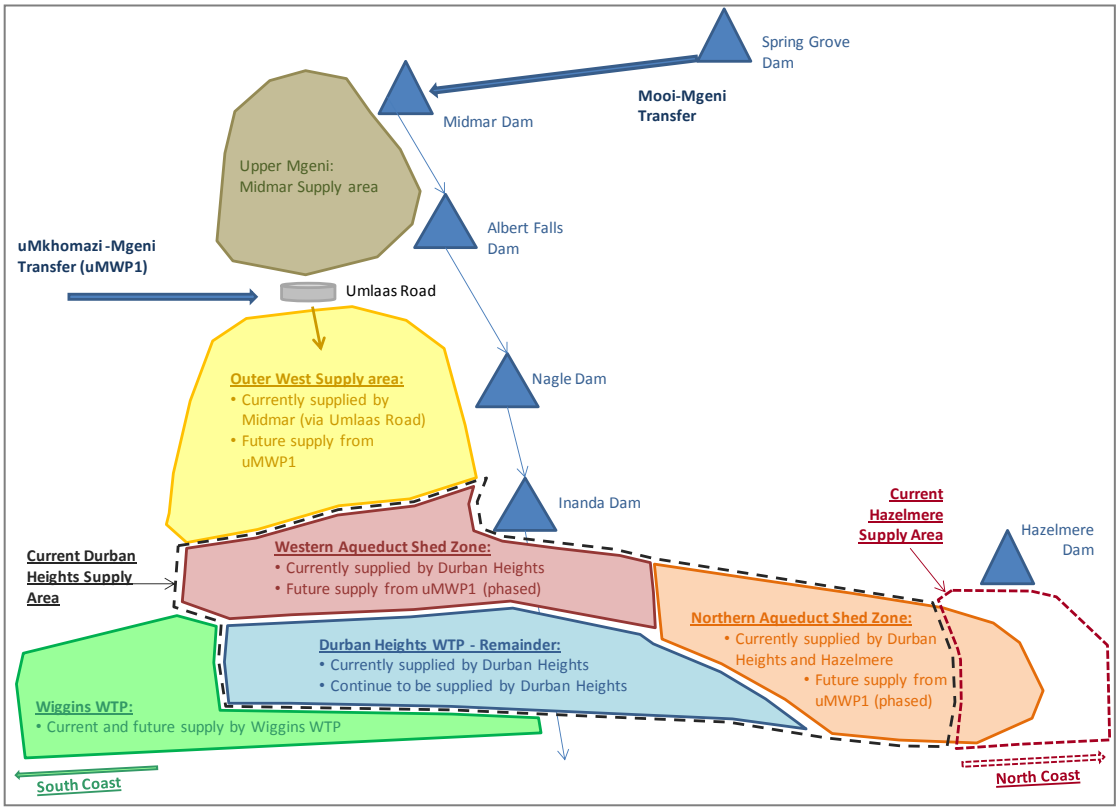

Figure 3.2: Schematic of water supply areas in the Mgeni WSS

Two water requirement projections, namely a Low- and High-growth scenario were developed for the uMWP-1 supply areas (indicated earlier in **Table 3.1**) as part of the *Module 3: Technical Feasibility Study: Potable Water* study. Further details can be obtained in the *Water Demand Projections and Phasing of Infrastructure Report* (Knight Piésold, 2014).

Based on discussions held between the *Module 1: Technical Feasibility Study: Raw Water* and *Module 3: Technical Feasibility Study: Potable Water* study teams the Low-scenario was considered to be the most realistic and appropriate for the purpose of sizing and timing uMWP-1 infrastructure. This was based on a number of considerations including the fact that the Low-scenario more closely follows the 1.5% growth rate adopted over recent years by Umgeni Water for water requirement projections of the Mgeni WSS. The water requirement projections are shown in **Figure 3.3**, including both Low- and High-scenarios, together with scenarios based on 1.5% and 2.5% growth rates for comparison purposes. **Figure 3.4** shows the Low-scenario, separated into the three main uMWP-1 sub-areas discussed earlier.

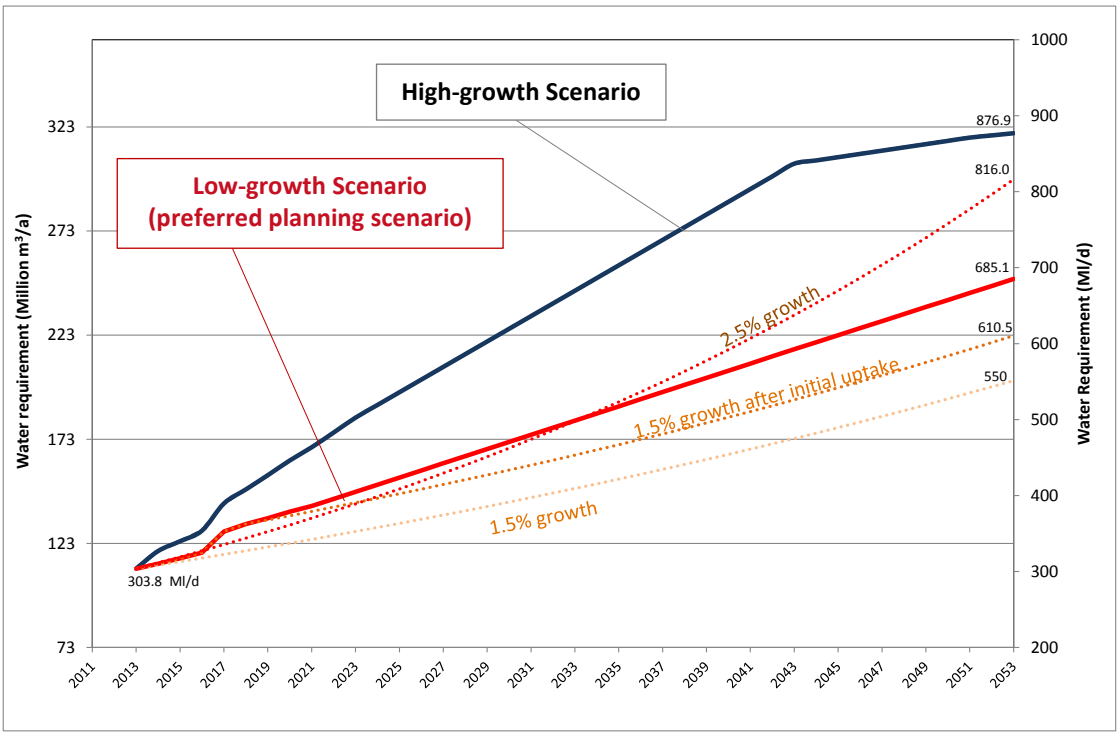

Figure 3.3: Updated uMWP-1 water requirement projection scenarios

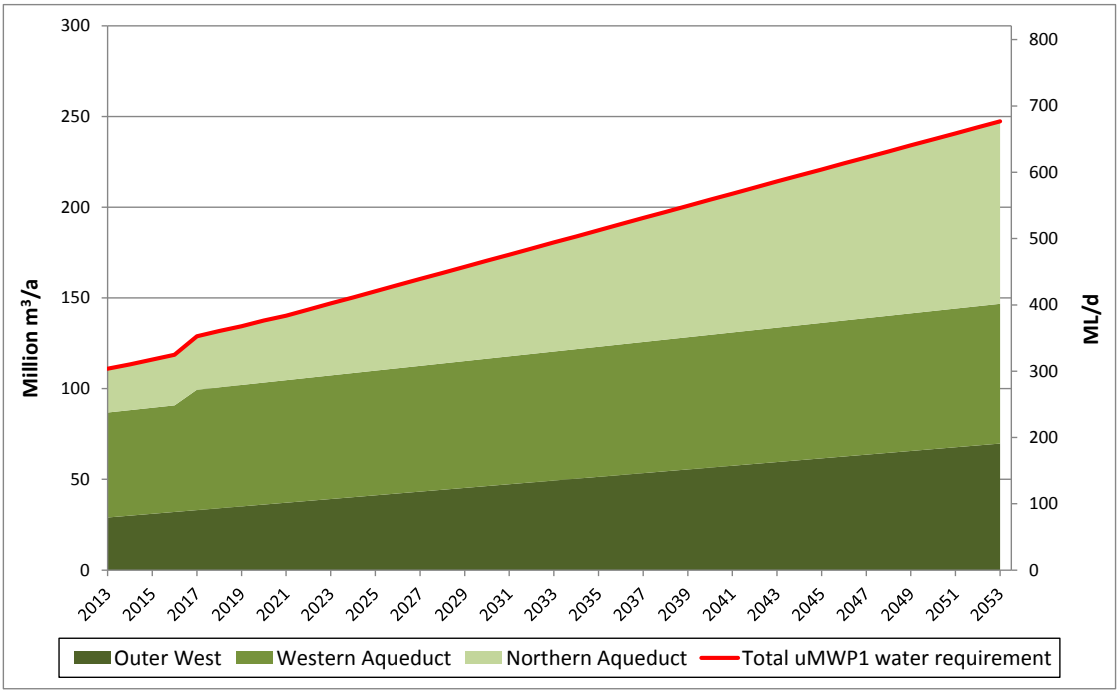

Figure 3.4: Selected uMWP-1 water requirement projection scenario, sub-divided into three main areas

The water requirement projections indicated for the Western and Northern Aqueduct sub-areas in **Figure 3.4** includes shed zones, which will be shed from Durban Heights WTP onto the uMWP-1. As such the water requirements shown in **Figure 3.4** are the maximum projected requirements for the supply areas in

question. Initially the supply from the uMWP-1 will be lower and phased in, up to the full requirements over time. This phasing will be based on growth in water requirements and infrastructure capacity constraints within the Mgeni WSS, as discussed in detail in the *Module 3* report on *Water Demand Projections and Phasing of Infrastructure* (Knight Piésold, 2014), as well as in the *Water Resources Planning Model Report* (AECOM et al., 2014).

The uMWP-1 supply area will form an integrated part of the Mgeni WSS and can therefore not be viewed as a separate entity. This is particularly important when the benefit of the uMWP-1 is assessed in the form of system water balances and for comparing the uMWP-1 against other augmentation options. This is further motivated considering the interconnected nature of the Mgeni WSS.

3.2.2 North Coast Supply area

As highlighted in **Section 3.2.1**, the uMWP supply area includes parts of eThekwini on the North Coast up to the La Mercy, for which significant growth in water requirements have been projected. Through the planned Northern Aqueduct the Mgeni WSS will be expanded northwards to augment water supply to these areas due to the water availability constraints of local resources, i.e. Hazelmere Dam.

It must be noted that while this feasibility study is considering the uMWP, other potential interventions such as desalination have been considered as possible alternatives. As such the proposed ***Tongaat Desalination Plant*** could also deliver water to the La Mercy Reservoir from where it would gravitate to the Avondale Reservoir via a new pipeline to the Bifurcation Point. Alternatively water will be pumped to the Waterloo Reservoir via a new pipeline from where it could be pumped back up the Northern Aqueduct. More detail on the desalination option is contained in the *Investigation into the Possibility for Desalination Plants to Augment the Water Supply on the North and South Coasts* (AURECON, 2013).

The water requirements of the alternative Desalination scheme for the North Coast area are similar to those of the Northern Aqueduct supply area, and will fully utilise the capacity of the proposed 150 Mℓ/d Tongaat Desalination Plant if implemented.

For the purpose of comparison, unit reference values (URV) were determined for the uMWP-1 and the alternative desalination option as part of this Feasibility

Study and the results are discussed in *P WMA 11/U10/00/3312/3/1/6: Supporting Document 6: Economic Comparison of the uMkhomazi-Mgeni Transfer Scheme with Desalination and Re-use Options Report* (AECOM, et al., 2014).

3.2.3 South Coast supply area

Further to the northern expansion of the Mgeni WSS through the proposed Northern Aqueduct and the implementation of the uMWP-1 (as discussed in the previous subsection) the extension of the South Coast Pipeline (SCP) has resulted in the expansion of the system southwards along the South Coast. Water is currently supplied from Wiggins to the Toti WTP and the South Coast Pipeline (SCP) via the South Coast Augmentation (SCA) pipeline. In 2011 this volume was in the order of 12 million m^3/a (32 Mℓ/d). The capacity has recently been increased through the South Coast Booster pump station, which will increase the capacity to deliver water from Wiggins to the South Coast, but this is limited to under 24 million m^3/a (65 Mℓ/d) after taking account of local users along the SCA before the Toti WTP. The load of the South Coast on Wiggins and the Mgeni WSS is thus limited to the SCA capacity.

Water requirement projections for the South Coast include both the eThekwini and Ugu Municipal areas, with the bulk of the requirement located within the eThekwini supply area. Water requirements for the South Coast were recently updated and provided to the study team by eThekwini Municipality. More detail on current supply volumes and projected water requirements of the South Coast are included in **Appendix E**.

The water requirement projection scenarios for the South Coast are summarised in **Figure 3.5** which shows both the eThekwini portion (in red) and the total including the Ugu portion (in blue). Water requirement projections for the South Coast previously provided by Umgeni Water are also included for reference purposes (in green). The infrastructure capacity limitations of the SCA together with the capacity of the local resource are also highlighted on the graph as two dashed horizontal lines. These show (i) the SCA capacity limitation that caps the water requirements of the South Coast that can be placed on the Mgeni WSS (in red); and (ii) the current water availability constraints to the South Coast supply area (in yellow).

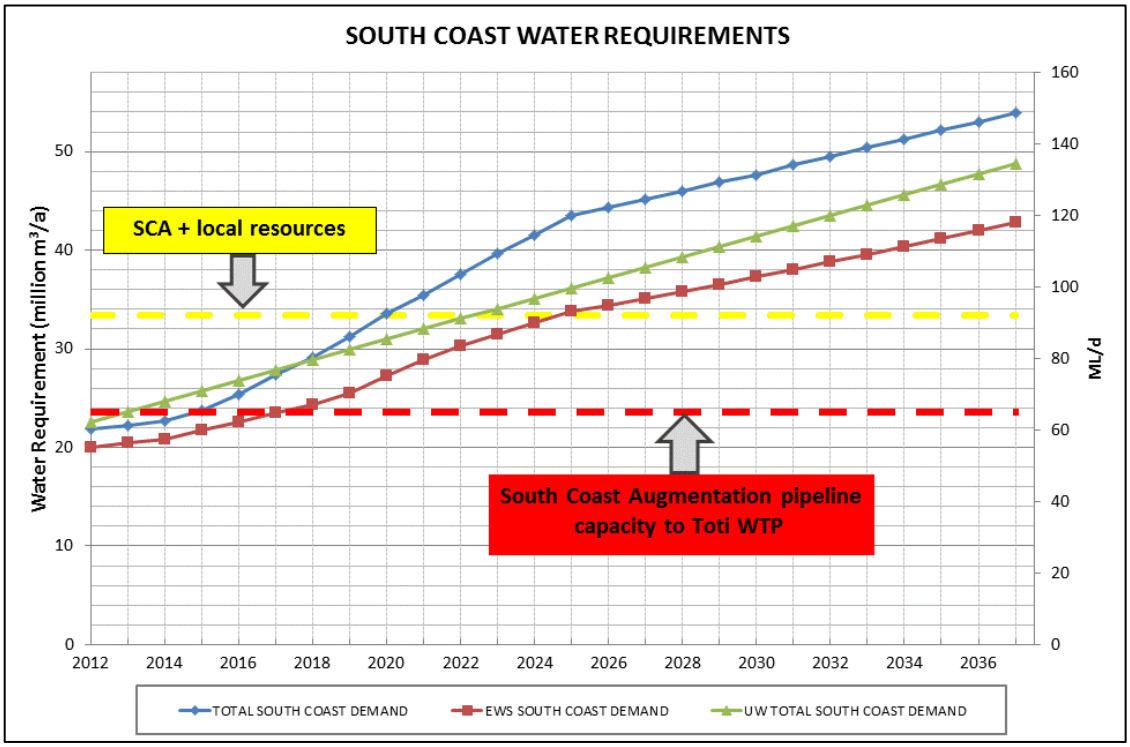

Figure 3.5: South Coast water requirement projection scenarios

In order for the full water requirements of the South Coast to be satisfied in future, an additional water resource needs to be found to augment or replace supply from the Mgeni WSS. For this purpose the options of either the desalinisation of sea water or the proposed Ngwadini off-channel storage dam are currently being considered as part of the recently commissioned DWA study *Continuation of the Reconciliation Strategy of the KwaZulu-Natal Coast Metropolitan Area: Phase 2*. For the purpose of comparison, URVs were determined for the uMWP-1, desalination and Ngwadini Dam as part of this *Feasibility Study* and the results are discussed in *P WMA 11/U10/00/3312/3/1/6: Supporting Document 6: Economic Comparison of the uMkhomazi-Mgeni Transfer Scheme with Desalination and Re-use Options Report* (AECOM, et al., 2014). Projected water requirement for this area are expected to grow from the current 22 million m^3/a to 40 million m^3/a in 2023 and 55 million m^3/a in 2040.

3.2.4 Remainder of the Mgeni WSS

Water requirement projections for the remaining sub-areas of the Mgeni WSS (shown earlier in **Figure 3.2**) were developed largely based on the *September 2011 Scenario* for the system obtained from Umgeni Water. This projection is updated annually by Umgeni Water based on actual recorded sales figures and an assumed long-term annual growth rate of 1.5%. It should be noted that the *September 2011 Scenario* projection was also adopted for the most recent

update of the DWA *Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas* discussed earlier in **Section 3.1**.

More information on each of the sub-areas in question is provided below:

- ***Upper Mgeni:*** Areas such as Pietermaritzburg and Howick fall within the supply area of Midmar Dam. The water requirements projection was developed based on the annual growth rate of 1.5%, as adopted for the *September 2011 Scenario*, and recorded sales figures obtained from Umgeni Water for the area in question.
- ***Wiggins:*** Low lying areas in southern and central eThekwini supplied from Wiggins WTP. The water requirement projection was obtained from the *September 2011 Scenario*.
- ***Durban Heights Remainder:*** Defined as the area currently supplied from Durban Heights WTP but excluding those areas that will be supplied from the proposed uMWP-1 through the Western and Northern aqueducts (as discussed earlier in **Section 3.2.1**). The water requirement projection was developed based on the projection for the entire Durban Heights supply area obtained from the *Module 3: Technical Feasibility Study: Potable Water* (Knight Piésold, 2014) and subtracting the projected requirements for the portions of that will be supplied from the uMWP-1.
- ***Industrial re-use***: Industrial users that make use of treated effluent. These were kept unchanged and capped at 8.8 million m^3/a.

3.2.5 Total Mgeni WSS

A water requirement projection for the total Mgeni WSS was developed based on the individual projections for each of the defined sub-areas of the system discussed in the above subsections and the results are presented in both **Table 3.2** and on the updated water balance in **Figure 3.6**. As such, the projection includes additional water requirement volumes for the expanded supply area along the North and South Coast, which is of great importance because this (i) ensures that the associated expansion of the Mgeni WSS is adequately accounted for in the planning process; and (ii) allows for comparison of the uMWP with other augmentation options identified for supplying the North and/or South Coast areas. It should be noted that the integrated planning of these other interventions and possible prioritisation and phasing will be addressed as part of the *Continuation of the Reconciliation Strategy of the KwaZulu-Natal Coast Metropolitan Area: Phase 2* study.

Table 3.2: Long-term water requirement projection for the Mgeni WSS (updated)

Supply area	Water requirement (million m3/a) for indicated level of development								
	2013	2015	2020	2025	2030	2035	2040	2045	2050
Outer West Area	29.0	31.0	36.1	41.2	46.3	51.4	56.5	61.6	66.7
Western Aqueduct	57.8	58.4	67.2	68.7	70.2	71.7	73.2	74.7	76.1
Northern Aqueduct	24.1	26.5	34.1	43.7	53.9	64.1	74.4	84.5	94.5
South Coast	12.2	13.7	23.6	23.8	23.8	23.8	23.8	23.8	23.8
Upper Mgeni	80.6	83.0	89.4	96.2	103.0	109.8	116.7	123.7	130.7
Wiggens	81.4	83.1	89.5	96.5	103.9	111.9	120.6	129.6	138.5
Durban Heights Rem.	104.0	106.0	118.3	123.2	128.1	133.0	137.9	142.9	148.1
Industrial re-use	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Total	**397.9**	**410.6**	**467.2**	**502.0**	**537.9**	**574.5**	**611.8**	**649.5**	**687.1**

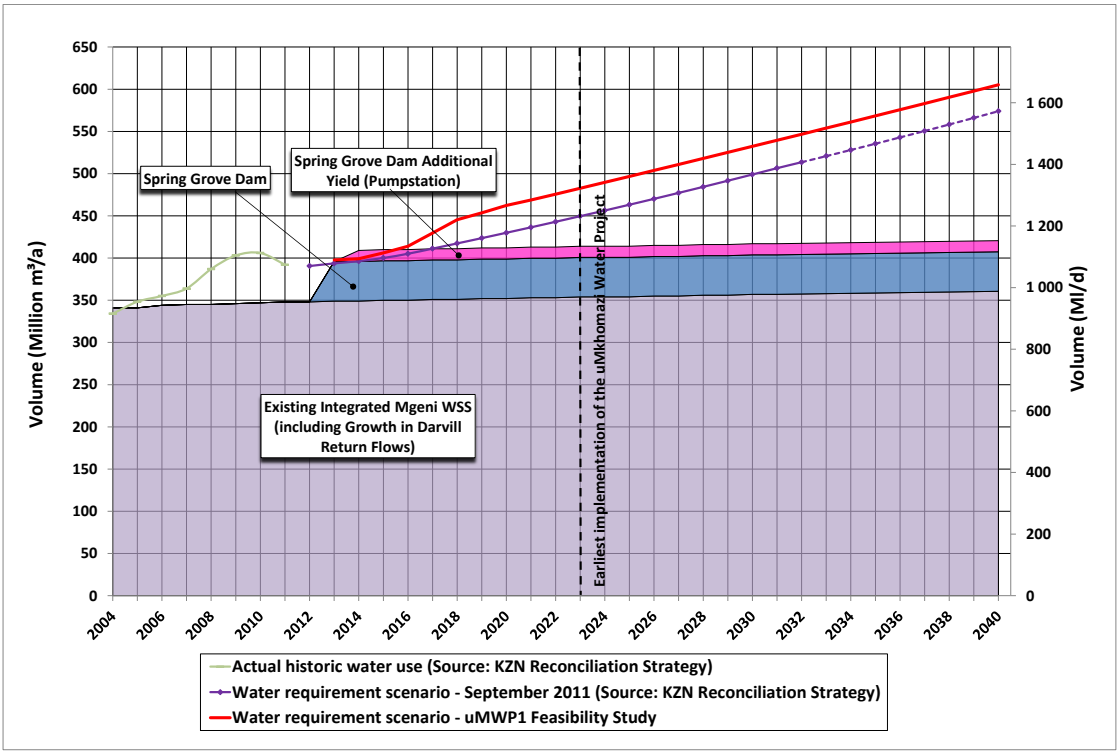

Figure 3.6: Long-term water requirement projection for the Mgeni WSS (updated)

Finally it should be noted that during the *Feasibility Study*, some tasks had to be completed at an early stage to ensure the study program was adhered to. This included the initial selection of the Smithfield Dam site as well as the conveyance infrastructure. These tasks had to be conducted based on ***existing or preliminary water requirement projection and resource yield information available at the time***, which was only updated at a later stage (as discussed

earlier in this report). A summary of the relevant sources of information is provided in **Table 3.3** and the associated study reports are listed below:

- *P WMA 11/U10/00/3312/2/3/1/2 Supporting Document 2: Dam Position Report*.
- *P WMA 11/U10/00/3312/2/3/1/3 Supporting Document 3: Optimization of Scheme Configuration*.

More detail on the sources of data and assumptions included in the preliminary water requirement projections are included in **Appendix F**. In this regard it should be noted that the team assessed the changes between the preliminary and final water requirements and deemed that it was not necessary to re-do work as a result thereof.

Table 3.3: Summary of the application of preliminary water requirement projections for the uMWP-1 and Mgeni WSS

Water supply area	Source of information	
	Water requirement projections and footprint areas	Resource yields
uMWP-1	(Knight Piésold Consulting, 2010)	(Ninham Shand, Mkomazi/Mooi-Mgeni Transfer Scheme Pre-feasibility Study; Mkomazi-Mgeni Transfer Scheme: Supporting Report No.4 - Hydrology & Water Resources (PB U100-00-0899), 1999)
Mgeni WSS	(WRP, DMM, Golder, Kv3, & Zitholele, Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas; Executive Summary (PWMA 11/000/00/1107), 2009)	(WRP, DMM, Golder, Kv3, & Zitholele, Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas; Executive Summary (PWMA 11/000/00/1107), 2009)

Note: With adjustments made by the Study Team as required.

3.3 SHEDDING OF WATER REQUIREMENTS ONTO THE UMWP-1

As mentioned in **Section 2.2**, the uMWP-1 will not immediately supply the full volume required by the uMWP-1 supply area. The rationale behind this is that the capacity of the uMWP-1 WTP, to be located near Baynesfield, will only be increased as required – thereby deferring large capital expenditure until existing infrastructure in the Mgeni WSS is fully utilised. This anticipated growing volume to be supplied needs to be estimated for the purposes of phasing the infrastructure of the uMWP-1 and, in particular, the Baynesfield WTW. The phasing of water requirements onto the uMWP-1 is also required for estimating the hydropower potential of the uMWP-1 as a secondary benefit.

Water requirements of the Western and Northern aqueducts will be shed onto the uMWP-1 once Durban Heights WTP reaches its operating capacity of 500 to 550 Mℓ/d (approximately 80% of its design capacity of 615 Mℓ/d). The *Module 3: Technical Feasibility Study: Potable Water* study team conducted an exercise of determining the required phasing of water requirements onto the uMWP-1. This was undertaken by considering the operation capacity of Durban Heights WTP, as well as other key infrastructure capacity constraints. This provided an indication for the likely phased increases in the capacity of the Baynesfield WTP. Detailed information in this regard is provided in the *Module 3* report on *Water Demand Projections and Phasing of Infrastructure* (Knight Piésold, 2014).

However at the time of conducting the hydropower potential assessment, this detailed plan for phasing of water supply onto the uMWP-1 was not yet available. As such, an exercise was conducted by the *Module 1: Technical Feasibility Study: Raw Water* study team to estimate the likely shedding of supply onto the uMWP-1 by adding the water requirement of the ***Outer West Area*** (as discussed in **Section 3.2.1**) to the shed volume from Durban Heights WTP. This preliminary theoretical growing volume will, in reality, occur in a more stepwise manner, as later indicated by the planning of the *Module 3: Technical Feasibility Study: Potable Water* study team, but the initial estimate was considered sufficient for the purposes of establishing the hydropower potential and viability thereof as a secondary benefit. The *Water Resources Planning Model* (WRPM) was later used to assess the hydropower potential of the uMWP-1 transfer. Further to this, the WRPM was also used to test the proposed shedding of supply onto the uMWP-1 from a water resources limitation perspective. Further information on these analyses is provided in the *P WMA 11/U10/00/3312/2/4 - Water Resources Planning Model Report* (AECOM et al., 2014).

The preliminary theoretical water transfer volume with shedding of water requirements onto the uMWP-1 is presented in **Figure 3.7**. The figure shows that, by 2023, which is the earliest implementation date for the uMWP-1, the volume estimated for the uMWP-1 is approximately 100 million m^3/a. In addition the full shedding of water requirements onto the uMWP-1 occurs by around 2040.

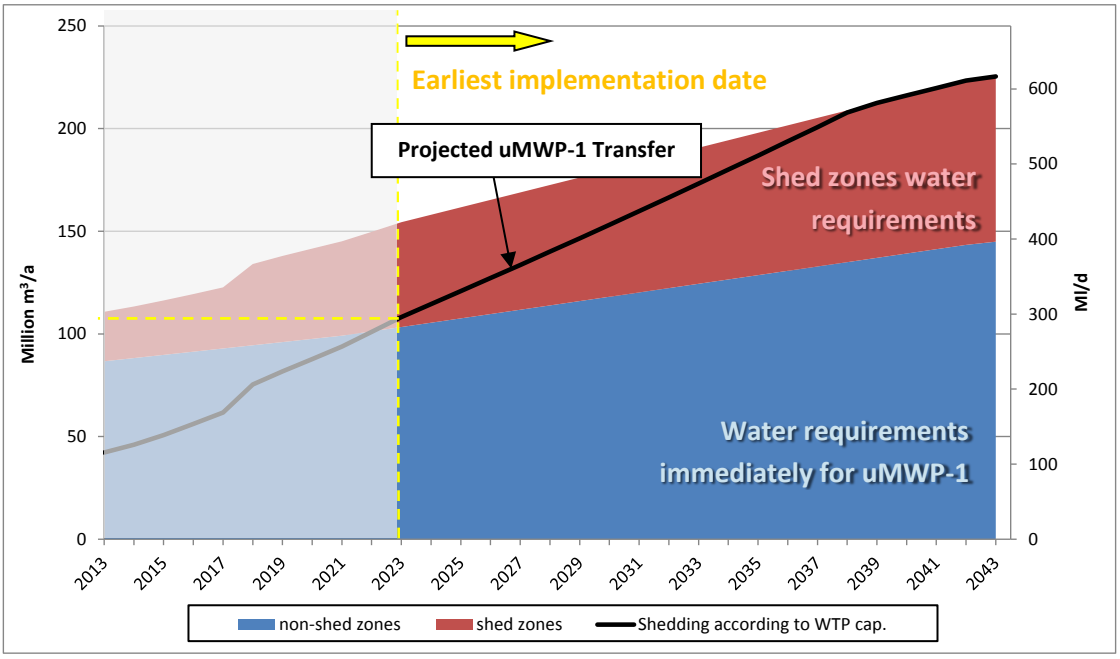

Figure 3.7: Projected water supply from uWMP-1 with shedding from Durban Heights (preliminary)

4 CONCLUSIONS

The historical, existing, as well as projected water requirement scenarios were developed for the entire study area, including separate estimates for various supply areas including:

- The uMkhomazi River catchment.
- The upper uMlaza River catchments, where the proposed uMWP balancing dam and water treatment works at Baynesfield are to be located.
- The integrated Mgeni WSS.
- The uMWP-1 water transfer supply area within the Mgeni WSS.

Pertinent conclusions in this regard are provided below.

- The uMkhomazi River catchment is currently fairly undeveloped, with the notable exception of extensive tracts of commercial forestry and irrigated areas in the central catchment areas around the towns of Richmond, Ixopo, Bulwer and Impendle, as well as water abstractions for SAPPI-SAICCOR.
- The current net water use within the uMkhomazi River catchment totals 159 million m^3/a (15% of the total natural MAR of the catchment) and based on the selected water requirement projections it is estimated that this may grow to 192 million m^3/a by 2050.
- In contrast, the upper uMlaza River catchment is highly developed, predominantly for the cultivation and irrigation of sugarcane and vegetables, with a total current net water requirement of 36 million m^3/a (over 60% of the natural MAR).
- Water requirement projections were not developed for the upper uMlaza River catchment since the proposed uMWP balancing dam will be located on a small tributary of the uMlaza River and it is unlikely that further development will be allowed within the small upstream catchment area.
- The uMWP-1 is intended to augment the water supply of the Mgeni WSS, by supplying water into a portion of the system with a current total water requirement of approximately 400 million m^3/a.
- Water from the uMWP-1 will feed the Outer West area will be distributed through the Western and Northern Aqueducts to users currently fed by the Durban Heights WTP, thereby reducing the load on the existing resources in the Mgeni WSS.

- The supply from the uMWP-1 is planned to be increased as the infrastructure in the Mgeni WSS reaches its operating capacity. This means that water use will be shed off the Mgeni WSS onto the uMWP in such a way that makes full utilisation of the existing bulk infrastructure, and delays unnecessary capital expenditure.
- The projected water requirements for the identified area to be augmented by the uMWP-1 grow from approximately 110 million m^3/a in 2013 to around 230 million m^3/a in 2050. The anticipated water requirements in 2023, the earliest possible implementation date of the uMWP-1, are in the order of 150 million m^3/a.
- Based on the above as well as updated water requirement projections for other areas within the Mgeni WSS, including the expanded supply area along the North and South Coast, a new water requirement projection scenario was developed for the system as a whole. According to this scenario the total system water requirement will grow from the current 398 million m^3/a to around 480 million m^3/a in 2023 and 612 million m^3/a in 2040.

5 RECOMMENDATIONS

Based on the results presented in this report and the conclusions in **Section 4**, the following recommendations are made:

- Estimates of historical water use in the uMkhomazi and upper uMlaza river catchments should be used in the hydrological analysis of this *Feasibility Study* for the purpose of rainfall-runoff model calibration and the naturalisation of gauged stream flows for the catchments in question.
- Projected water requirement scenarios developed for the uMkhomazi River catchment should be used for assessing the potential impacts of future in-catchment developments on the yield of both phases of the uMWP, namely Smithfield and Impendle dams.
- Projected water requirement scenarios developed for the uMWP-1 transfer supply area, as well as for other supply areas within the Mgeni WSS, should be used for the purpose of future system water availability and water balance assessments.
- Some activities involved in determining water requirement projections for the Mgeni WSS overlapped with the scope of the recently commissioned DWA study *Continuation of the Reconciliation Strategy of the KwaZulu-Natal Coast Metropolitan Area: Phase 2*. That study should therefore aim to integrate the uMWP-1 supply area information into the Mgeni WSS and also to ensure that the level of detail of the remaining portions of the Mgeni WSS is brought up to a similar level of detail. (It must be noted, more of a reminder than a recommendation, that it is important to ensure that the double-counting or omission of water users does not occur. In addition, the return flow volumes resulting from the new water requirement projections must be updated accordingly and the resulting impact on the Mgeni WSS verified.)
- Water requirement and return flow projection scenarios presented here were developed based on a number of assumptions and limitations as described in the report. It is therefore recommended that the actual water use and return flows in the study area should be monitored and that, as part of the *Reconciliation Strategy* and other relevant initiatives, projections are continuously re-evaluated and revised accordingly.

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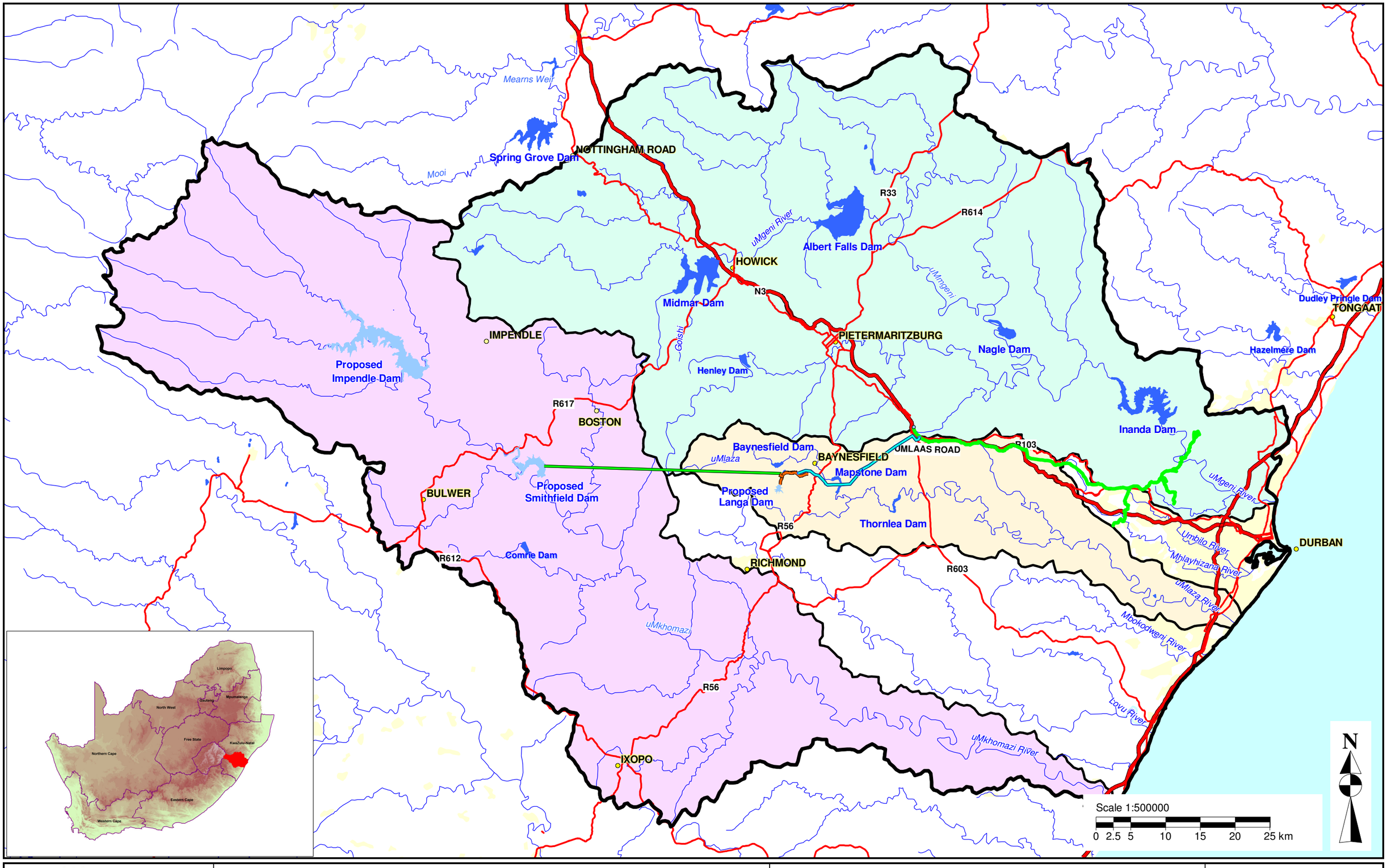
Appendix A

Figures



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AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water (uMWP1-1/RW) Locality map - Study area

Legend

- Project Area
- Towns
- Rivers
- Proposed Dams
- Roads
- National Route
- Roads
- Proposed Conveyance Structure
- Western Aqueduct (eThekwini Municipality)
- Raw Water Pipeline
- Potable Water Pipeline

FIGURE A.1

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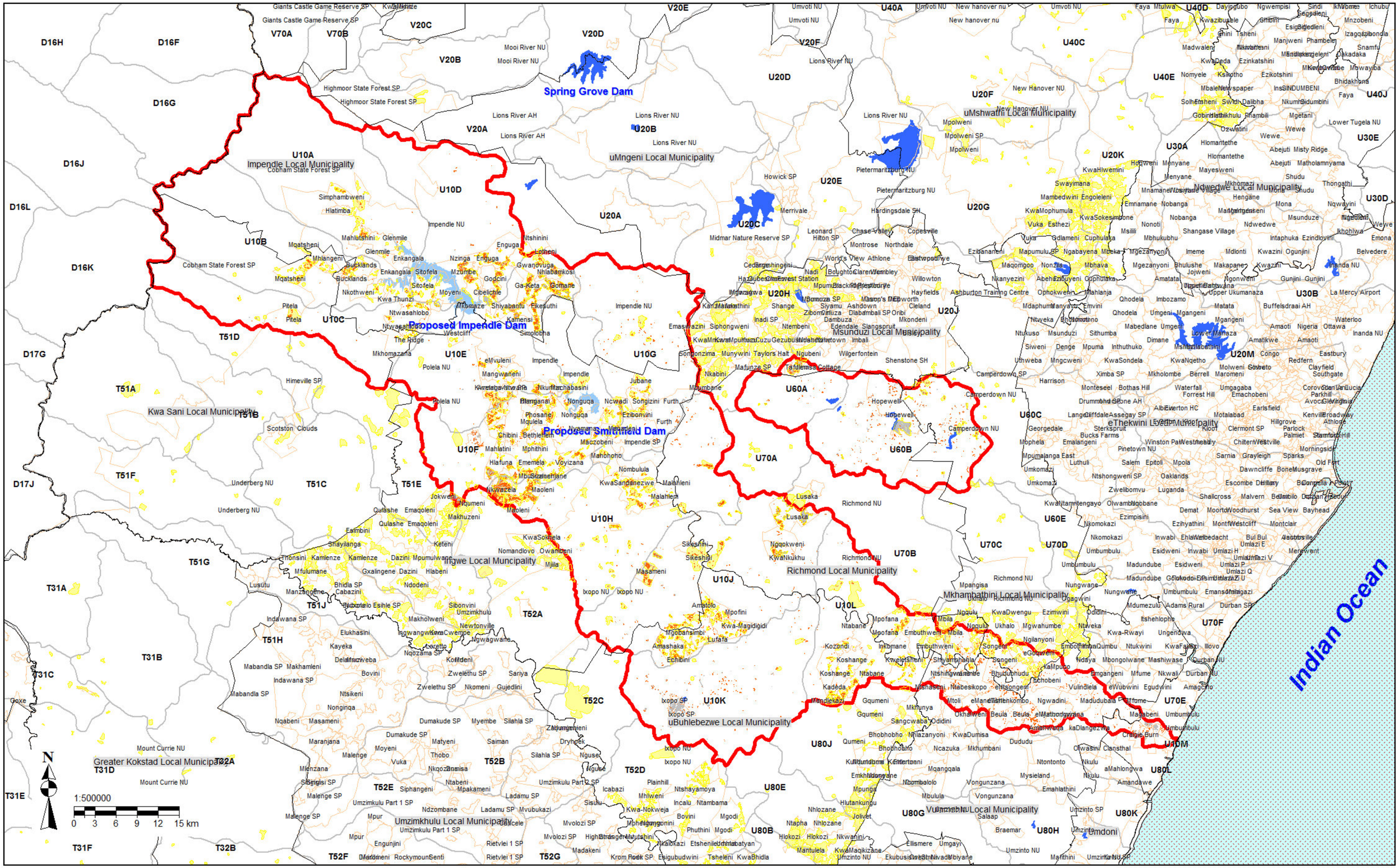
View Ref:	Locality Map
Project No:	J01763



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AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water (uMWP1-1/RW) Sub-places/enumerator areas within the study area

Legend

- uMkhomazi & Upper uMlaza River Catchments
- Quaternary Catchments
- Local Municipalities
- Sub-Places/Enumeration Areas
- SP_SA(Sub Places)
- Proposed Dams
- Existing Dams
- Communities

SPOT 5 LAND USE DATA

- Built up dense settlement
- Low density settlement

FIGURE A.2

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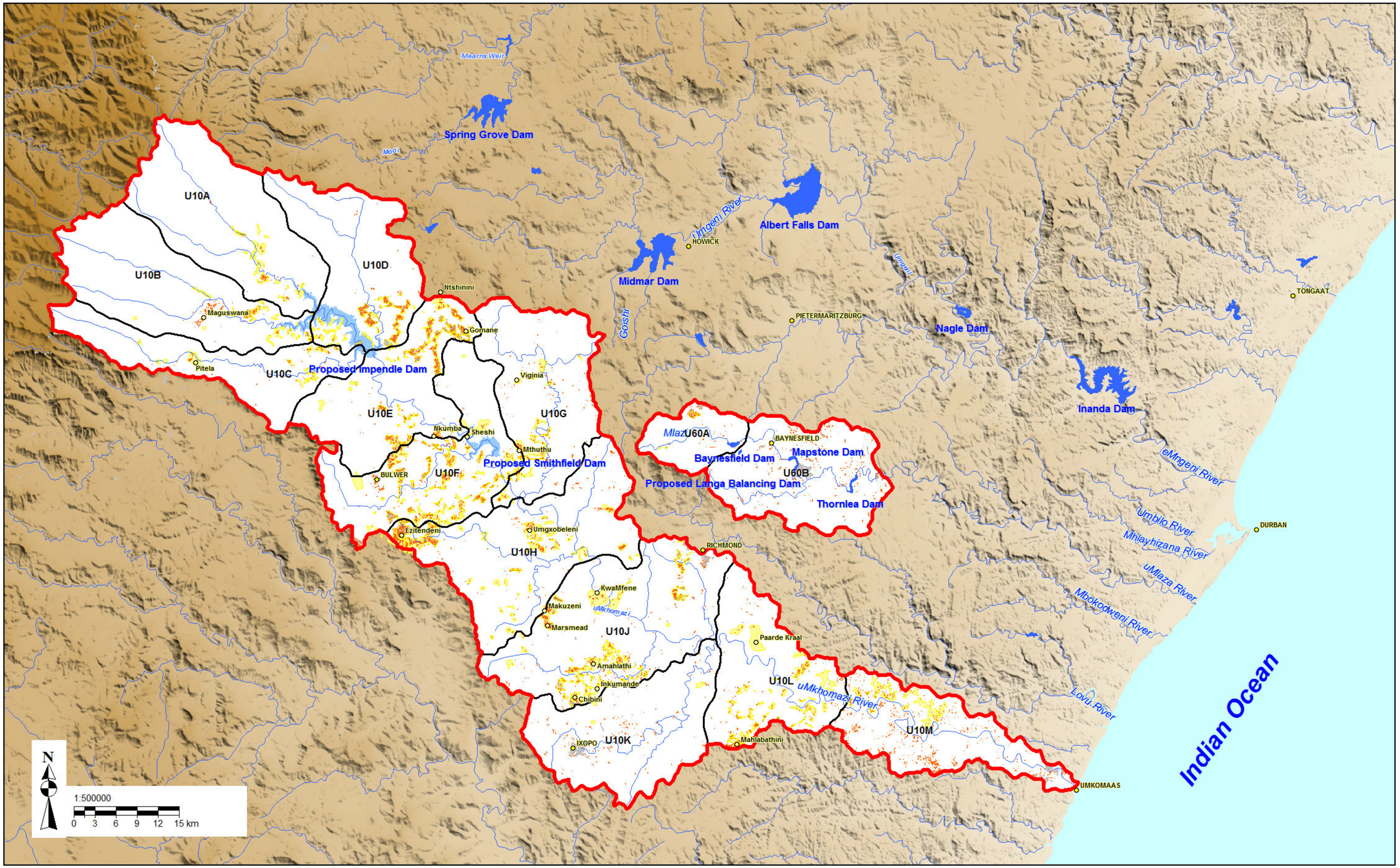
Project No:	J01763



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AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Urban and rural settlements within the study arera

Legend

- uMkhomazi & Upper uMlaza River Catchments
- Quaternary Catchments
- Proposed Dams
- Existing Dams
- Rivers
- Minor Towns
- Communities

SPOT 5 LAND USE DATA

- Built up dense settlement
- Low density settlement

FIGURE A.3

Drawn:	LC Gallagher
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View Ref:	Urban and rural settlements study arera
Project No:	J01763

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Department: Water Affairs
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Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Municipal areas within the study area

Legend

- uMkhomazi & Upper uMlaza River Catchments
- Qautenary Catchments
- District Municipalities
- Local Municipalities
- Proposed Dams
- Rivers

FIGURE A.4

Drawn:	LC Gallagher
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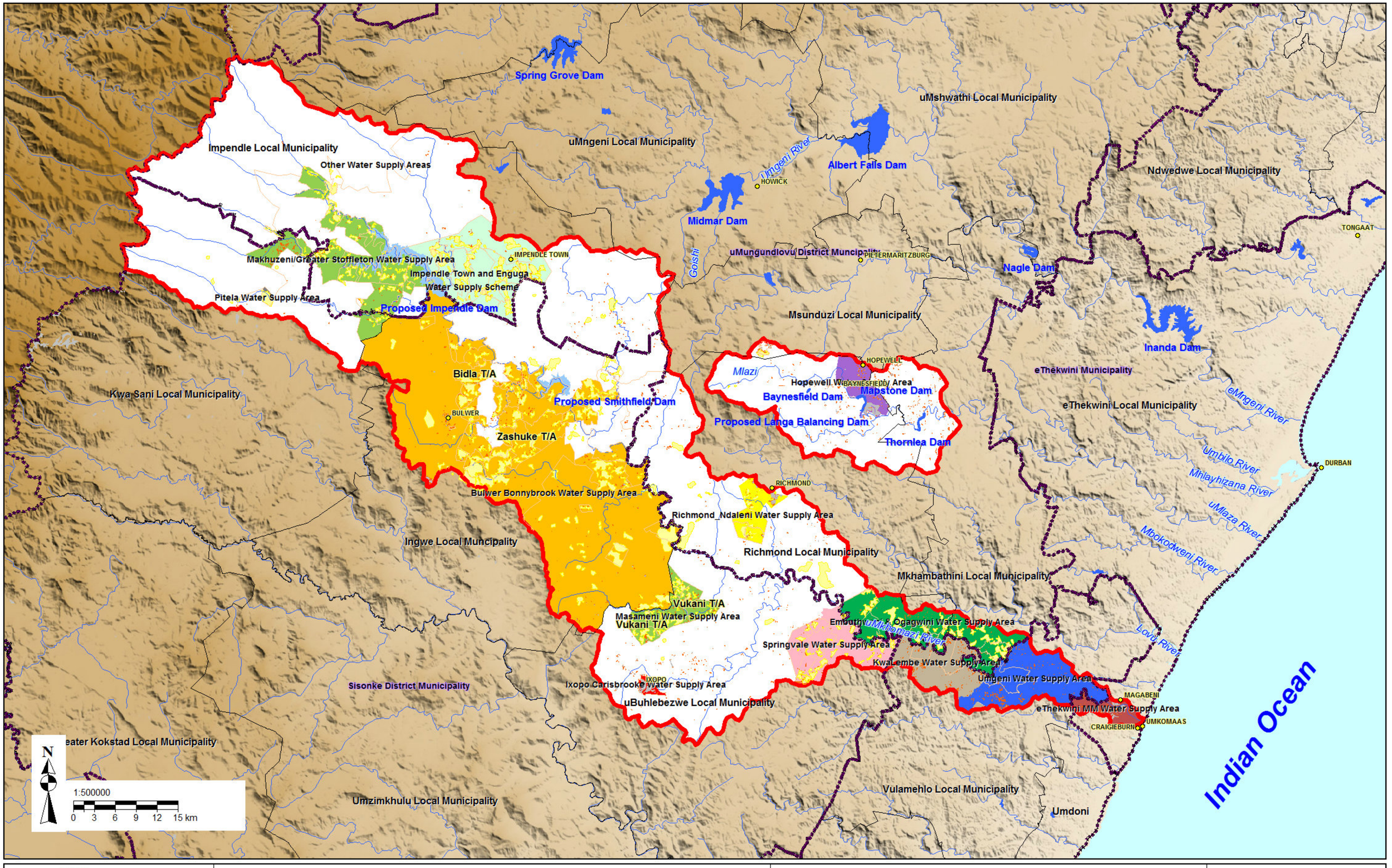
View Ref:	Municipal Areas
Project No:	J01763



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Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Water supply areas within the study area

Legend

- uMkhomazi & Upper uMlaza River Catchments
- District Municipalities
- Local Municipalities
- Sub Places/Enumeration areas
- Rivers
- Proposed Dams
- Existing Dams
- Communities

Water Supply Areas

- Other Water Supply Areas
- Umgeni Water Supply Area
- eThekwini MM Water Supply Area
- KwaLembe Water Supply Area
- Embuthweni & Ogagwini Water Supply Area
- Springvale Water Supply Area
- Hopewell Water Supply Area
- Richmond/Ndaleni Water Supply Area
- Masameni Water Supply Area
- Ixopo Carisbrooke Water Supply Area
- Bulwer Donnybrook Water Supply Area
- Makhuzeni/Greater Stoffleton Water Supply Area
- Impendle/Town and Enguga Water Supply Area
- Pitela Water Supply Area

SPOT 5 LAND USE DATA

- Built up dense settlement
- Low density settlement

FIGURE A.5

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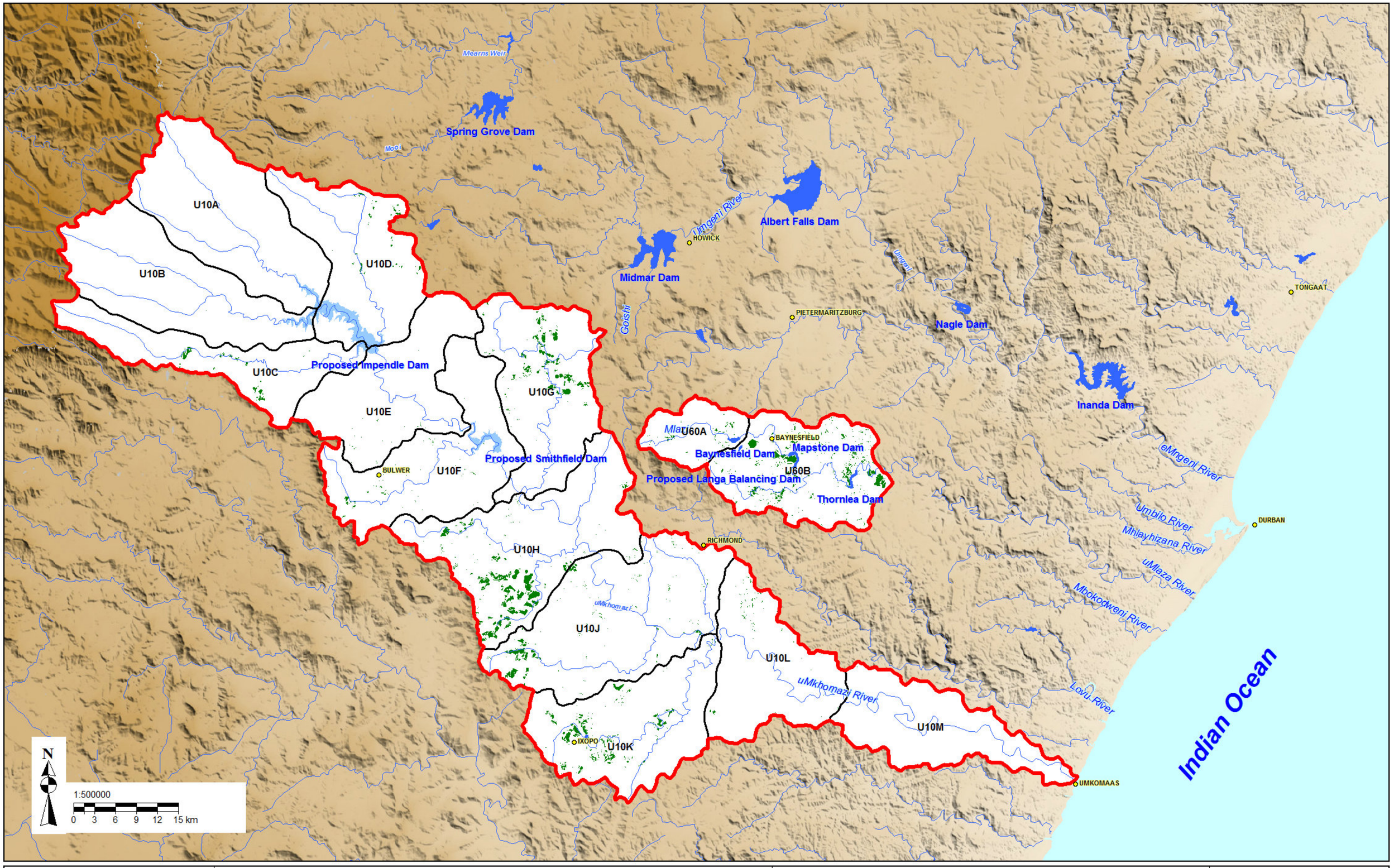

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Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Irrigated areas at the 2008 - development level

Legend

- uMkhomazi & Upper uMlaza Catchments
- Quaternary Catchments
- Major Towns
- Proposed Dams
- Existing Dams
- Rivers

SPORT 5 LAND USE DATA

- Irrigation

FIGURE A.6

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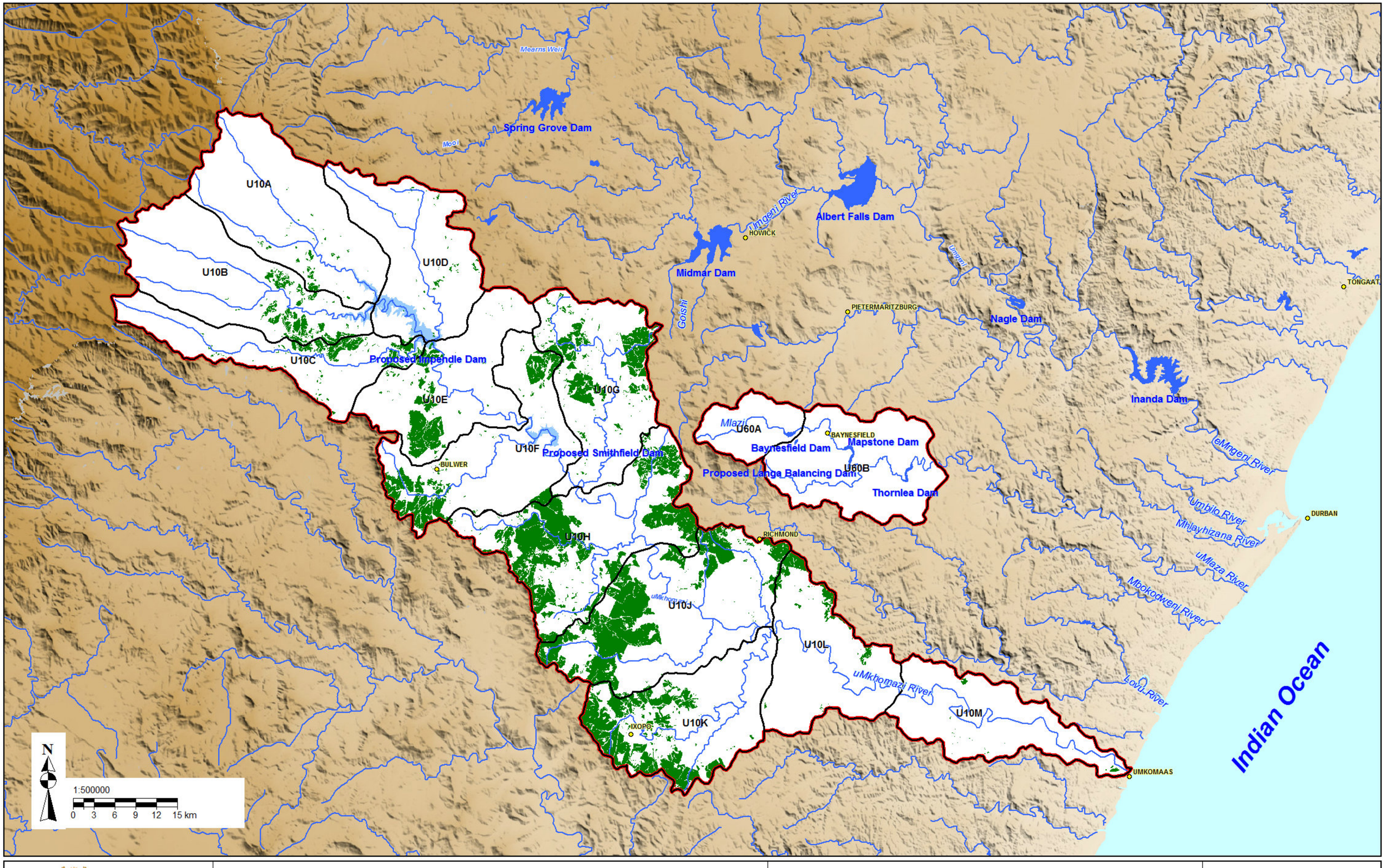

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Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Areas under commercial forestry at the 2008 - development level

Legend

- uMkhomazi & Upper uMlaza Catchments
- Quaternary Catchments
- Major Towns
- Proposed Dams
- Existing Dams
- Rivers

SPOT 5 LANDUSE DATA

- Commercial Foretry

FIGURE A.7

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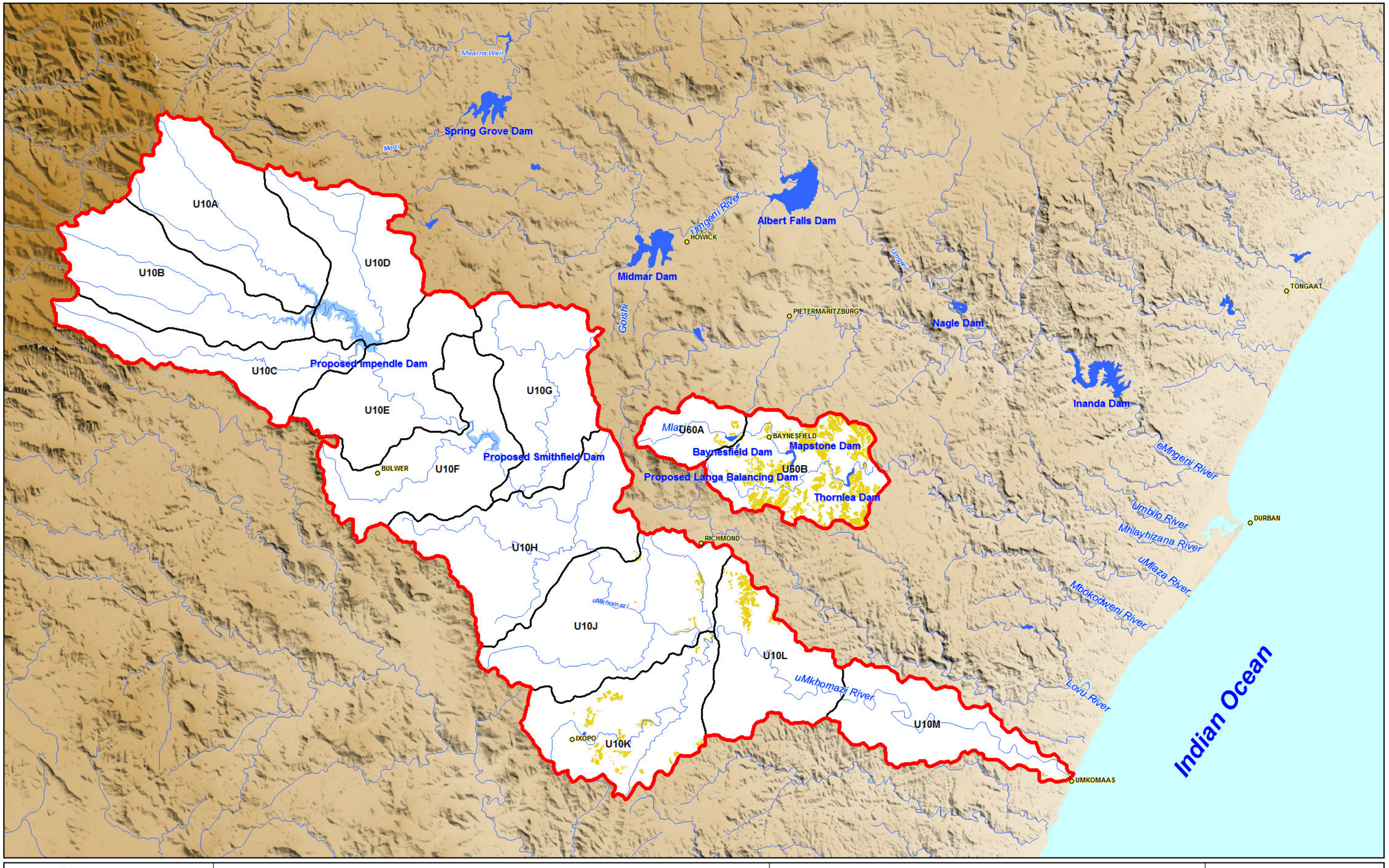

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Project Name :

uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water (uMWP1-1/RW) Areas under level dry-land sugarcane at the 2008 - development level

Legend

- uMkhomazi & Upper uMlaza Catchments
- Quaternary Catchments
- Major Towns
- Proposed Dams
- Existing Dams
- Rivers

SPORT 5 LAND USE DATA

- Dry-land surgarcane

FIGURE A.8

Drawn:	LC Gallagher
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View Ref:	Irrigation Areas
Project No:	J01763

Legend

- eThekwini Municipality Border

Proposed Footprints

- uMWP WSA
- North Coast WSA from Tongaat Desal Plant
- South Coast WSA from Ngwadini Dam/Lovu Desal Plant
- Suburbs
- Umgeni Water Infrastructure
- eThekwini Municipality Infrastructure
- Umbumbulu - Eston Pipeline (Umgeni Water)
- Western Aqueduct (eThekwini Municipality)
- Western Aqueduct (Umgeni Water)

Albert Falls Dam
Midmar Dam
Henley Dam
Baynesfield Dam
Nagle Dam
Hazelmere Dam
Dudley Pringle Dam
uMungundlovu District Municipality
eThekwini Municipality
Indian Ocean

Njengabantu, Nadi, Mtulwa, Mbulwane, Ngwempisi, Sindi, Mhlangakazi, Nhlakazi, Ohlange, Mvozana, Ikhabane, Ichubu, Madundube, Faya, Kwazibusele, Esigedleni, Chibini, Izagqaya, Glen Mill, Chini, Manjweni, Madwaleni, Nkivane, KwaSathane, KwaQwabe, iLembe, Makhovane, KwaDeda, Nomyele, Newspaper, Ezikotshini, Msikeni, Insuze, Hanguza, Solhem, Swidi, Dalibha, Phambili, Sidumbini, Malende, Hlathikhulu, Ozwathini, Wewe, Etete, Nkobongo, Abejuti, Matholamnyama, KwaHlwemini, Hlomantethe, Mayesweni, Swayimana, Menyane, Thongathi, Mkhomazi, Engoleleni, Mnamane/ Usuthu, Shudu, Mangangeni, Mona, KwaMophumula, Nobanga, Nqwayini, Makhuluseni, Vuka, Odlameni, Nonoti, Msilili, Shangase Village, Ndwedwe, Wewe, Tugela, Merrivale, Hardingsdale SH, Copesville, Chase Valley, Emona, Ezibananeni, Cuphulaka, Mbhukubhu, Imeme, Mdlonti, Kwazini, Ogunjini, Belvedere, Montrose, Bishopstowe, Cedarge, Wembley, Eastwood, Nadi, Maqomgoo, Nonzila, Enbuyeni, Mbeka, Amatata, Gunjini, Redcliffe, La Mercy Airport, Haza, Chaewe, Prestbury, Scottsville, Nkanyezini, Cuphulaka, Ngudlintaba, Ngonweni, Abehuzi, Imbozamo, Matata, Ezibomvini, Caluza, Smeroe, Mason's Mill, Emvini, Qhodela, Buffelsdraai AH, Shange, Dambuza, Cleland, Ntweka, Bhobhonono, Umgeni, Ottawa, Bisley, Mgangeni, Siphongweni, Ntembeni, Newtown, Ntukuso, Nonoti, Mabedlane, Amatikwe, Amaoti, Inhlazatshe, Imbali, Siweni, Mpuma, Lower Manaza, Taylors Halt, Ngubeni, Wilgerfontein, Uthweba, Harrison, Sithumba, Dimane, Mshazi, Eastbury, Molweni, Soweto, Mimosa Cottage, Shenstone SH, Esikhelekehleni, Mkholombe, Cato Ridge, Maromeni, Southgate, Ntuzuma C, Hopewell, Forrest Hill, Corovoca, La Lucia, Ntuzuma A, Hillcrest, Avoca, Virginia, Motalabad, Earlsfield, Langeni, Everton, Kloof, Parlock, Parkhill, Mophela, Sterkspruit, Winston Park, Palmiet, Mpumalanga East, Ashley, Grayleigh, Umkomazi, Mandlakazi, Epitoli, Mpola, Nazareth, Bonela, Old Fort, Zwelibomvu, Oaklands, Durban, Pointe, Olwambeni, Nqobane, Shallcross, Congella, Ezimpisini, Woodhurst, Sea View, Fynnlands, Demat, Inwabi, Nkomokazi, Montford, Jacobs, Lusaka, Ezinyathini, Umlazi H, Umlazi V, Merewent, Mgandleni, KwaNkukhu, Umbumbulu, Madundube, Esidweni, Isipingo Beach, Umlazi U, Mpangisa, Nungwane, Ukhalo, Emansomini, Ezimwini, Mdumezulu, Adams Rural, Mpofini, Kwa-Magidigidi, Mpofana, Mgwahumbe, Ogagwini, Ungendwa, Ngqulu, Kwa-Rwayi, Embuthweni, Mbila, Ngilanyoni, Ntweka, Ntukwini, KwaFakazi, Kozondi, Inkumane, Illovo, Songeni, eGoqweni, kaMpuco, Mbongolwane, Koshange, Ntshingwana, Nkwali, Kweletsheni, kaMampungushe, Ndaya, eWubwini, Ntabane, KwaLembe, Echobeni, Ntabesikopo, Mfume, Kadeda, Ngwadini, Vulindlela, Mtoli, eMandlalathi, Umbumbulu, Gqumeni, Mkhunya, Odidini, Beula, Madudubala, Sangcwaba, kaDlangezwa, Clansthal, Qumeni, KwaDumisa, Dududu, Bhobhobho, Ncazuka, Emkhubane, Ehlanzeni, Nkulu, Ntontonto, Ndonyane, Ncombololo, Vongunzana, Mysieland, Amandawe, Mpunga, Jolivet, Salaap, Mgodi, Ntapha, Nkwanini, Braemar, Umzinto, Ellismere, Umhlabatyan, Mantulela, KwaMaqikizane, St. Nivads, Mbiyane, KwaBhidla, Hlokozi, Amangamazi, Mhlabatshane, Hlokozi, Thyavini, Umgai, Uswani, Phungashe, Kagoleta, Gugha, Magwaza, Shozi, Mpongozini, Kwasosibo, Sangqu, KwaNkalokazi, Quha, Shabane, Nkwazi, Sipofu, Umzinto AH, uMzumbe, Vulkani, Phongolo, Deyi, Bombo, Nkangala, Wowana, Dinsi, Goba, KwaBombo, Nyonyana, Inselele, Gumatane, Ngcengesi, Nkulu, Odeke, Dibi, Nyangwini, Inkulu, Taleni, Mabheleni, Ixopo, KwaBangibizo, Ndumakude, Msinsini, Cathula, Ngcazolo, Mbonje, Mnamfu, Sidaka, Sunduza, Mvozana, Mayekeni, Hlanzeni, Velumemeze

Scale 1:400000

0 3 6 9 12 15 km

N

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

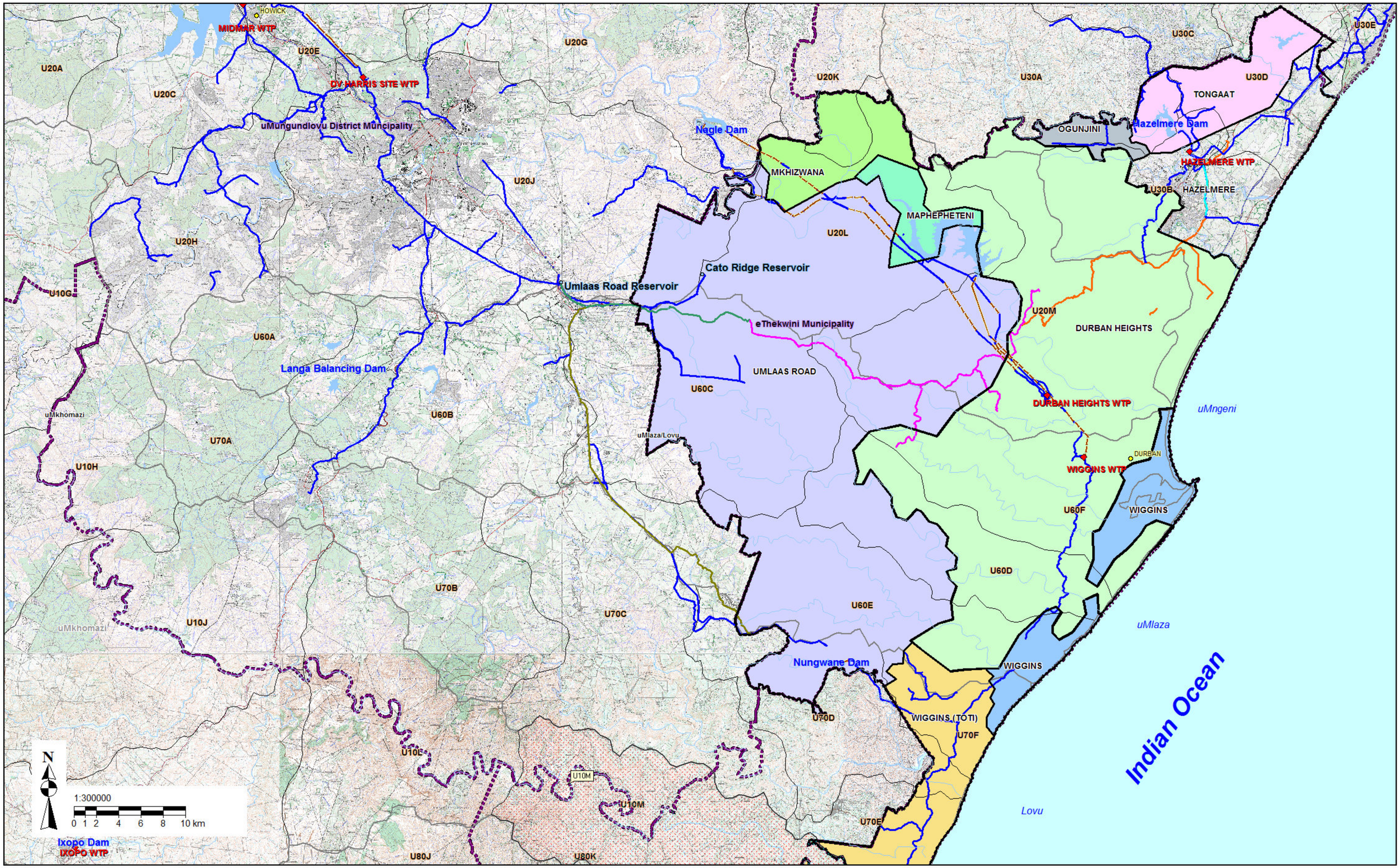
AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Proposed water supply areas: uMWP, North Coast and South Coast

FIGURE A.9

Drawn:	LC Gallagher
Checked:	A Combrinck
Date:	2014-03-04
Map Ref:	uMkomzi.map
View Ref:	South Coast Water Supply Area
Project No:	J01763



water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water (uMWP1-1/RW) Recently constructed Western Aqueduct and planned extension of the Northern Aqueduct

Legend

- Quaternary Catchments
- eThekwini Municipality Border
- Umgeni Water Operated Infrastructure
  - Proposed Northern Aqueduct (UW)
  - Proposed uMkhomazi Potable Water Pipeline (UW)
  - Umbumbulu - Eston Pipeline (Umgeni Water)
  - Existing Hazelmere to Waterloo Pipeline (UW)
  - Proposed Western Aqueduct (UW)
  - Umgeni Water Tunnels
- Water Treatment Plants
- Existing UW WTP Supply Areas
  - DURBAN HEIGHTS
  - HAZELMERE
  - MAPHEPHETENI
  - MKHIZWANA
  - OGUNJINI
  - TONGAAT
- UMLAAS ROAD
- WIGGINS
- WIGGINS (TOTI)

FIGURE A.10

Drawn:	LC Gallagher
Checked:	A Combrinck
Date:	2014-03-04
Map Ref:	uMkomzi.map
View Ref:	Stream flow gauging
Project No:	J01763

Appendix B

Domestic water supply areas

Table B-1: Summary of domestic water supply areas

Water Supply Area (WSA) (from the *Development of a Reconciliation Strategy for All Towns in the Eastern Region*) *(formal urban centre within WSA)*	Within District Municipality (DM)	Source of water	Water purification works (WPW)	Wastewater Treatment Works (WwTW)	Point of return flows
Bulwer Donnybrook Water Supply Area	Sisonke DM	**(1) GW:** Boreholes (Donnybrook & Highflats) and springs (Bulwer) **(2) SW:** Supplemented from weir on the Mkobeni River	Bulwer WPW only formal WPW within this WSA	Bulwer WwTW only formal WwTW within this WSA	N/A
(Bulwer)	*Sisonke DM*	***(1) GW:** Boreholes & springs (6 km NW of the town)* ***(2) SW:** Supplemented from weir on the Mkobeni River (during winter months - 1/3 of the supply)*	*Bulwer WPW*	*Bulwer WwTW*	*Mkobeni River*
Ixopo/Carisbrooke Water Supply Area	Sisonke DM	**(1) SW:** Ixopo (Homefarm/Solly Butler Dam) on the Xobho River **(2) GW:** Boreholes	Ixopo WPW only formal WPW within this WSA	Ixopo WwTW only formal WwTW within this WSA	N/A
(Ixopo)	*Sisonke DM*	***(1) SW:** Ixopo (Homefarm Dam/Solly Butler Dam) on the Xobho River with support from 2 upstream farm dams if Ixopo Dam < 20% storage level (owned & operated by Umgeni Water)* ***(2) GW:** Borehole (to make up shortfalls)* *(Note: These 2 sources are used conjunctively)*	*Ixopo WPW*	*Ixopo WwTW*	*Sludge dried on beds and disposed of on a local farm owend by Umgeni Water*
Masameni Water Supply Area	Sisonke DM	No information available	No information available	No information available	No information available
Springvale Water Supply Area	Sisonke DM	No information available	No information available	No information available	No information available
Makhuzeni/Greater Stoffleton Water Supply Area	Sisonke DM/Umgungundlovu DM	**(1) SW:** Abstraction of water from the Mkomazi River (to communities such as Makhuzeni & Stepmore) **(2) GW:** Abstraction from boreholes (to areas of Stepmore, Netherby & surrounding communities)	Makhuzeni WPW - only the water from the river is treated	No WwTW (areas dependent on VIPs)	N/A
Pitela Water Supply Area	Sisonke DM	No information available	No information available	No information available	No information available
Richmond/Ndaleni Water Supply Area	Umgungundlovu DM	**(1) SW:** Beaulieu Dam on the Lovu River **(2) GW:** Few boreholes providing small quantity of supplementary flow to the WTW	Richmond WPW only formal WPW within this WSA	Richmond WwTW only formal WwTW within this WSA	N/A
(Richmond)	*Umgungundlovu DM*	*(1) Beaulieu Dam on the Lovu River* *(2) Few boreholes providing small quantity of supplementary flow to the WTW*	*Richmond WPW*	*Richmond WwTW*	*Lovu River*
Hopewell Water Supply Area	Umgungundlovu DM	**Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply:** An off-take from the '61 pipeline supplies Thornville Reservoir through a pump station, located soon after the off-take. The reservoir serves the Thornville and Baynesfield area. An off-take on the pipeline to Baynesfield supplies water to the Hopewell Reservoir that serves as reticulation storage for the Hopewell community.	Midmar WPW	No information available	No information available
(Hopewell)	*Umgungundlovu DM*	***Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply:*** *An off-take from the '61 pipeline supplies Thornville Reservoir through a pump station, located soon after the off-take. The reservoir serves the Thornville and Baynesfield area. An off-take on the pipeline to Baynesfield supplies water to the Hopewell Reservoir that serves as reticulation storage for the Hopewell community.*	*Midmar WPW*	*No information available*	*No information available*
Impendle Town & Enguga Water Supply Scheme	Umgungundlovu DM	**(1) SW:** Limited abstraction from the Nzinga River to Impendle Town **(2) GW:** Groundwater development that supplies surrounding communities	Impendle WPW only formal WPW within this WSA	Impendle WwTW only formal WwTW within this WSA	N/A
(Impendle)	*Umgungundlovu DM*	***(1) SW:** Limited abstraction from the Nzinga River to Impendle Town*	*Impendle WPW*	*No WwTW* *(areas dependent on VIPs)*	*N/A*
Embuthweni & Ogagwini Water Supply Area	Umgungundlovu DM	**(1) Embuthweni area - GW:** Boreholes (main source) **(2) Ogagwini area - SW:** Bulk water supply from Umgeni Water	No formal WPW within this WSA	No WwTW (areas dependent on VIPs)	N/A
KwaLembe Water Supply Area	Ugu DM	Run of river abstraction from the uMkhomazi River	Kwalembe WPW	No WwTW (areas dependent on VIPs)	N/A
Umgeni Water Supply Area	Ugu DM	Umgeni Water Bulk Water Reticulation Systems *(assumed)*	Various Umgeni Water WPWs *(assumed)*	Various Umgeni Water WwTW *(assumed)*	Various rivers (assumed)
eThekwini MM Water Supply Area	Ugu DM	-	-	-	-
Umkomaas	Ugu DM	***Umgeni Water's Lower Mgeni System, Craigieburn Sub-system:*** *Supplied off the South Coast pipeline Phase 1 via the Amanzimtoti WPW. Water is sourced from Nungwane Dam as well as the Mgeni River, fed from Nagle & Inanda dams, supported by Albert Falls and Midmar dams as well as the MMTS). Water is fed through the Singh's off-take point.*	*Amanzimtoti WPW* *(Craigieburn WPW has been closed)*	*No information available*	*No information available*
Craigieburn	Ugu DM	***Umgeni Water's Lower Mgeni System, Craigieburn Sub-system:*** *Supplied off the South Coast pipeline Phase 1 via the Amanzimtoti WPW. Water is sourced from Nungwane Dam as well as the Mgeni River, fed from Nagle & Inanda dams, supported by Albert Falls and Midmar dams as well as the MMTS). Water is fed through the Singh's off-take point.*	*Amanzimtoti WPW* *(Craigieburn WPW has been closed)*	*No information available*	*No information available*
Magabeni	Ugu DM	***Umgeni Water's Lower Mgeni System, Craigieburn Sub-system:*** *Supplied off the South Coast pipeline Phase 1 via the Amanzimtoti WPW. Water is sourced from Nungwane Dam as well as the Mgeni River, fed from Nagle & Inanda dams, supported by Albert Falls and Midmar dams as well as the MMTS). Water is fed through the Singh's off-take point.*	*Amanzimtoti WPW* *(Craigieburn WPW has been closed)*	*No information available*	*No information available*
Other water supply areas	Sisonke DM/Umgungundlovu/Ugu DM	Groundwater (assumed)	-	-	-

Appendix C

Domestic water requirements

Table C.1: Domestic water requirements (urban and rural) for the historical (1925) scenario

Water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)																
			1925													
			Water requirements													Return flows
	Source of water	Return flows	Total population (whole of the uMkhomazi River catchment) excl. institutions	Total WR (whole of the uMkhomazi River catchment) excl. institutions (AADD)	Total GW (AADD)	Total SW (AADD)	Schools	Clinics	Hospitals	Total WR (whole of the uMkhomazi River catchment) incl. institutions (AADD)	Total WR (whole of the uMkhomazi River catchment) incl. institutions (GAADD)	Excl. WR of areas supplied from outside the uMWP (AADD)	Total WR for the uMkhomazi River catchment (GAADD)	Total GW (GAADD)	Total SW (GAADD)	
uMkhomazi River catchment																
U10A													10	5	5	
(% GW/SW spilt)																
U10B													14	7	7	
(% GW/SW spilt)																
U10C													14	7	7	
(% GW/SW spilt)																
U10D													40	20	20	
(% GW/SW spilt)																
U10E													156	78	78	
(% GW/SW spilt)																
(Impendle Town only)	*(1) SW: Raw water from the Nzinga River* *(2) GW: GW development that supplies surrounding communities*	*No WwTW*											106	4 687	4 687	0
U10F													88	44	44	
(% GW/SW spilt)																
(Bulwer only)	*(1) GW: Boreholes & springs* *(2) SW: Supplemented from weir on the Mkobeni River*	*Bulwer WwTW* *(Design capacity 0.1 M ℓ/d)*											8	92	92	0
U10G													22	11	11	
(% GW/SW spilt)																
U10H													61	30	30	
(% GW/SW spilt)																
U10J													52	26	26	
(% GW/SW spilt)																
(Richmond - "Lusaka" only)	*(1) Beaulieu Dam on the Lovu River* *(2) Few boreholes providing small quantity of supplementary flow to the WTW*	*Richmond WwTW* *(Design capacity 1.6 Mℓ/d)*											118	59	59	0
U10K													123	62	62	
(% GW/SW spilt)																
(Ixopo only)	*(1) SW: Ixopo Dam on the Xobho River with support from 2 upstream farm dams* *(2) GW: Borehole*	*Ixopo WwTW* *(no return flows)*											98	49	49	0
U10L													37	19	19	
(% GW/SW spilt)																
U10M													19	9	9	
(% GW/SW spilt)																
(Umkomaas only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*											11	5	5	0
(Graigieburn only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*											85	42	42	0
(Magabeni only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*											24	12	12	0
Total (kℓ/d)													**636**	**318**	**318**	**0**
Total (Mm^3/a)													**0.23**	**0.12**	**0.12**	**0.00**
uMlaza River catchment																
U60A													18	9	9	0
(% GW/SW spilt)																
U60B													165	83	83	0
(% GW/SW spilt)																
(Hopewell only)	*Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply*	*No information available*											124	62	62	0
Total (kℓ/d)													**183**	**92**	**92**	**0**
Total (Mm^3/a)													**0.07**	**0.03**	**0.03**	**0.00**
Total water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)													***820***	***410***	***410***	***0***
Total water requirements of the uMkhomazi River and uMlaza River catchments (million m^3/a)													**0.30**	**0.15**	**0.15**	**0.00**

Table C.2: Domestic water requirements (urban and rural) for the 2001 scenario

Water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)																
			2001													
			Water requirements													Return flows
	Source of water	Return flows	Total population (whole of the uMkhomazi River catchment) excl. institutions	Total WR (whole of the uMkhomazi River catchment) excl. institutions (AADD)	Total GW (AADD)	Total SW (AADD)	Schools	Clinics	Hospitals	Total WR (whole of the uMkhomazi River catchment) incl. institutions (AADD)	Total WR (whole of the uMkhomazi River catchment) incl. institutions (GAADD)	Excl. WR of areas supplied from outside the uMWP (AADD)	Total WR for the uMkhomazi River catchment (GAADD)	Total GW (GAADD)	Total SW (GAADD)	
uMkhomazi River catchment																
U10A			3 331	118	71	46	7	0	0	128	160		160	97	63	
(% GW/SW spilt)					*60.65%*	*39.35%*										
U10B			4 336	171	95	76	8	0	0	183	229		229	127	102	
(% GW/SW spilt)					*55.34%*	*44.66%*										
U10C			3 036	158	91	67	5	1	0	186	232		232	134	98	
(% GW/SW spilt)					*57.74%*	*42.26%*										
U10D			10 167	477	251	226	14	1	0	518	648		648	341	307	
(% GW/SW spilt)					*52.63%*	*47.37%*										
U10E			21 715	1 948	1 018	929	22	2	0	2 021	2 526		2 526	1 320	1 205	
(% GW/SW spilt)					*52.28%*	*47.72%*										
(Impendle Town only)	*(1) SW: Raw water from the Nzinga River (2) GW: GW development that supplies surrounding communities*	*No WwTW*	9 198	1 380	690	690				1 380	1 725		1 725	862	862	0
U10F			22 192	939	676	263	28	8	0	1 141	1 426		1 426	1 027	400	
(% GW/SW spilt)					*71.98%*	*28.02%*										
(Bulwer only)	*(1) GW: Boreholes & springs (2) SW: Supplemented from weir on the Mkobeni River*	*Bulwer WwTW (Design capacity 0.1 M ℓ/d)*	731	110	77	33				110	137		137	96	41	41
U10G			5 545	251	233	18	7	1	0	282	352		352	326	26	
(% GW/SW spilt)					*92.72%*	*7.28%*										
U10H			19 514	743	599	144	15	1	0	786	982		982	792	190	
(% GW/SW spilt)					*80.63%*	*19.37%*										
U10J			31 148	2 298	979	1 319	26	0	0	2 337	2 921	1 662	843	359	484	
(% GW/SW spilt)					*42.61%*	*57.39%*										
(Richmond - "Lusaka" only)	*(1) Beaulieu Dam on the Lovu River (2) Few boreholes providing small quantity of supplementary flow to the WTW*	*Richmond WwTW (Design capacity 1.6 Mℓ/d)*	10 185	1 528	458	1 069				1 528	1 910		1 910	573	1 337	573
U10K			12 822	1 422	410	1 012	23	7	0	1 597	1 996		1 996	576	1 420	
(% GW/SW spilt)					*28.85%*	*71.15%*										
(Ixopo only)	*(1) SW: Ixopo Dam on the Xobho River with support from 2 upstream farm dams (2) GW: Borehole*	*Ixopo WwTW (no return flows)*	8 434	1 265	253	1 012				1 265	1 581		1 581	316	1 265	0
U10L			14 802	501	376	125	23	3	0	596	745	111	606	455	152	
(% GW/SW spilt)					*75.01%*	*24.99%*										
U10M			42 325	2 524	155	2 368	31	2	0	2 610	3 263	2365	306	19	287	
(% GW/SW spilt)					*6.16%*	*93.84%*										
(Umkomaas only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	940	141	0	141				141	176		176	0	176	0
(Graigieburn only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	7 303	1 095	0	1 095				1 095	1 369		1 369	0	1 369	0
(Magabeni only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	2 062	309	0	309				309	387		387	0	387	0
Total (kℓ/d)			**190 931**	**11 551**	**4 956**	**6 595**	**209**	**26**	**0**	**12 384**	**15 480**	**4 139**	**10 307**	**5 573**	**4 734**	**614**
Total (Mm³/a)				**4.22**	**1.81**	**2.41**	**0.08**	**0.01**	**0.00**	**4.52**	**5.65**	**1.51**	**3.76**	**2.03**	**1.73**	**0.22**
uMlaza River catchment																
U60A			4 702	235	235	0	0	0	0	235	294		294	294	0	
(% GW/SW spilt)					*100.00%*	*0.00%*										
U60B			20 005	2 143	538	1 605	0	0	0	2 143	2 679		2 679	673	2 006	
(% GW/SW spilt)					*25.11%*	*74.89%*										
(Hopewell only)	*Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply*	*No information available*	10 699	1 605	0	1 605				1 605	2 006		2 006	0	2 006	0
Total (kℓ/d)			**24 708**	**2 378**	**773**	**1 605**	**0**	**0**	**0**	**2 378**	**2 973**		**2 973**	**967**	**2 006**	**0**
Total (Mm³/a)				**0.87**	**0.28**	**0.59**	**0.00**	**0.00**	**0.00**	**0.87**	**1.09**	**0.00**	**1.09**	**0.35**	**0.73**	**0.00**
Total water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)			***215 639***	***13 929***	***5 729***	***8 200***	***209***	***26***	***0***	***14 762***	***18 453***	***4 139***	***13 280***	***6 540***	***6 740***	***614***
Total water requirements of the uMkhomazi River and uMlaza River catchments (million m³/a)				**5.08**	**2.09**	**2.99**	**0.08**	**0.01**	**0.00**	**5.39**	**6.74**	**1.51**	**4.85**	**2.39**	**2.46**	**0.22**

Table C.3: Domestic water requirements (urban and rural) for the current (2012) scenario

Water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)																
			2012													
			Water requirements													Return flows
	Source of water	Return flows	Total population (whole of the uMkhomazi River catchment) excl. institutions	Total WR (whole of the uMkhomazi River catchment) excl. institutions (AADD)	Total GW (AADD)	Total SW (AADD)	Schools	Clinics	Hospitals	Total WR (whole of the uMkhomazi River catchment) incl. institutions (AADD)	Total WR (whole of the uMkhomazi River catchment) incl. institutions (GAADD)	Excl. WR of areas supplied from outside the uMWP (AADD)	Total WR for the uMkhomazi River catchment (GAADD)	Total GW (GAADD)	Total SW (GAADD)	
uMkhomazi River catchment																
U10A			3 813	134	80	53	7	0	0	144	180		180	108	72	
(% GW/SW spilt)					*60.10%*	*39.90%*										
U10B			4 404	173	95	78	8	0	0	185	231		231	127	104	
(% GW/SW spilt)					*55.03%*	*44.97%*										
U10C			3 001	155	89	66	5	1	0	183	229		229	131	98	
(% GW/SW spilt)					*57.31%*	*42.69%*										
U10D			11 732	551	290	261	14	1	0	592	740		740	389	350	
(% GW/SW spilt)					*52.63%*	*47.37%*										
U10E			24 883	2 241	1 170	1 070	22	2	0	2 314	2 892		2 892	1 510	1 382	
(% GW/SW spilt)					*52.22%*	*47.78%*										
(Impendle Town only)	*(1) SW: Raw water from the Nzinga River (2) GW: GW development that supplies surrounding communities*	*No WwTW*	10 614	1 592	796	796				1 592	1 990		1 990	995	995	0
U10F			24 881	1 053	758	295	28	8	0	1 255	1 569		1 569	1 129	439	
(% GW/SW spilt)					*71.99%*	*28.01%*										
(Bulwer only)	*(1) GW: Boreholes & springs (2) SW: Supplemented from weir on the Mkobeni River*	*Bulwer WwTW (Design capacity 0.1 Mℓ/d)*	819	123	86	37				123	154		154	108	46	46
U10G			6 260	284	264	21	7	1	0	315	393		393	365	28	
(% GW/SW spilt)					*92.78%*	*7.22%*										
U10H			21 505	813	652	161	15	1	0	856	1 069		1 069	857	212	
(% GW/SW spilt)					*80.14%*	*19.86%*										
U10J			30 207	2 236	964	1 272	26	0	0	2 275	2 844	1 608	835	360	475	
(% GW/SW spilt)					*43.10%*	*56.90%*										
(Richmond - "Lusaka" only)	*(1) Beaulieu Dam on the Lovu River (2) Few boreholes providing small quantity of supplementary flow to the WTW*	*Richmond WwTW (Design capacity 1.6 Mℓ/d)*	9 391	1 477	443	1 034				1 477	1 847		1 847	554	1 293	554
U10K			11 693	1 297	374	923	23	7	0	1 472	1 840		1 840	531	1 309	
(% GW/SW spilt)					*28.85%*	*71.15%*										
(Ixopo only)	*(1) SW: Ixopo Dam on the Xobho River with support from 2 upstream farm dams (2) GW: Borehole*	*Ixopo WwTW (no return flows)*	7 692	1 154	231	923				1 154	1 442		1 442	288	1 154	0
U10L			13 830	470	356	115	23	3	0	565	706	107	572	433	140	
(% GW/SW spilt)					*75.62%*	*24.38%*										
U10M			42 697	2 774	146	2 628	31	2	0	2 860	3 575	2637	279	15	264	
(% GW/SW spilt)					*5.26%*	*94.74%*										
(Umkomaas only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	1 106	166	0	166				166	207		207	0	207	0
(Graigieburn only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	8 588	1 288	0	1 288				1 288	1 610		1 610	0	1 610	0
(Magabeni only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	2 425	364	0	364				364	455		455	0	455	0
Total (kℓ/d)			**198 906**	**12 182**	**5 238**	**6 944**	**209**	**26**	**0**	**13 015**	**16 269**	**4 352**	**10 829**	**5 955**	**4 874**	**600**
Total (Mm^3/a)				**4.45**	**1.91**	**2.53**	**0.08**	**0.01**	**0.00**	**4.75**	**5.94**	**1.59**	**3.95**	**2.17**	**1.78**	**0.22**
uMlaza River catchment																
U60A			4 976	247	247	0	0	0	0	247	308		308	308	0	
(% GW/SW spilt)					*100.00%*	*0.00%*										
U60B			18 966	2 050	498	1 552	0	0	0	2 050	2 562		2 562	623	1 940	
(% GW/SW spilt)					*24.30%*	*75.70%*										
(Hopewell only)	*Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply*	*No information available*	10 346	1 552	0	1 552				1 552	1 940		1 940	0	1 940	0
Total (kℓ/d)			**23 942**	**2 297**	**745**	**1 552**	**0**	**0**	**0**	**2 297**	**2 871**		**2 871**	**931**	**1 940**	**0**
Total (Mm^3/a)				**0.84**	**0.27**	**0.57**	**0.00**	**0.00**	**0.00**	**0.84**	**1.05**	**0.00**	**1.05**	**0.34**	**0.71**	**0.00**
Total water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)			***222 848***	***14 478***	***5 982***	***8 496***	***209***	***26***	***0***	***15 312***	***19 140***	***4 352***	***13 700***	***6 886***	***6 813***	***600***
Total water requirements of the uMkhomazi River and uMlaza River catchments (million m^3/a)				**5.28**	**2.18**	**3.10**	**0.08**	**0.01**	**0.00**	**5.59**	**6.99**	**1.59**	**5.00**	**2.51**	**2.49**	**0.22**

Table C.4: Domestic water requirements (urban and rural) for the future (2042) Low-scenario

Water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)															
			2042 - LOW GROWTH SCENARIO												
			Water requirements												Return flows
	Source of water	Return flows	Total population (whole of the uMkhomazi River catchment) excl. institutions	Total WR (whole of the uMkhomazi River catchment) excl. institutions (AADD)	Total GW (AADD)	Total SW (AADD)	Schools	Clinics	Hospitals	Total WR (whole of the uMkhomazi River catchment) incl. institutions (AADD)	Total WR (whole of the uMkhomazi River catchment) incl. institutions (GAADD)	Excl. WR of areas supplied from outside the uMWP (AADD)	Total WR for the uMkhomazi River catchment (GAADD)	Total GW (GAADD)	Total SW (GAADD)	
uMkhomazi River catchment																
U10A			3 168	109	64	45	7	0	0	120	150		150	88	62	
(% GW/SW spilt)					*58.48%*	*41.52%*										
U10B			3 260	126	68	59	8	0	0	138	173		173	93	80	
(% GW/SW spilt)					*53.56%*	*46.44%*										
U10C			2 086	106	58	49	5	1	0	134	167		167	91	77	
(% GW/SW spilt)					*54.25%*	*45.75%*										
U10D			9 973	468	246	222	14	1	0	509	637		637	335	302	
(% GW/SW spilt)					*52.63%*	*47.37%*										
U10E			23 478	1 995	1 059	936	22	2	0	2 068	2 586		2 586	1 373	1 213	
(% GW/SW spilt)					*53.09%*	*46.91%*										
(Impendle Town only)	*(1) SW: Raw water from the Nzinga River (2) GW: GW development that supplies surrounding communities*	*No WwTW*	9 022	1 353	677	677				1 353	1 692		1 692	846	846	0
U10F			30 802	1 303	937	366	28	8	0	1 505	1 881		1 881	1 353	528	
(% GW/SW spilt)					*71.93%*	*28.07%*										
(Bulwer only)	*(1) GW: Boreholes & springs (2) SW: Supplemented from weir on the Mkobeni River*	*Bulwer WwTW (Design capacity 0.1 M ℓ/d)*	1 016	152	107	46				152	191		191	133	57	57
U10G			7 161	318	293	25	7	1	0	349	436		436	401	35	
(% GW/SW spilt)					*92.01%*	*7.99%*										
U10H			25 199	928	728	200	15	1	0	970	1 213		1 213	951	262	
(% GW/SW spilt)					*78.43%*	*21.57%*										
U10J			16 148	1 356	623	733	26	0	0	1 395	1 744	981	518	238	280	
(% GW/SW spilt)					*45.96%*	*54.04%*										
(Richmond - "Lusaka" only)	*(1) Beaulieu Dam on the Lovu River (2) Few boreholes providing small quantity of supplementary flow to the WTW*	*Richmond WwTW (Design capacity 1.6 Mℓ/d)*	6 008	901	270	631				901	1 126		1 126	338	789	338
U10K			819	91	26	65	23	7	0	265	332		332	96	236	
(% GW/SW spilt)					*28.85%*	*71.15%*										
(Ixopo only)	*(1) SW: Ixopo Dam on the Xobho River with support from 2 upstream farm dams (2) GW: Borehole*	*Ixopo WwTW (no return flows)*	538	81	16	65				81	101		101	20	81	
U10L			4 216	160	146	15	23	3	0	255	319	65	237	215	22	
(% GW/SW spilt)					*90.82%*	*9.18%*										
U10M			33 051	3 040	50	2 990	31	2	0	3 127	3 908	3016	139	2	136	
(% GW/SW spilt)					*1.66%*	*98.34%*										
(Umkomaas only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	1 471	221	0	221				221	276		276	0	276	0
(Graigieburn only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	11 422	1 713	0	1 713				1 713	2 142		2 142	0	2 142	0
(Magabeni only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	3 225	484	0	484				484	605		605	0	605	0
Total (kℓ/d)			**159 360**	**10 002**	**4 299**	**5 704**	**209**	**26**	**0**	**10 836**	**13 545**	**4 062**	**8 468**	**5 236**	**3 232**	**395**
Total (Mm^3/a)				**3.65**	**1.57**	**2.08**	**0.08**	**0.01**	**0.00**	**3.96**	**4.94**	**1.48**	**3.09**	**1.91**	**1.18**	**0.14**
uMlaza River catchment																
U60A			4 544	218	218	0	0	0	0	218	273		273	273	0	
(% GW/SW spilt)					*100.00%*	*0.00%*										
U60B			8 172	1 050	104	947	0	0	0	1 050	1 313		1 313	130	1 183	
(% GW/SW spilt)					*9.87%*	*90.13%*										
(Hopewell only)	*Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply*	*No information available*	6 311	947	0	947				947	1 183		1 183	0	1 183	0
Total (kℓ/d)			**12 716**	**1 269**	**322**	**947**	**0**	**0**	**0**	**1 269**	**1 586**		**1 586**	**403**	**1 183**	**0**
Total (Mm^3/a)				**0.46**	**0.12**	**0.35**	**0.00**	**0.00**	**0.00**	**0.46**	**0.58**	**0.00**	**0.58**	**0.15**	**0.43**	**0.00**
Total water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)			***172 077***	***11 271***	***4 621***	***6 650***	***209***	***26***	***0***	***12 105***	***15 131***	***4 062***	***10 054***	***5 638***	***4 415***	***395***
Total water requirements of the uMkhomazi River and uMlaza River catchments (million m^3/a)				**4.11**	**1.69**	**2.43**	**0.08**	**0.01**	**0.00**	**4.42**	**5.52**	**1.48**	**3.67**	**2.06**	**1.61**	**0.14**

Table C.5: Domestic water requirements (urban and rural) for the future (2042) Medium-scenario

Water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)															
			2042 - MEDIAN GROWTH SCENARIO												
			Water requirements												Return flows
	Source of water	Return flows	Total population (whole of the uMkhomazi River catchment) excl. institutions	Total WR (whole of the uMkhomazi River catchment) excl. institutions (AADD)	Total GW (AADD)	Total SW (AADD)	Schools	Clinics	Hospitals	Total WR (whole of the uMkhomazi River catchment) incl. institutions (AADD)	Total WR (whole of the uMkhomazi River catchment) incl. institutions (GAADD)	Excl. WR of areas supplied from outside the uMWP (AADD)	Total WR for the uMkhomazi River catchment (GAADD)	Total GW (GAADD)	Total SW (GAADD)	
uMkhomazi River catchment																
U10A			5 130	178	105	73	7	0	0	189	236		236	139	96	
(% GW/SW spilt)					*59.13%*	*40.87%*										
U10B			4 588	178	96	81	8	0	0	190	237		237	129	109	
(% GW/SW spilt)					*54.21%*	*45.79%*										
U10C			2 907	148	83	65	5	1	0	176	220		220	123	97	
(% GW/SW spilt)					*56.03%*	*43.97%*										
U10D			16 003	751	395	356	14	1	0	792	991		991	521	469	
(% GW/SW spilt)					*52.63%*	*47.37%*										
U10E			33 524	3 040	1 584	1 455	22	2	0	3 113	3 891		3 891	2 028	1 863	
(% GW/SW spilt)					*52.12%*	*47.88%*										
(Impendle Town only)	*(1) SW: Raw water from the Nzinga River (2) GW: GW development that supplies surrounding communities*	*No WwTW*	14 478	2 172	1 086	1 086				2 172	2 715		2 715	1 357	1 357	0
U10F			32 214	1 364	982	382	28	8	0	1 566	1 957		1 957	1 409	548	
(% GW/SW spilt)					*72.00%*	*28.00%*										
(Bulwer only)	*(1) GW: Boreholes & springs (2) SW: Supplemented from weir on the Mkobeni River*	*Bulwer WwTW (Design capacity 0.1 M ℓ/d)*	1 061	159	111	48				159	199		199	139	60	60
U10G			8 210	374	347	27	7	1	0	404	505		505	469	36	
(% GW/SW spilt)					*92.90%*	*7.10%*										
U10H			26 933	1 003	794	209	15	1	0	1 045	1 307		1 307	1 035	272	
(% GW/SW spilt)					*79.17%*	*20.83%*										
U10J			27 643	2 068	922	1 146	26	0	0	2 107	2 634	1 458	811	362	450	
(% GW/SW spilt)					*44.58%*	*55.42%*										
(Richmond - "Lusaka" only)	*(1) Beaulieu Dam on the Lovu River (2) Few boreholes providing small quantity of supplementary flow to the WTW*	*Richmond WwTW (Design capacity 1.6 Mℓ/d)*	8 932	1 340	402	938				1 340	1 675		1 675	502	1 172	502
U10K			8 616	956	276	680	23	7	0	1 130	1 413		1 413	408	1 005	
(% GW/SW spilt)					*28.85%*	*71.15%*										
(Ixopo only)	*(1) SW: Ixopo Dam on the Xobho River with support from 2 upstream farm dams (2) GW: Borehole*	*Ixopo WwTW (no return flows)*	5 668	850	170	680				850	1 063		1 063	213	850	
U10L			11 179	386	300	86	23	3	0	480	600	97	479	373	106	
(% GW/SW spilt)					*77.78%*	*22.22%*										
U10M			43 709	3 456	120	3 336	31	2	0	3 543	4 428	3378	205	7	198	
(% GW/SW spilt)					*3.48%*	*96.52%*										
(Umkomaas only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	1 557	234	0	234				234	292		292	0	292	0
(Graigieburn only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	12 094	1 814	0	1 814				1 814	2 268		2 268	0	2 268	0
(Magabeni only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	3 415	512	0	512				512	640		640	0	640	0
Total (kℓ/d)			**220 655**	**13 902**	**6 006**	**7 896**	**209**	**26**	**0**	**14 735**	**18 419**	**4 933**	**12 252**	**7 003**	**5 250**	**562**
Total (Mm³/a)				**5.07**	**2.19**	**2.88**	**0.08**	**0.01**	**0.00**	**5.38**	**6.72**	**1.80**	**4.47**	**2.56**	**1.92**	**0.21**
uMlaza River catchment																
U60A			5 723	278	278	0	0	0	0	278	348		348	348	0	
(% GW/SW spilt)					*100.00%*	*0.00%*										
U60B			16 131	1 796	389	1 407	0	0	0	1 796	2 245		2 245	486	1 759	
(% GW/SW spilt)					*21.64%*	*78.36%*										
(Hopewell only)	*Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply*	*No information available*	9 383	1 407	0	1 407				1 407	1 759		1 759	0	1 759	0
Total (kℓ/d)			**21 853**	**2 074**	**667**	**1 407**	**0**	**0**	**0**	**2 074**	**2 593**		**2 593**	**834**	**1 759**	**0**
Total (Mm³/a)				**0.76**	**0.24**	**0.51**	**0.00**	**0.00**	**0.00**	**0.76**	**0.95**	**0.00**	**0.95**	**0.30**	**0.64**	**0.00**
Total water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)			***242 509***	***15 976***	***6 672***	***9 304***	***209***	***26***	***0***	***16 810***	***21 012***	***4 933***	***14 845***	***7 836***	***7 009***	***562***
Total water requirements of the uMkhomazi River and uMlaza River catchments (million m³/a)				**5.83**	**2.44**	**3.40**	**0.08**	**0.01**	**0.00**	**6.14**	**7.67**	**1.80**	**5.42**	**2.86**	**2.56**	**0.21**

Table C.6: Domestic water requirements (urban and rural) for the future (2042) High-scenario

Water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)															
			2042 - HIGH GROWTH SCENARIO												
			Water requirements												Return flows
	Source of water	Return flows	Total population (whole of the uMkhomazi River catchment) excl. institutions	Total WR (whole of the uMkhomazi River catchment) excl. institutions (AADD)	Total GW (AADD)	Total SW (AADD)	Schools	Clinics	Hospitals	Total WR (whole of the uMkhomazi River catchment) incl. institutions (AADD)	Total WR (whole of the uMkhomazi River catchment) incl. institutions (GAADD)	Excl. WR of areas supplied from outside the uMWP (AADD)	Total WR for the uMkhomazi River catchment (GAADD)	Total GW (GAADD)	Total SW (GAADD)	
uMkhomazi River catchment															
U10A			6 400	223	133	90	7	0	0	234	292		292	174	118	
(% GW/SW spilt)					*59.62%*	*40.38%*										
U10B			5 656	220	121	100	8	0	0	232	290		290	159	131	
(% GW/SW spilt)					*54.77%*	*45.23%*										
U10C			3 634	186	107	79	5	1	0	213	267		267	153	114	
(% GW/SW spilt)					*57.33%*	*42.67%*										
U10D			19 828	931	490	441	14	1	0	972	1 215		1 215	639	576	
(% GW/SW spilt)					*52.63%*	*47.37%*										
U10E			40 441	3 724	1 933	1 791	22	2	0	3 797	4 746		4 746	2 463	2 283	
(% GW/SW spilt)					*51.90%*	*48.10%*										
(Impendle Town only)	*(1) SW: Raw water from the Nzinga River (2) GW: GW development that supplies surrounding communities*	*No WwTW*	17 938	2 691	1 345	1 345				2 691	3 363		3 363	1 682	1 682	0
U10F			35 366	1 497	1 078	419	28	8	0	1 699	2 124		2 124	1 530	594	
(% GW/SW spilt)					*72.02%*	*27.98%*										
(Bulwer only)	*(1) GW: Boreholes & springs (2) SW: Supplemented from weir on the Mkobeni River*	*Bulwer WwTW (Design capacity 0.1 M ℓ/d)*	1 164	175	122	52				175	218		218	153	65	65
U10G			9 305	427	398	29	7	1	0	457	572		572	533	39	
(% GW/SW spilt)					*93.18%*	*6.82%*										
U10H			29 908	1 120	891	229	15	1	0	1 163	1 453		1 453	1 156	297	
(% GW/SW spilt)					*79.53%*	*20.47%*										
U10J			39 778	2 732	1 218	1 513	26	0	0	2 771	3 464	1 849	1 153	514	639	
(% GW/SW spilt)					*44.60%*	*55.40%*										
(Richmond - "Lusaka" only)	*(1) Beaulieu Dam on the Lovu River (2) Few boreholes providing small quantity of supplementary flow to the WTW*	*Richmond WwTW (Design capacity 1.6 Mℓ/d)*	11 326	1 699	510	1 189				1 699	2 124		2 124	637	1 487	637
U10K			17 657	1 959	565	1 394	23	7	0	2 133	2 667		2 667	769	1 897	
(% GW/SW spilt)					*28.85%*	*71.15%*										
(Ixopo only)	*(1) SW: Ixopo Dam on the Xobho River with support from 2 upstream farm dams (2) GW: Borehole*	*Ixopo WwTW (no return flows)*	11 615	1 742	348	1 394				1 742	2 178		2 178	436	1 742	
U10L			18 669	624	456	167	23	3	0	718	898	123	744	545	200	
(% GW/SW spilt)					*73.17%*	*26.83%*										
U10M			58 863	4 130	198	3 932	31	2	0	4 216	5 271	3973	305	15	290	
(% GW/SW spilt)					*4.79%*	*95.21%*										
(Umkomaas only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	1 736	260	0	260				260	325		325	0	325	0
(Graigieburn only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	13 484	2 023	0	2 023				2 023	2 528		2 528	0	2 528	0
(Magabeni only)	*Umgeni Water's Lower Mgeni System, Craigieburn Sub-system*	*No information available - assume various Umgeni Water's WwTW*	3 807	571	0	571				571	714		714	0	714	0
Total (kℓ/d)			**285 504**	**17 773**	**7 588**	**10 185**	**209**	**26**	**0**	**18 607**	**23 258**	**5 945**	**15 828**	**8 650**	**7 178**	**703**
Total (Mm³/a)				**6.49**	**2.77**	**3.72**	**0.08**	**0.01**	**0.00**	**6.79**	**8.49**	**2.17**	**5.78**	**3.16**	**2.62**	**0.26**
uMlaza River catchment																
U60A			6 676	327	327	0	0	0	0	327	408		408	408	0	
(% GW/SW spilt)					*100.00%*	*0.00%*										
U60B			24 453	2 513	728	1 785	0	0	0	2 513	3 141		3 141	911	2 231	
(% GW/SW spilt)					*28.99%*	*71.01%*										
(Hopewell only)	*Umgeni Water's Upper Mgeni System via Midmar WTP to Umlaas Road Reservoir Sub-system, Thornville/Hopewell Supply*	*No information available*	11 898	1 785	0	1 785				1 785	2 231		2 231	0	2 231	0
Total (kℓ/d)			**31 128**	**2 840**	**1 055**	**1 785**	**0**	**0**	**0**	**2 840**	**3 550**		**3 550**	**1 319**	**2 231**	**0**
Total (Mm³/a)				**1.04**	**0.39**	**0.65**	**0.00**	**0.00**	**0.00**	**1.04**	**1.30**	**0.00**	**1.30**	**0.48**	**0.81**	**0.00**
Total water requirements of the uMkhomazi River and uMlaza River catchments (kℓ/d)			***316 633***	***20 613***	***8 643***	***11 970***	***209***	***26***	***0***	***21 446***	***26 808***	***5 945***	***19 377***	***9 968***	***9 409***	***703***
Total water requirements of the uMkhomazi River and uMlaza River catchments (million m³/a)				**7.52**	**3.15**	**4.37**	**0.08**	**0.01**	**0.00**	**7.83**	**9.78**	**2.17**	**7.07**	**3.64**	**3.43**	**0.26**

Appendix D

Irrigation water requirements

Table D.1: Historical irrigated areas supplied from dams

Quaternary catchment	Total irrigated area (km^2), for indicated level of development						
	1925	1950	1970	1983	1989	1995	2008 to 2012
uMkhomazi River catchment							
U10A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10B	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10C	0.00	0.13	0.23	0.58	0.80	1.15	0.75
U10D	0.00	0.48	0.86	2.15	2.97	4.26	1.80
U10E	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10F	0.00	0.00	0.00	0.00	0.00	0.00	0.17
U10G	0.00	0.51	0.92	2.29	3.18	4.56	4.34
U10H	0.00	0.69	1.24	3.11	4.31	6.18	8.96
U10J	0.00	0.35	0.64	1.59	2.21	3.16	2.47
U10K	0.00	0.51	0.91	2.28	3.16	4.53	4.76
U10L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10M	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-total:	**0.00**	**2.67**	**4.80**	**12.00**	**16.64**	**23.84**	**23.25**
uMlaza River catchment							
U60A	0.01	0.09	0.12	0.16	0.18	0.18	0.25
U60B	0.60	3.61	5.00	6.62	7.30	7.30	9.98
Sub-total:	**0.61**	**3.70**	**5.12**	**6.79**	**7.48**	**7.48**	**10.23**
Total:	**0.61**	**6.36**	**9.91**	**18.79**	**24.13**	**31.33**	**33.47**

Note: Based on water source classification in WARMS (Tylcoat, 2011).

Table D.2: Historical irrigated areas supplied from run-of-river schemes

Quaternary catchment	Total irrigated area (km^2), for indicated level of development						
	1925	1950	1970	1983	1989	1995	2008 to 2012
uMkhomazi River catchment							
U10A	0.00	0.73	1.31	3.27	4.53	6.50	0.00
U10B	0.00	0.68	1.23	3.07	4.25	6.10	0.00
U10C	0.00	0.34	0.60	1.51	2.09	3.00	1.95
U10D	0.00	0.11	0.19	0.49	0.67	0.97	0.00
U10E	0.00	0.00	0.00	0.00	0.00	0.00	0.25
U10F	0.00	0.00	0.00	0.00	0.00	0.00	1.18
U10G	0.00	0.67	1.21	3.03	4.21	6.02	5.73
U10H	0.00	0.84	1.51	3.77	5.23	7.49	10.87
U10J	0.00	1.33	2.39	5.99	8.31	11.90	9.30
U10K	0.00	0.68	1.23	3.07	4.26	6.11	6.41
U10L	0.00	0.77	1.38	3.47	4.81	6.88	0.69
U10M	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Sub-total:	**0.00**	**6.15**	**11.06**	**27.68**	**38.37**	**54.97**	**36.40**
uMlaza River catchment							
U60A	0.06	0.37	0.52	0.69	0.76	0.76	1.03
U60B	1.56	9.37	12.98	17.21	18.97	18.97	25.93
Sub-total:	**1.62**	**9.74**	**13.50**	**17.90**	**19.73**	**19.73**	**26.96**
Total:	**1.62**	**15.89**	**24.55**	**45.57**	**58.11**	**74.70**	**63.36**

Note: Based on water source classification in WARMS (Tylcoat, 2011).

Table D.3: Historical irrigated areas supplied from groundwater

Quaternary catchment	Total irrigated area (km^2), for indicated level of development						
	1925	1950	1970	1983	1989	1995	2008 to 2012
uMkhomazi River catchment							
U10A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10B	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10D	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10E	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10F	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10G	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10H	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U10J	0.00	0.00	0.01	0.01	0.02	0.03	0.02
U10K	0.00	0.03	0.05	0.12	0.16	0.23	0.24
U10L	0.00	0.26	0.47	1.17	1.62	2.32	0.23
U10M	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-total:	**0.00**	**0.29**	**0.52**	**1.30**	**1.80**	**2.58**	**0.50**
uMlaza River catchment							
U60A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U60B	0.10	0.62	0.86	1.15	1.26	1.26	1.73
Sub-total:	**0.10**	**0.62**	**0.86**	**1.15**	**1.26**	**1.26**	**1.73**
Total:	**0.10**	**0.91**	**1.38**	**2.45**	**3.07**	**3.84**	**2.23**

Note: Based on water source classification in WARMS (Tylcoat, 2011).

Table D.4: Monthly crop evapotranspiration data for the uMkhomazi River catchment, from SAPWAT

Quaternary catchment[2]	WARMS crop type	Crop evapotranspiration, ET_C (mm)[1]												
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
U10A	Lucerne	96	107	114	111	94	87	66	46	34	40	55	79	**929**
	Pastures (perennial)	93	101	107	105	88	79	61	49	39	46	62	81	**911**
	Ryegrass	119	90	0	0	0	35	73	72	60	70	90	111	**720**
U10B	Lucerne	96	107	114	111	94	87	66	46	34	40	55	79	**929**
	Pastures (perennial)	93	101	107	105	88	79	61	49	39	46	62	81	**911**
	Ryegrass	119	90	0	0	0	35	73	72	60	70	90	111	**720**
U10C	Lucerne	96	107	114	111	94	87	66	46	34	40	55	79	**929**
	Pastures (perennial)	93	101	107	105	88	79	61	49	39	46	62	81	**911**
	Ryegrass	119	90	0	0	0	35	73	72	60	70	90	111	**720**
U10D	Pastures (perennial)	93	101	107	105	88	79	61	49	39	46	62	81	**911**
	Ryegrass	119	90	0	0	0	35	73	72	60	70	90	111	**720**
U10E	Potatoes	60	118	145	134	0	0	0	0	0	0	0	0	**457**
	Ryegrass	119	90	0	0	0	35	73	72	60	70	90	111	**720**
U10F	Potatoes	60	118	145	134	0	0	0	0	0	0	0	0	**457**
	Ryegrass	119	90	0	0	0	35	73	72	60	70	90	111	**720**
U10G	Maize	0	0	30	69	118	116	54	0	0	0	0	0	**387**
	Pastures (perennial)	93	101	107	105	88	79	61	49	39	46	62	81	**911**
	Ryegrass	119	90	0	0	0	35	73	72	60	70	90	111	**720**
U10H	Pastures (perennial)	82	97	98	94	87	84	63	52	51	62	73	85	**928**
	Ryegrass	105	87	0	0	0	31	73	76	78	94	106	116	**766**
U10J	Citrus	88	101	101	98	90	89	49	66	67	81	89	97	**1 016**
	Pastures (perennial)	82	97	98	94	87	84	63	52	51	62	73	85	**928**
	Ryegrass	105	87	0	0	0	31	73	76	78	94	106	116	**766**

Quaternary catchment[2]	WARMS crop type	Crop evapotranspiration, ET_C (mm)[1]												
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	Sugarcane	90	113	123	128	123	122	98	83	77	82	88	96	**1 223**
	Vegetables (summer)	25	63	113	116	91	27	0	0	0	0	0	0	**435**
	Vegetables (winter)	0	0	0	0	0	28	49	71	77	83	72	29	**409**
U10K	Cabbage	0	0	35	93	103	0	0	0	0	0	0	0	**231**
	Pastures (perennial)	82	97	98	94	87	84	63	52	51	62	73	85	**928**
	Ryegrass	105	87	0	0	0	31	73	76	78	94	106	116	**766**
	Sugarcane	90	113	123	128	123	122	98	83	77	82	88	96	**1 223**
	Vegetables (summer)	25	63	113	116	91	27	0	0	0	0	0	0	**435**
	Vegetables (winter)	0	0	0	0	0	28	49	71	77	83	72	29	**409**
U10L	Citrus	88	101	101	98	90	89	49	66	67	81	89	97	**1 016**
	Maize	0	0	29	63	116	122	56	0	0	0	0	0	**386**
	Potatoes	54	114	132	121	0	0	0	0	0	0	0	0	**421**
U10M	Macadamia	116	133	134	129	108	85	50	36	37	44	50	90	**1 012**
	Vegetables (summer)	25	63	113	116	91	27	0	0	0	0	0	0	**435**
	Vegetables (winter)	0	0	0	0	0	28	49	71	77	83	72	29	**409**

Notes: *(1) SAPWAT weather stations used are "COBHAM – BOS" for U10A to U10G and "RICHMOND: SAPEKOE E" for U10H to U10M.*

(2) Only crop types that occur in catchment are shown.

Table D.5: Monthly crop evapotranspiration data for the upper uMlaza River catchment, based on SAPWAT

Quaternary catchment[2]	WARMS crop type	Crop evapotranspiration, ET_C (mm)[1]												
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
U60A	Avocados	102	126	142	144	120	96	69	55	44	55	75	86	**1 114**
	Maize	0	0	28	64	113	112	49	0	0	0	0	0	**366**
	Pastures (perennial)	82	89	94	96	85	77	56	42	32	40	57	70	**820**
	Vegetables (summer)	27	61	109	118	90	26	0	0	0	0	0	0	**431**
	Vegetables (winter)	0	0	0	0	0	28	46	57	49	55	62	28	**325**
U60B	Citrus	88	93	99	100	89	83	44	53	42	53	71	81	**896**
	Pastures (perennial)	82	89	94	96	85	77	56	42	32	40	57	70	**820**
	Sugarcane	90	105	120	130	120	111	87	66	48	53	69	79	**1 078**
	Vegetables (summer)	27	61	109	118	90	26	0	0	0	0	0	0	**431**
	Vegetables (winter)	0	0	0	0	0	28	46	57	49	55	62	28	**325**

Notes: *(1) SAPWAT weather station used is "BAYNESFIELD ESTATE".*

(2) Only crop types that occur in catchment are shown.

Appendix E

South Coast water requirements

The South Coast water supply area comprises parts of eThekwini Municipality as well as the Ugu District Municipality south of the Wiggins WTW supply area. The area extends along the coastal strip from Amanzimtoti southwards to the Mtwalume River and includes parts of the uMkhomazi, Mzinto, Mpambanyoni, Mzumbe and Mtwalume river catchments.

The South Coast supply area has been included in this report to consider the following options:

- The proposed ***Ngwadini Off-channel Storage Dam*** on the lower uMkhomazi River;
- A proposed ***Lovu Desalination Plant*** will deliver water via the South Coast Pipeline (SCP) to Quarry Reservoir to the south and the Amanzimtoti Reservoir to the north, which would also supply the South Coast Augmentation (SCA) pipeline and reduce the load on the Wiggins WTW;
- The proposed ***Lower uMkhomazi Abstraction Weir***, with support from Smithfield Dam.

Water supply areas and reservoirs proposed to be serviced by the preferred South Coast augmentation option are summarised in **Table E.1**.

Table E.1: Summary of supply areas and reservoirs included the South Coast water supply area

eThekwini Municipality Water Supply Area (WSA)	
Magflow / Almond Reservoir	Umkomaas Offtake
Ilovo Reservoir	Mgobhozini EW Meter
A.E.C.I. Backfeed	Panorama Par
Lewis Drive Reservoir	Mnini Offtake
Rawsp	KwaMakhutha Reservoir
Craigieburn Pumping	Magabheni
Craigieburn DSB	
Ugu District Municipality Water Supply Area (WSA)	
Mgobozini	Umdoni
Scottburg South	Kelso
Pennington	Umzinto
Ellingam	Mtwalume

Comparison between the possible schemes for augmenting water supply to the South Coast is presented in the study report *P WMA 11/U10/00/3312/3/1/6: Supporting Document 6: Economic Comparison of the uMkhomazi-Mgeni Transfer Scheme with Desalination and Re-use Options Report* (AECOM, AGES, MMA, & Urban-Econ, The

uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water; P WMA 11/U10/00/3312/3/1/6 - Supporting document 6: Economic comparison of the uMkhomazi-uMgeni transfer scheme with desalination and re-use options, 2014).

Table E.1: Water sales figures for the South Coast water supply area

		June 12	July 12	August 12	Sept 12	Octo 12	Nov 12	Dec 12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Total
Acc No.	**Description**	(kl)	(kl)	(kl)	(kl)	(kl)	(kl)	(kl)	(kl)	(kl)	(kl)				
W024547	**Magflow / Almond Reservoir**	202474	209959	210045	238436	152614	84336	141718	122390	91726	283076	278043	274899	267760	
W024548	**Illovo Reservoir**	164334	171804	168409	170307	181201	169392	199252	202077	190157	198 013.00	186 744.00	181 137.00	163 715.00	
W024549	**A.E.C.I. Backfeed**	7712	6917	10109	6075	11237	6657	3735	4050	12184	10 192.00	12 538.00	12 813.00	10 641.00	
W024550	**Lewis Drive Reservoir**	232038	243027	235007	217583	253854	213638	269165	268897	219185	236 319.00	220 845.00	230 854.00	232 941.00	
W024551	**Rawsp**	28045	29547	32998	34864	35513	35953	36972	37598	34271	36 787.00	36 111.00	36 463.00	34 910.00	
W024552	**Craigieburn WTP Pumping**	174780	187069	181706	188351	189674	191185	199055	199625	180592	197 532.00	185 650.00	195 780.00	184 763.00	
W024553	**Craigieburn WTP DSB**	71771	72591	74288	74165	72789	76690	76186	70669	65928	73 324.00	71 356.00	73 987.00	68 547.00	
W024554	**Umkomaas Offtake**	61070	65160	61920	54200	58710	58277	65550	64440	51370	56 320.00	63 820.00	60 370.00	50 410.00	
W024555	**Mgobhozini EW Meter**	23539	26357	22342	31989	26553	25433	27731	28470	29897	33 102.00	26 118.00	25 639.00	25 374.00	
W024556	**Panorama Park**	63519	68093	57671	61802	65511	62229	67254	65123	54899	65 365.00	64 710.00	65 569.00	63 533.00	
W024557	**Mnini Offtake**	18183	30569	29919	28797	31665	31480	34349	32589	30541	29 595.00	27 161.00	28 239.00	26 023.00	
W024558	**KwaMakhutha Reservoir**	499730	519420	529540	519870	539240	547070	586080	583760	541610	657 210.00	598 230.00	601 480.00	580 720.00	
W024559	**SCA Inflow**	1335210	1439595	1451284	1406563	1452969	1442917	1614027	1541689	1244016	1 354 154.00	1 319 671.00	1 301 101.00	1 231 472.00	
W025300	**Magabheni**	3515	4872	4763	12520	9857	13974	11031	12360	12135	14 112.00	14 242.00	8 791.00	6 331.00	
		June 12	**July 12**	**August 12**	**Sept 12**	**Octo 12**	**Nov 12**	**Dec 12**	**Jan-13**	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	Total
Acc No.	**Description**	(kl/day)	(kl/day)	(kl/day)	(kl/day)	(kl/day)	(kl/day)	(kl/day)	(kl/day)	(kl/day)	(kl/day)				
W024547	**Magflow / Almond Reservoir**	6749.13	6772.87	6775.65	7947.87	4923.03	2720.52	4723.93	3948.06	3275.93	9131.48	9268.10	8867.71	8925.33	6 440
W024548	**Illovo Reservoir**	5477.80	5542.06	5432.55	5676.90	5845.19	5464.26	6641.73	6518.61	6791.32	6387.52	6224.80	5843.13	5457.17	5 985
W024549	**A.E.C.I. Backfeed**	257.07	223.13	326.10	202.50	362.48	214.74	124.50	130.65	435.14	328.77	417.93	413.32	354.70	294
W024550	**Lewis Drive Reservoir**	7734.60	7839.58	7580.87	7252.77	8188.84	6891.55	8972.17	8674.10	7828.04	7623.19	7361.50	7446.90	7764.70	7 785
W024551	**Rawsp**	934.83	953.13	1064.45	1162.13	1145.58	1159.77	1232.40	1212.84	1223.96	1186.68	1203.70	1176.23	1163.67	1 157
W024552	**Craigieburn Pumping**	5826.00	6034.48	5861.48	6278.37	6118.52	6167.26	6635.17	6439.52	6449.71	6372.00	6188.33	6315.48	6158.77	6 252
W024553	**Craigieburn DSB**	2392.37	2341.65	2396.39	2472.17	2348.03	2473.87	2539.53	2279.65	2354.57	2365.29	2378.53	2386.68	2284.90	2 385
W024554	**Umkomaas Offtake**	2035.67	2101.94	1997.42	1806.67	1893.87	1879.90	2185.00	2078.71	1834.64	1816.77	2127.33	1947.42	1680.33	1 946
W024555	**Mgobhozini EW Meter**	784.63	850.23	720.71	1066.30	856.55	820.42	924.37	918.39	1067.75	1067.81	870.60	827.06	845.80	903
W024556	**Panorama Park**	2117.30	2196.55	1860.35	2060.07	2113.26	2007.39	2241.80	2100.74	1960.68	2108.55	2157.00	2115.13	2117.77	2 087
W024557	**Mnini Offtake**	606.10	986.10	965.13	959.90	1021.45	1015.48	1144.97	1051.26	1090.75	954.68	905.37	910.94	867.43	989
W024558	**KwaMakhutha Reservoir**	16657.67	16755.48	17081.94	17329.00	17394.84	17647.42	19536.00	18830.97	19343.21	21200.32	19941.00	19402.58	19357.33	18 652
W024559	**SCA Inflow**	44507.00	46438.55	46815.61	46885.43	46869.97	46545.71	53800.90	49731.90	44429.14	43682.39	43989.03	41971.00	41049.07	46 017
W025300	**Magabheni**	117.17	157.16	153.65	417.33	317.97	450.77	367.70	398.71	433.39	455.23	474.73	283.58	211.03	343

Table E.2: Projected water requirements for the South Coast water supply area

				Supply Area (Reservoir)																			
Date	Magflow / Almond Water Demand (2% rate)	Illovo Reservoir Water Demand (2% rate)	A.E.C.I. Backfeed Water Demand (2% rate)	Lewis Drive Reservoir Water Demand (2% rate)	Rawsp Water Demand (2% rate)	Craigieburn Pumping Water Demand (2% rate)	Craigieburn DSB Water Demand (2% rate)	Umkomaas Offtake Water Demand (2% rate)	Mgobhozini EW Meter Water Demand (2% rate)	Panorama Park Water Demand (2% rate)	Mnini Offtake Water Demand (2% rate)	KwaMakhutha Reservoir Water Demand (2% rate)	Magabheni Water Demand (2% rate)	Mgobozini Water Demand (1% rate)	Scottburg South Water Demand (1% rate)	Pennington Water Demand (0.25% rate)	Ellingam Water Demand (0.25% rate)	Umdoni Water Demand (0.25% rate)	Kelso Water Demand (0.25% rate)	Umzinto Water Demand (1% rate)	Mtwalume Water Demand (0.25% rate)	TOTAL DEMAND (Ml/day)	TOTAL DEMAND (EXCLUDING UGU) Ml/day
12/13	6 440	5 985	294	7 785	1 157	6 252	2 385	1 946	903	2 087	989	18 652	343	800	4 200	-	-	-	-	-	-	60	55
13/14	6 569	6 105	300	7 941	1 180	6 377	2 433	1 985	921	2 128	1 009	19 025	350	808	4 221	-	-	-	-	-	-	61	56
14/15	6 700	6 227	306	8 100	1 204	6 504	2 481	2 024	939	2 171	1 029	19 405	357	816	4 242	-	-	-	-	-	-	63	57
15/16	6 834	6 352	313	8 262	1 228	7 934	2 531	2 065	958	2 214	1 050	19 793	364	824	4 763	-	-	-	-	-	-	65	60
16/17	6 971	6 479	319	8 427	1 252	9 238	2 582	2 106	977	2 259	1 071	20 189	372	832	5 287	500	500	500	250	-	-	70	62
17/18	7 110	6 608	325	8 596	1 277	10 718	2 633	2 148	997	2 304	1 092	20 593	379	841	5 814	1 001	1 001	1 001	501	500	-	75	65
18/19	7 253	6 741	332	8 768	1 303	12 085	2 686	2 191	1 017	2 350	1 114	21 005	387	849	6 343	1 504	1 504	1 504	752	505	-	80	67
19/20	7 398	6 875	338	8 943	1 329	13 727	2 740	2 235	1 037	2 397	1 137	21 425	680	858	6 874	2 008	2 008	2 008	1 004	1 010	-	86	70
20/21	7 546	7 013	345	9 122	1 356	16 781	2 795	2 932	1 058	2 445	1 159	21 853	693	866	6 909	2 513	2 513	2 513	1 256	1 020	-	93	75
21/22	7 696	7 153	352	9 304	1 383	19 698	2 850	3 436	1 079	2 494	1 182	22 290	707	875	6 943	2 519	2 519	2 519	1 259	1 530	-	98	80
22/23	7 850	7 296	359	9 490	1 410	21 687	2 907	4 255	1 101	2 544	1 206	22 736	721	884	6 978	2 525	2 525	2 525	1 263	1 546	1 875	104	84
23/24	8 007	7 442	366	9 680	1 439	23 159	2 966	4 818	1 123	2 594	1 230	23 191	736	893	7 013	2 531	2 531	2 531	1 266	2 061	3 755	109	87
24/25	8 168	7 591	373	9 874	1 467	24 697	3 025	5 314	1 145	2 646	1 255	23 655	750	901	7 048	2 538	2 538	2 538	1 269	2 082	5 639	115	90
25/26	8 331	7 743	381	10 071	1 497	26 592	3 085	5 420	1 168	2 699	1 280	24 128	765	910	7 083	2 544	2 544	2 544	1 272	2 603	7 528	120	93
26/27	8 497	7 898	389	10 273	1 527	27 124	3 147	5 529	1 191	2 753	1 306	24 610	781	920	7 119	2 550	2 550	2 550	1 275	2 629	7 547	122	95
27/28	8 667	8 056	396	10 478	1 557	27 666	3 210	5 639	1 215	2 808	1 332	25 103	796	929	7 154	2 557	2 557	2 557	1 278	3 155	7 566	125	97
28/29	8 841	8 217	404	10 688	1 588	28 219	3 274	5 752	1 240	2 864	1 358	25 605	812	938	7 190	2 563	2 563	2 563	1 282	3 186	7 585	127	99
29/30	9 018	8 381	412	10 901	1 620	28 784	3 340	5 867	1 264	2 922	1 385	26 117	828	947	7 226	2 570	2 570	2 570	1 285	3 718	7 604	129	101
30/31	9 198	8 549	421	11 119	1 653	29 359	3 407	5 985	1 290	2 980	1 413	26 639	845	957	7 262	2 576	2 576	2 576	1 288	3 755	7 623	131	103
31/32	9 382	8 720	429	11 342	1 686	29 947	3 475	6 104	1 315	3 040	1 441	27 172	862	966	7 298	2 582	2 582	2 582	1 291	4 293	7 642	134	105
32/33	9 570	8 894	438	11 569	1 719	30 546	3 544	6 226	1 342	3 101	1 470	27 715	879	976	7 335	2 589	2 589	2 589	1 294	4 336	7 661	136	107
33/34	9 761	9 072	446	11 800	1 754	31 156	3 615	6 351	1 369	3 163	1 500	28 270	897	986	7 372	2 595	2 595	2 595	1 298	4 879	7 680	139	109
34/35	9 956	9 253	455	12 036	1 789	31 780	3 687	6 478	1 396	3 226	1 530	28 835	915	996	7 408	2 602	2 602	2 602	1 301	4 928	7 699	141	111
35/36	10 155	9 438	464	12 277	1 825	32 415	3 761	6 608	1 424	3 290	1 560	29 412	933	1 006	7 445	2 608	2 608	2 608	1 304	4 977	7 719	144	114
36/37	10 358	9 627	474	12 522	1 861	33 063	3 836	6 740	1 452	3 356	1 591	30 000	951	1 016	7 483	2 615	2 615	2 615	1 307	5 027	7 738	146	116
37/38	10 566	9 820	483	12 773	1 898	33 725	3 913	6 874	1 481	3 423	1 623	30 600	970	1 026	7 520	2 621	2 621	2 621	1 311	5 077	7 757	149	118

Appendix F

Preliminary water requirement projection for the Mgeni WSS

The preliminary water requirement projection scenario adopted for the uMWP-1 was developed based on work conducted by consultants Knight Piésold on behalf of the eThekwini Municipality as part of the *Western Aqueduct Project* (Knight Piésold Consulting, 2010) and is based on the projection of ***Average Annual Daily Demand (AADD)***. Initially growth up to 2023 is rapid due to update of backlogs and other influences. Various growth rates were considered after 2023 of between 1.1% and 1.5%. Ultimately, a growth rate of 1.3% was assumed which took into account higher growth in specific development nodes of 1.5% and lower growth in other areas of 1.1%. The resulting projection is shown on **Figure F.1**, indicated by the purple line. It is important to note that this projection is based on the total water requirements of a selected set of target water users and not the capacity of the Western Aqueduct.

Finally, a water requirement projection was also developed assuming the ***Summer Daily Demand (SDD)*** and this is shown as the pink line in **Figure F.1**. This peak demand projection was included for the purposes of sizing conveyance infrastructure for peak demands. For this purpose a SDD peak factor of 1.25 and 1.5 was considered in consultation with the eThekwini Municipality as part of this study (AECOM, AGES, MMA, & Urban-Econ, The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water; P WMA11/U10/00/3312/3/1/1 - Supporting document 1: Optimisation of conveyance system report, 2014).

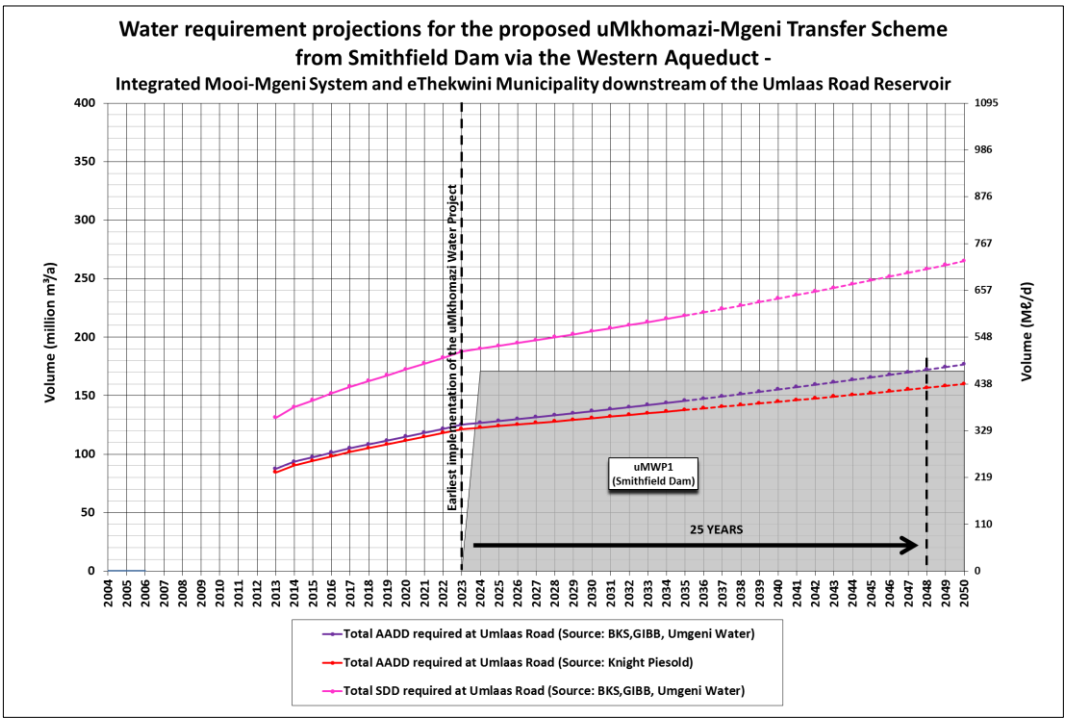


Figure F.1: Preliminary water requirement projections for the uMWP-1