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Limpopo Water Management Area North Reconciliation Strategy

DRAFT RECONCILIATION STRATEGY

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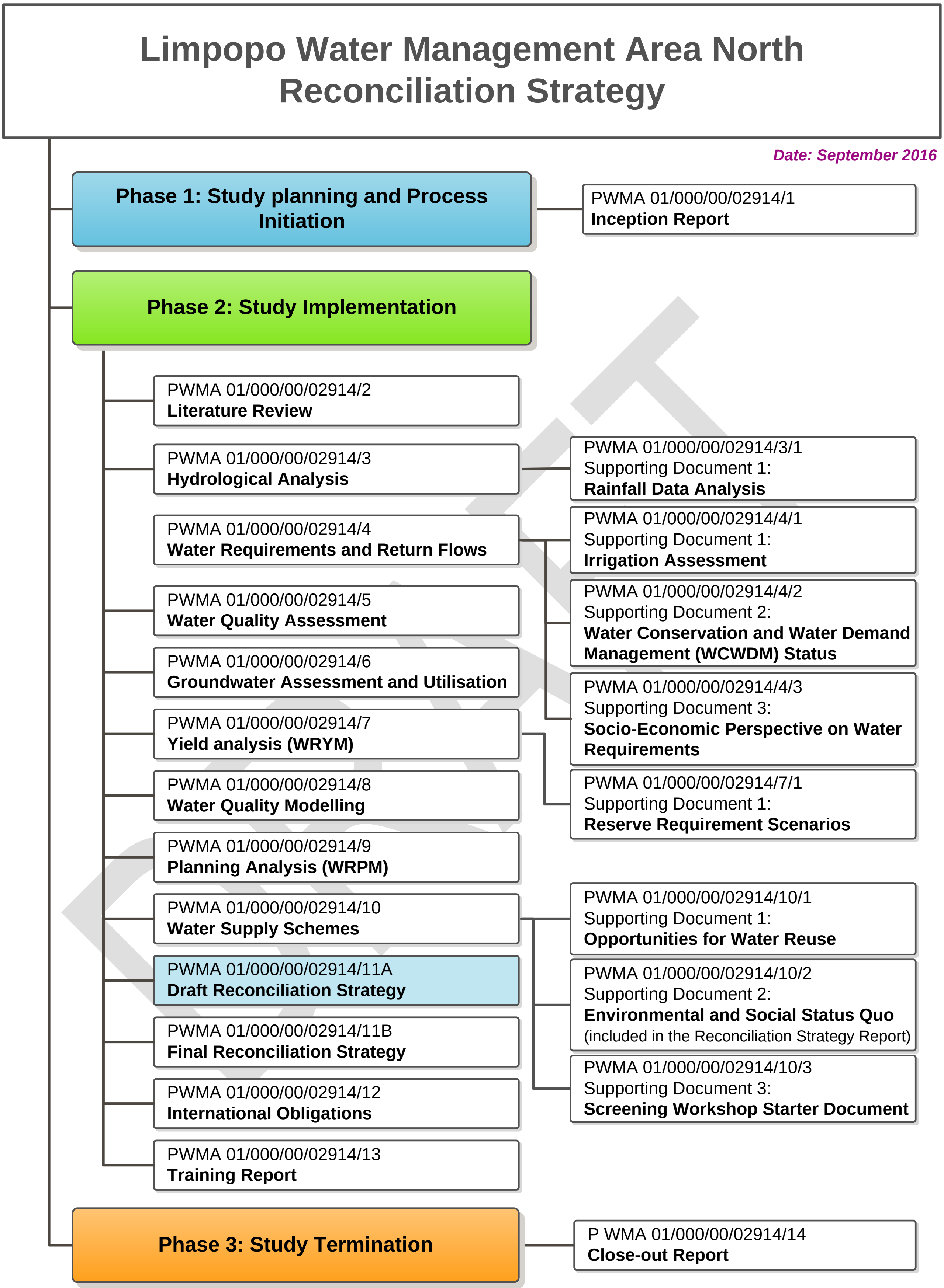
Limpopo Water Management Area North Reconciliation Strategy
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Phase 1: Study planning and Process Initiation
PWMA 01/000/00/02914/1 Inception Report
Phase 2: Study Implementation
PWMA 01/000/00/02914/2 Literature Review
PWMA 01/000/00/02914/3 Hydrological Analysis
PWMA 01/000/00/02914/3/1 Supporting Document 1: Rainfall Data Analysis
PWMA 01/000/00/02914/4 Water Requirements and Return Flows
PWMA 01/000/00/02914/4/1 Supporting Document 1: Irrigation Assessment
PWMA 01/000/00/02914/4/2 Supporting Document 2: Water Conservation and Water Demand Management (WCWDM) Status
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PWMA 01/000/00/02914/7 Yield analysis (WRYM)
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PWMA 01/000/00/02914/10/2 Supporting Document 2: Environmental and Social Status Quo (included in the Reconciliation Strategy Report)
PWMA 01/000/00/02914/10/3 Supporting Document 3: Screening Workshop Starter Document
PWMA 01/000/00/02914/11A Draft Reconciliation Strategy
PWMA 01/000/00/02914/11B Final Reconciliation Strategy
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List of Abbreviations

AECOM	AECOM SA (Pty) Ltd
AMD	Acid mine drainage
ARC	Agricultural Research Council
BHN	Basic human needs
CMA	Catchment management agency
CoAL	Coal of Africa Limited
CTL	Coal-to-liquid
D: RR	Directorate Reserve Requirements
D:NWRP	Directorate: National Water Resource Planning
DM	District Municipality
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC(1)	Ecological Category
EC	Electrical conductivity
EWR	Ecological water requirements
EWRM	Ecological Water Resource Monitoring
GDS	Green Drop System
GRA1	Groundwater Resource Assessment 1
GRA2	Groundwater Resource Assessment 2
GRIP	Groundwater Resource Information Project
GWS	Groundwater schemes
HFY	Historic firm yield
IAP	Invasive alien plants
IPPs	Independent power producers
IWR	Institute for Water Research
LBPTC	Limpopo Basin Permanent Technical Committee
LEIP	Special Economic Zone
LIMCOM	Limpopo Water Course Commission
LM	Local Municipality
MAR	Mean annual run-off
MBET	Marapong-Boikarabelo Effluent Transfer
MCWAP	Mokolo and Crocodile River (West) Water Augmentation Project
NGA	National Groundwater Archive
NRW	Non-revenue water
NWA	National Water Act

ORWRDP	Olifants River Water Resources Development Project
PES	Present Ecological State
PESEIS	Present Ecological State Ecological Importance and Sensitivity
PPL	Potgietersrus Platinum Mine (Now Mogalakwena Platimum Mine)
PRWwTW	Polokwane Regional WwTW
REC	Recommended Ecological Category
ResGen	Resource Generation Limited
RSA	Republic of South Africa
RWH	Rainwater harvesting
RWQO	Resource Water Quality Objectives
RWS	Regional Water Scheme
SAB	South African Breweries
SEZ	Limpopo Eco-Industrial Park
SSC	Study Steering Committee
TDS	Total Dissolved Solids
TSS	Total suspended solids
WCWDM	Water Conservation And Water Demand Management
WMS	Water Management System
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WSA	Water Service Authorities
WSP	Water Service Providers
WSS	Water Supply Scheme
WTW	Water Treatment Works
WUA	Water Use Associations
WUL	Water Use License
WULA	Water Use License Applications
WwTW	Wastewater Treatment Works
ZINWA	Zimbabwe National Water Authority

List of Units

a	annum
ha	hectare
kℓ	kilolitre
km	kilometre
km^2	square kilometre
ℓ/c/d	liter per capita per day
ℓ/s	litre per second
m	metre
m^3	cubic meter
m^3/a	cubic meter per annum
Mℓ/d	megalitre per day
mm	millimetre
$m^3/ha/a$	cubic meter per hectare per annum

1 INTRODUCTION

1.1 APPOINTMENT OF PROFESSIONAL SERVICE PROVIDER (PSP)

The Department of Water and Sanitation (DWS), then Department of Water Affairs (DWA) appointed *AECOM SA (Pty) Ltd* in association with three sub-consultants *Hydrosol*, *Jones and Wagener* and *VSA Rebotile Metsi Consulting* with effect from 1 March 2014 to undertake the *Limpopo Water Management Area North Reconciliation Strategy*.

1.2 BACKGROUND TO THE PROJECT

The DWS (then DWA) identified a need for the development of the Limpopo Water Management Area (WMA) North Reconciliation Strategy. The Limpopo WMA North refers to the Limpopo WMA described in the first edition of the **National Water Resource Strategy** (NWRS-1) published in 2004. The 19 initial WMAs were consolidated into nine WMAs during 2012 and acknowledged in the second edition of the **National Water Resource Strategy** (NWRS-2) of 2013. The newly defined Limpopo WMA also includes the original Crocodile (West) and Marico WMA as well as the Luvuvhu River catchment, previously part of the Luvuvhu and Letaba WMA. However, these additional areas are not part of this Reconciliation Strategy.

The Limpopo WMA North comprises of six main river catchments; Matlabas, Mokolo, Lephalala, Mogalakwena, Sand and Nzhelele and are shown in Figure 1.1. The very small Nwanedi catchment forms part of the Nzhelele catchment. Most of these catchments rely on their own water resources and are managed independently from neighbouring catchments. This implies that some catchments require separate and independent reconciliation strategies whilst others need integrated water management reconciliation strategies.

The main urban areas within the WMA include Mokopane, Polokwane, Mookgophong, Modimolle, Lephalale, Musina and Louis Trichardt. Approximately 760 rural communities are scattered throughout the WMA, mostly concentrated in the central region. The main economic activities are irrigation and livestock farming as well as expanding mining operations due to the vast untapped mineral resources in the area. The water resources, especially surface water resources, are heavily stressed due to the present levels of development. It is crucial that water supply is secured and well managed.

The most western area of the Limpopo WMA North, the Matlabas catchment, is a dry catchment with no significant dams and with a low growth potential for land-use development.

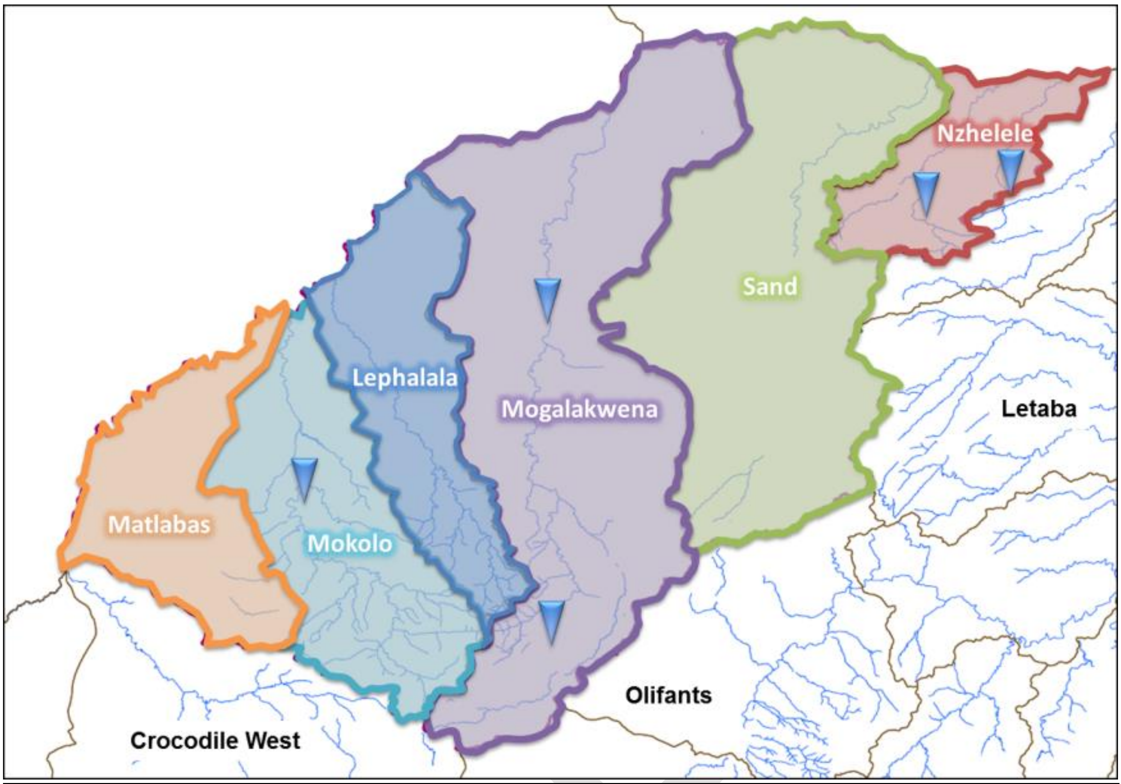

Figure 1.1 Overview of the catchments of the Limpopo WMA North

The large Mokolo Dam, in the Mokolo catchment, supplies water to the Matimba Power Station, Medupi Power Station, Grootegeluk Coal Mine, the Lephalale Local Municipality (LM) as well as a number of downstream irrigators. The dam is able to meet the bulk of the current requirements but will in future rely on transfers from other WMAs to meet the water requirements at a sufficiently high assurance of supply.

The middle reaches of the Lephalala catchment have a high conservation value with irrigation activities dominant in the remainder of the catchment. Irrigation in this area is supplied by surface water and alluvial aquifer abstraction.

The bulk of the water resources in the Mogalakwena catchment have been fully developed. The Doorndraai Dam is over-allocated. Additional water to support the rapid expanding mining activities in the vicinity of Mokopane needs to be augmented by transfers from the Flag Boshielo Dam in the adjacent Olifants River catchment. Glen Alpine Dam currently supplies water to emerging farmers, who has not yet taken up their full allocated quota, and is expected to supply the growing domestic requirements in future.

Groundwater resources in the Mogalakwena and Sand catchments have been extensively utilised, and possibly over-exploited by the dominating irrigation sector. The expanding urban and industrial requirements of Polokwane and Makhado LMs, currently supplied by Albasini Dam, rely heavily on water transfers from adjacent WMAs. This includes transfers from the Ebenezer Dam, Dap Naude Dam, Flag Boshielo Dam and Nandoni Dam in the Olifants River catchment.

Domestic and irrigation water in the small but highly developed Nzhelele catchment is supplied through the Mutshedzi Dam Regional Water Scheme (RWS) and the Nzhelele Dam RWS, as well as extensively from groundwater resources. The inflows to the Mutshedzi and Nzhelele dams have been reduced as a result of afforestation upstream of these dams. The area is in deficit due to the over-allocation and over development of irrigation.

The Sand and Nzhelele catchments have high coal mining potential but the availability of local water resources may limit future mining development.

1.3 STUDY AREA

The Limpopo WMA North is the most northern WMA in South Africa and refers to the area described as the Limpopo WMA in NWRS-1. Refer to Figure 1.2 for the location and general layout of the study area. The areas indicated in grey show the additional catchment and WMA areas included in the Limpopo WMA as per NWRS-2 and which do not form part of the study area for this Reconciliation Strategy.

The Limpopo WMA North forms part of the internationally shared Limpopo River Basin which also includes sections of Botswana, Zimbabwe and Mozambique. The Limpopo River forms the entire length of the northern international border between South Africa and Botswana and Zimbabwe before flowing into Mozambique and ultimately draining into the Indian Ocean. The dry Limpopo WMA North is augmented with transfers from the adjacent Letaba, Olifants and Crocodile West river catchments. No transfers are currently made from the Limpopo WMA North to other WMAs.

The main rivers in the study area, which form the six major catchment areas, are the Matlabas, Mokolo, Lephalala, Mogalakwena, Sand and Nzhelele rivers. These rivers, together with other smaller tributaries, flow northwards and discharge into the Limpopo River.

The climate over the study area is temperate and semi-arid in the south to extremely arid in the north. Mean annual rainfall ranges from 300 mm to 700 mm with the potential evaporation well in excess of the rainfall. Rainfall is seasonal with most rainfall occurring in the summer with thunderstorms. Runoff is low due to the prevalence of sandy soils in the most of the study area, however, loam and clay soils are also found.

The topography is generally flat to rolling, with the Waterberg on the south and the Soutpansberg in the north-east as the main topographic features. Grassland and sparse bushveld shrubbery and trees cover most of the terrain.

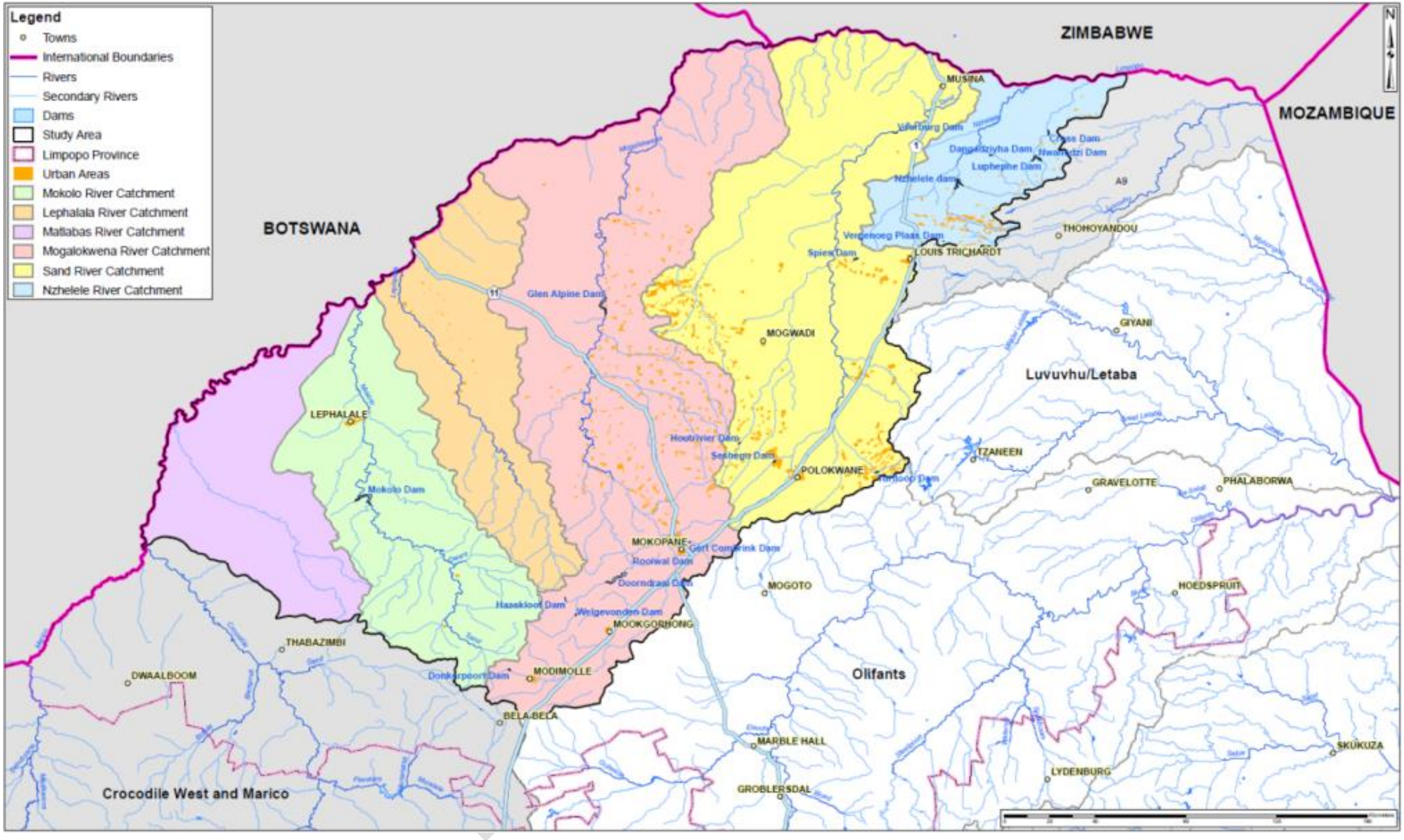

Figure 1.2 General layout of the study area

The southern and western parts of the WMA are mainly underlain by sedimentary rocks, whilst metamorphic and igneous rocks are found in the northern and eastern parts. With the exception of some alluvium deposits and dolomites near Mokopane and Thabazimbi, these formations are mostly not of high water bearing capacity. The mineral rich Bushveld Igneous Complex extends across the south-eastern part of the WMA, and precious metals are mined at various localities throughout the area. Large coal deposits are found in the north-west.

Several wildlife and nature conservation areas have been proclaimed in the WMA, of which the Nylsvley Nature Reserve, Mapungubwe National Park and the Marekele National Park are probably the best known.

The demarcation of the District Municipalities and the Local Municipalities in the study area is shown in **Figure 1.3** and **Figure 1.4**, respectively.

A brief overview of each of the six major catchments that comprises the study area is provided and summarised in **Table 1.1**.

Table 1.1 Summary of catchment area, runoff, precipitation and evaporation characteristics

Catchment	Tertiary catchment	WR2005				
		Gross area (km^2)	Net area (km^2)	MAR (million m^3/a)	MAP (mm/a)	MAE (mm/a)
Matlabas	A41	6 014	3 612	50.5	516	1 899
Mokolo	A42	8395	7610	263.7	558	1 807
Lephalala	A50	6 725	5 041	143.3	490	1 880
Mogalakwena	A61	5 452	5 227	163.0	614	1 750
	A62	5 795	5 584	68.9	479	1 883
	A63	8 067	6 981	40.5	391	2 014
Sand	A71	12 307	11 932	70.2	392	1 820
	A72	3 462	2 592	16.3	406	1 924
Nzhelele	A80	4 203	4 064	15.0	115	1 746

Notes: (1) MAR = Mean annual run-off

Figure 1.3 Demarcation of District Municipalities

Figure 1.4 Demarcation of Local Municipalities

1.3.1 Matlabas catchment (A41)

The Matlabas catchment is a dry catchment with non-perennial flow and hence no sustainable yield from surface water. The limited water use in this catchment is mostly from groundwater, which is under-exploited. The majority of the water required in this catchment is for irrigation purposes with the very small local population abstracting water from boreholes for personal use.

1.3.2 Mokolo catchment (A42)

The Mokolo catchment is located in the higher rainfall portion of this WMA and is also the most developed catchment from a water resources point of view. The Mokolo Dam is the largest dam in the WMA and provides water for a multitude of uses, the most important being the supply to the Matimba Power Station and Grootegeluk coal mine. There is also a significant amount of irrigation from groundwater.

Groundwater is under-utilised and could be used to support increased domestic requirements, provided the water quality is acceptable. High future water requirements are expected as a large amount of mining potential has been identified within the Waterberg Coal Field which falls within this catchment.

1.3.3 Lephalala catchment (A50)

The Lephalala catchment has limited water resources. Irrigation takes place mainly in the higher rainfall upper reaches where there are a large number of farm dams, while lower in the catchment irrigators make use of water from alluvial aquifers. Nevertheless, the catchment appears to be stressed and no new allocations should be made for irrigation purposes. Additional water for domestic purposes should be sourced from groundwater. The middle reaches of the Lephalala catchment has a high conservation value.

1.3.4 Mogalakwena River (A61 to A63)

The Mogalakwena catchment has limited surface water resources but large groundwater resources, which have already been extensively exploited by the irrigation sector. There is a rapid expansion of mines in the area and the water supply to these mines must be secured as a matter of priority. Additional water resources are groundwater and transfers from the Olifants River catchment.

1.3.5 Sand catchment (A71)

The Sand catchment is a dry catchment with very limited surface water resources. However, it has exceptional groundwater reserves which have been fully and possibly over-exploited, mostly by irrigation. The water requirements are large compared to the rest of the WMA, but again irrigation is the largest water user. Although the urban requirements are high, a large portion amount of water is supplied through transfers from other WMAs.

1.3.6 Nzhelele catchment (A80A to A80J)

The Nzhelele catchment *(A80A to A80G*) is small and is dominated by irrigation, with a small area of afforestation and domestic use by the rural sector. Nzhelele Dam is the second largest dam in the Limpopo North WMA and provides most of the water requirements in this catchment while groundwater is also extensively used.

The Nwanedzi catchment *(A80H to A80J*) is a small catchment in the north-eastern corner of the WMA characterised by over-allocated and over-developed large areas under irrigation and included as part of the Nzhelele catchment.

1.4 MAIN OBJECTIVES OF THE STUDY

The main objective of the study is to formulate a water resource reconciliation strategy for the entire Limpopo WMA North up to 2040. The Reconciliation Strategy must:

a) address growing water demands as well as water quality problems experienced in the catchment;
b) identify resource development options; and
c) provide reconciliation interventions, structural and administrative/ regulatory.

To achieve these objectives, the following aspects are included in the study:

- Review of all available information regarding current and future water requirements projections as well as options for reconciliation;
- Determine current and future water requirements and return flows and compile projection scenarios;
- Configure the system models (WRSM2000 rainfall-runoff catchment model, also known as the Pitman Model, the Water Resources Yield Model (WRYM) and the Water Resources Planning Model (WRPM)) in the study area at a quaternary catchment scale, or smaller, where required, in a manner that is suitable for allocable water quantification. This includes updating the hydrological data and accounting for groundwater surface water interaction;
- Assess the water resources and existing infrastructure and incorporate the potential for water conservation and water demand management (WCWDM) and water reuse as reconciliation options; and
- Develop a Reconciliation Strategy.

1.5 SCOPE OF THIS REPORT

The purpose of this report is to present the Draft Reconciliation Strategy for the Limpopo North WMA in preparation for the Final Reconciliation Strategy, which is considered as the primary deliverable for this Study. This report provides a synthesis of all of the information collected and work performed to formulate the Strategy during the study period. The report mainly describes the following three main aspects:

- The status quo of the surface and groundwater resources within the study area, in terms of quantity and quality;

- The projected future water requirements within the study area and the current water supply situation in terms of water balances;
- Possible intervention options that could be implemented to reconcile the projected future water requirement with the available water quantity and quality.

The Draft Reconciliation Strategy will be presented to stakeholders at the fourth Study Steering Committee (SSC) meeting scheduled for 22 September 2016. The Final Reconciliation Strategy will build on this report as well as the input, recommendations and approval from the relevant SSC members (stakeholders) received during and after the fourth SSC meeting.

2 CURRENT AND PROJECTED FUTURE WATER REQUIREMENTS

2.1 INTRODUCTION

The historic water use and return flows for all the water users in the study area were assessed, and the projected future water requirements were determined as part of this Study. The base water use was taken at the 2010-development level and the future requirements were estimated for the period 2011 to 2040. Where applicable, two water requirement scenarios were formulated (high and low) taking into account potential developments in mining, industry and power generation, current and potential inter-basin water transfer schemes, domestic demographic projections, as well as agricultural activities. Return flow volumes from domestic users (via wastewater treatment works (WwTW)) and irrigation are also reported on in this document.

The following sections give an overview of the water requirements of the main water use sectors considered, including:

- Irrigation sector;
- Domestic sector;
- Mining and industrial sectors; and
- Others, such as livestock watering and streamflow reducers.

More detail information is recorded in the *Water Requirements and Return Flows Report (P WMA 01/000/00/02914/4)* and the associated *Supporting Document 3: Socio-Economic Perspective on Future Water Requirements (P WMA 01/000/00/02914/4/3).* Updated water requirements have been obtained after the completion of the *Water Requirements and Return Flows Report.* These updated water requirements have been incorporated into the water balances included in this report. The domestic, industrial and mining water requirements were mainly quantified per catchment and not necessarily by economic focus area. The water requirements per economic focus area, such as Lephalale, the Mogalakwena and Aganang LM, Polokwane LM, Louis Trichardt, Matoks and Musina, were mainly obtained from other recent studies. The water requirements of these are in line with those of the specific catchments.

2.2 IRRIGATION WATER REQUIREMENTS

The irrigation sector accounts for the highest water use in the study area. Approximately 666 km^2 is currently under irrigation. The main crops in the study area include tobacco and citrus, however, maize (16.6%) is the crop with the largest area under irrigation, followed by potatoes (12%) and wheat (10.7%). Dryland cultivation with crops such as grain sorghum and cotton are also practised.

The results obtained from the parallel *Validation and Verification Study* by DWS (DWS, 2015) were incorporated into the WRSM2000 rainfall-runoff model and based on a composite crop, determined through combining all of the water requirements of all the various crop types, the irrigation water use for each quaternary catchment were determined. Refer to the *Irrigation Assessment Report (P MWA 01/000/00/02914/4/1)* and the *Hydrological Analysis Report (P WMA 01/000/00/02914/3)*, as part of this Study, for more information on the irrigation requirement estimation.

A summary of the irrigation water requirement per catchment is provided in **Table** 2.1 . Distinction is made between the irrigation water supplied by surface water, via run-off-river, dams, schemes and the Limpopo River, and groundwater from local sources and Limpopo River sand aquifers.

Table 2.1 Summary of irrigation water requirements in the Limpopo WMA North at the 2010-development level

River catchment	Irrigation water requirements (million m^3/a)							
	Surface water				Groundwater			TOTAL
	Run-off-river & Dams	Schemes	Limpopo River	Total	Groundwater	Limpopo River aquifers	Total	
Matlabas	0.6	0.0	1.8	2.4	2	0.3	2.3	4.7
Mokolo	30.9	6.1	0.0	37	3.2	0.0	3.2	40.2
Lephalala	38.5	0.0	4.4	42.9	0.7	26.2	26.9	69.8
Mogalakwena	25.4	7.9	6.1	39.4	43.2	16.8	60.0	99.4
Sand	9.9	0.0	43.7	53.6	126.8	41.3	168.1	221.7
Nzhelele	0.8	18.7	5.7	25.2	3.8	0.1	3.9	29.1
TOTAL	**106.2**	**32.7**	**61.7**	**200.6**	**179.7**	**84.7**	**264.4**	**464.8**

At the 2010-development level, the irrigation sector required approximately 465 million m^3/a, which is equal to 72% of the total water use. Groundwater supplied 57% of the irrigation requirement. In total, surface water supplied 43%, of which only 7% is supplied from regulated government schemes. The majority of the irrigated area (48%) is located in the Sand catchment, supplied mainly by groundwater.

Based on the preliminary results of the *Validation and Verification Study* (DWS, 2015), the estimated unlawful irrigation water use is more than 23 million m^3/a in the study area, of which 12.9 million m^3/a is supplied by groundwater and 9.7 million m^3/a is supplied by surface water. This accounts approximately 5% of the total irrigation water requirement. The majority of unlawful use occurs in the Sand catchment, followed by the Mogalakwena and Lephalala River catchments. These figures, however, will only be confirmed after the completion of the verification process.

No significant growth in terms of irrigation water requirements is expected, due to the already stressed water resources and subsequent low assurance of supply in the irrigation sector. However, it should be noted that due to the improvement of the efficiency of irrigation systems, it is likely that the area under irrigation might expand, while using the same volume of water to irrigate. In the Mokolo, Lephalala and Sand catchments a large number of irrigation farmers have converted to game farming from 2000 to 2010, resulting in a reduction in the water irrigation water requirement over that perios. It should be considered that the reverse might happen in the future and farmers might start using their full allocation.

In light of the above, it was decided to keep the irrigation water requirement constant over the reconciliation period (2011 to 2040). It is thus recommended that this irrigation water requirement be closely monitored during the implementation and continuation phases of the Reconciliation Strategy.

2.3 DOMESTIC WATER REQUIREMENTS

Within the context of this Study, domestic water requirements refer to residential water requirements in both urban and rural areas, as well as the requirements of smaller industries supplied by municipal networks.

Residential water requirements, at the 2011-development level were estimated from a demographic and water service level analysis of settlement-level information from the national census of 2011. Population estimates from the DWS for the study area were also used.

The projected future water requirements were based on population growth estimations and the economic growth characteristics within the study area. The population growth projections from 2012 to 2040 are based on the actual averages per settlement classification per LM between 2001 and 2011, as well as on anticipated large project investments that will attract migration towards new jobs. Natural population growth rates are in long-term decline, but significant migratory shifts are occurring, away from remote rural areas towards urban areas and especially towards economic growth points.

The population in the study area is expected to grow at less than 1% per year until 2040. However, the population in the Mokolo and Sand catchments are expected to grow at an average of 1.23% and 1.68% per year, respectively from 2012 to 2040.

These future water requirements include the following assumptions:

- Water losses will reduce from 28.2% in 2011 to 25.7 in 2020, 23% in 2030 and 20% in 2040 if effective WCWDM is implemented; and
- Water service levels improve progressively.

The projected future water requirements are summarised in **Table 2.2**. The main urban centres in the study area are currently mainly supplied by bulk water supply schemes (WSSs) and transfers from neighbouring WMAs.

The majority of the smaller rural areas rely on local groundwater resources. Local surface water resources currently supply only 21% of the domestic water requirements, while groundwater supplies 44.5% and transfers into the study area supplies 34.5%. It should be noted that the Matlabas catchment do have some domestic users in terms of farmers, but the volume is considered negligible.

Table 2.2 Summary of domestic water requirements in the Limpopo WMA North

Catchment	Domestic water requirements (million m^3/a)								
	2011			2015	2020	2025	2030	2035	2040
	SW	GW	Total						
Matlabas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mokolo	3.8	0.8	4.6	4.9	5.2	5.7	6.1	6.6	7.0
Lephalala	0.0	2.8	2.8	3.0	3.2	3.4	3.6	3.8	3.9
Mogalakwena	10.4[(1)]	19.5	29.9	30.1	30.2	31.3	32.4	32.9	33.3
Sand	38.7[(2)]	17.1	55.8	58.3	60.7	65.1	69.4	73.6	77.8
Nzhelele	3.7	5.3	9.0	9.4	9.7	10.4	11.1	11.6	12.0
TOTAL	**56.6**[(3)]	**45.5**	**102.1**	**105.6**	**109.0**	**115.8**	**122.6**	**128.3**	**134.0**

Notes:

(1) Includes transfer of 1.95 million m^3/a from Roodeplaat Dam to Modimolle.

(2) Includes allocated transfers of 32.2 million m^3/a: 12 million m^3/a from Ebenezer Dam to Polokwane, 6.53 million m^3/a from Dap Naude Dam to Polokwane, 11.3 million m^3/a from Olifantspoort Weir to Polokwane and 2.4 million m^3/a from Albasini Dam to Louis Trichardt.

(3 Includes total transfer volume of 35.2 million m^3/a from neighbouring WMAs, local surface water only account for 21.4 million m^3/a.

An alternative scenario was also evaluated to determine the effect if water losses are not reduced and the improvement in water service levels will be slower. This resulted in an increase in the domestic water requirement of almost 4.5 million m^3/a (2.8% more) by 2040 for the study area.

Detail of the future domestic water requirements projections and assumptions are included in the *Socio-economic Perspective on Water Requirements Report (P WMA 01/000/00/0214/4/3)*.

2.4 INDUSTRIAL AND MINING WATER REQUIREMENTS

Mines are key economic performers in the study area and the country. There are a number of large mines and industries located in the study area that have significant water requirements. Some major mines and industries include:

- Grootegeluk Coal Mine;
- Matimba Power Station;
- Mogalakwena Platium Mine (previously the Potgietersrus Platinum Mine);
- Venitia Diamond Mine;
- Polokwane Silicon Smelter or the AngloPlat smelter; and

- Recently constructed Medupi Power Station, as well as the Biokarabelo Coal Mine and Power Station.

As mentioned in Section 1, mining operations are expanding due to the vast untapped mineral resources in the area. A number of new power stations, coal-to-liquid (CTL) fuel facilities by Sasol and mining operations by Exxaro are being planned for in the Lephalale and Steenbokpan area, in the northern portions of the Matlabas and Mokolo catchments

Additional platinum group metal mining operations, as well as other types of mines, have been planned for in the Mogalakwena Municipal area. Major industrial developments, such as the Musina Special Economic Zone (SEZ) and the Limpopo Eco-Industrial Park (LEIP) are planned in the Musina area, in the north of the Sand catchment. Major coal mining developments are expected between Musina and Louis Trichardt.

The projections of the future industrial and mining water requirements were sourced from several planning reports. The exact water requirements associated with these sectors, however, are difficult to determine for confidentiality reasons in some cases, and limited information. Furthermore, the future mining development potential is dependent on a number of factors, which cause the projected water requirements to fluctuate regularly.

The industrial and mining water requirements given in **Table 2.3** were based on the operations that have been confirmed to proceed at the time of compiling this Reconciliation Strategy. Operations that are not proceeding or are in the very early stages of exploration have not been included in the water requirements.

Table 2.3 Summary of industrial and mining water requirements in the Limpopo WMA North

Catchment	Industrial and mining water requirements (million m^3/a)								
	2011			2015	2020	2025	2030	2035	2040
	SW	GW	Total						
Matlabas	0.0	0.0	0.0	0.0	6.0	6.0	6.0	6.0	6.0
Mokolo(1)	18.3	0.0	18.3	27.0	35.8	61.1	86.3	110.4	110.4
Lephalala	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Mogalakwena	8.9(2)	6.5	15.3	21.3	26.5	36.8	47.0	55.5	64.0
Sand	7.5	3.3	10.8	15.1	38.3	48.8	56.0	58.8	61.6
Nzhelele	0.5	0	0.5	0.8	4.7	5.2	9.3	6.5	7.0
TOTAL	**26.3**	**9.9**	**45.0**	**64.0**	**111.4**	**157.9**	**204.7**	**237.3**	**249.1**

Note: (1) Includes some of the water users located in the Matlabas catchment, but which will be supplied from Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP) Phase 2A.

(2) Includes the transfer of treated effluent from Polokwane and Mokopane to the Mogalakwena Platinum Mine.

The growth in the industrial and mining water requirements in the Mogalakwena and Sand catchments will be mainly supplied by transfer schemes from neighbouring WMAs, such as *Mokolo-Crocodile River (West) Water Augmentation*

Project (MCWAP) Phase 2A and *Olifants River Water Resources Development Project* (ORWRDP) Phases 2B and 2G. The water requirements planned to be supplied by these aforementioned transfer schemes have fluctuated since the start of the projects but are continuously being updated. The water requirements for the LEIP and SEZ have also not been confirmed, however, preliminary estimates indicated that both developments will require approximately 11 million m^3/a by 2040.

2.5 OTHER USERS

The impact of livestock watering, afforestation and invasive alien plants (IAPs) have been taken into account in the determination of the projected future water requirements. However, is should be noted that afforestation and IAPs are not considered as water users but rather stream flow reducers.

2.5.1 Livestock watering

Livestock watering is primarily supplied from surface water resources. The tendency to convert land-use from irrigation to livestock farming, particularly game farming in the Mokolo, Lephalala and Sand catchments, has increased the stock watering requirements. **Table 2.4** provides a summary of the livestock watering requirements within the study area per catchment. For the purpose of this Study, no growth in the livestock watering requirements were assumed and were kept constant over the planning period from 2011 to 2040.

Table 2.4 Livestock water requirements in the Limpopo WMA North at the 2010-development level

Catchment	Livestock water requirement (million m^3/a)
Matlabas	2.28
Mokolo	2.11
Lephalala	2.39
Mogalakwena	11.49
Sand	4.39
Nzhelele	0.75
TOTAL	**25.16**

2.5.2 Invasive Alien Plants (IAP)

IAPs tend to utilise more water compared to indigenous plant species and subsequently reduce the available runoff in a catchment. IAPs in the riparian zone have the largest impact on the reduction of runoff due to the greater water availability from rivers.

The IAP distribution and extent were obtained from the latest IAP survey report – the *National Invasive Alien Plant Survey* (ARC, 2010), conducted by the Agricultural Research Council (ARC). With the exception of the Matlabas River catchment, IAPs are widespread throughout most of the catchments in the study area.

The highest density of IAP occurs in the Sand catchment with a total IAP condensed area of 134 km^2 (2% of catchment area). **Table 2.5** summarises the IAP distribution and the estimated 2010-development level runoff reduction used as input to the WRSM2000.

Table 2.5 Summary of IAP estimated runoff reduction for 2010-development levels in the Limpopo WMA North

Catchment	Condensed area (km^2)	Runoff reduction (million m^3/a)
Matlabas	0.0	0.0
Mokolo	26.2	0.0
Lephalala	12.6	1.2
Mogalakwena	83.5	2.6
Sand	134.3	1.0
Nzhelele	59.0	2.1
TOTAL	**315.5**	**6.9**

2.5.3 Afforestation

Afforestation is confined to the high rainfall regions (> 800 mm/a) on the slopes of the Soutpansberg mountains, in the upper reaches of the Nzhelele catchment and quaternary catchments A71C and A71H of the Sand catchment. Information on the area covered by afforestation was sourced from the *Validation and Verification Study* (DWS, 2015). The impact of afforestation on the water resources in the study area is considered negligible, reducing the runoff in the Nzhelele River catchment by approximately 2 million m^3/a, and 0.2 million m^3/a in the Sand River catchment.

2.5.4 Ecological water requirements

Ecological water requirements (EWRs) refer to the quantity, timing, and quality of water flow and storage required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems. These EWRs are an important non-consumptive water requirement that must be included in yield analyses to determine the impact of these requirements on the yield of an individual dam and/or the water resource in total. The releases for EWR are legal obligations to ensure that the upstream catchment delivers its equitable and fair share for maintaining the health of the downstream river in terms of water quantity.

All approved and signed-off EWR results from previous Reserve assessments, including desktops for Water Use License Applications (WULAs), were sourced from the Reserve database files curated by the Directorate Reserve Requirements (D: RR). Apart from the Mokolo and Matlabas catchments, no high level Reserve information (i.e. Rapid, Intermediate or Comprehensive level) for the Limpopo WMA North is available.

Desktop information on the ecological categories (EC[1]) is available from the Desktop *Present Ecological State Ecological Importance and Sensitivity (PESEIS)* (2012) assessment conducted per sub-quaternary reach for the country under the leadership of DWS and the Water Research Commission (DWS, 2014b)The information obtained from these assessments, e.g. Present Ecological State (PES) and Recommended Ecological Category (REC), can be used as first level desktop assessments to set the EC for the purposes of EWR determination and for Ecological Water Resource Monitoring (EWRM).

Even though there are some signed-off desktop reserve assessments available, the natural streamflow data were updated as part of this study (See *Hydrological Analysis Report (P WMA 01/000/00/02914/3)*) and this necessitated the update of the existing desktop EWR determinations. The Desktop Rapid Reserve module of the Grahamstown Institute for Water Research (IWR) model, *SPATSIM version 2.0.12.6* was used together with the derived EC and the REC.

For the purpose of this Study EWRs were not considered as a water requirement as such, but the effect of implementing EWRs in the study area on the yield of large dams was assessed. This impact is discussed in more detail in **Section 4.1.1**.

More detailed studies have to be conducted to better quantify the EWRs and subsequent impact on the yield of large dams for the following phases of the Reconciliation Strategy.

2.6 TOTAL WATER REQUIREMENTS

A summary of the current and future projected water requirements are included in **Table 2.6** and graphically shown in **Figure 2.1**. The mining and industrial sectors are by far the largest growing sectors in terms of water requirements, growing from 45 million m^3/a in 2010 to 249 million m^3/a in 2040 (454%). Associated with the growth in industrial and mining water requirement, domestic water requirements grows from 102 million m^3/a in 2010 to 134 million m^3/a in 2040 (31%).

Table 2.6 Summary of total water requirements in the Limpopo North WMA

Sector or water user	Water requirements (million m^3/a)						
	2011	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Irrigation	464.8	464.8	464.8	464.8	464.8	464.8	464.8
Domestic	102.1	105.6	109.0	115.8	122.6	128.3	134.0
Mining, industries and power generation	45.0	64.0	111.4	157.9	204.7	237.3	249.1
Livestock	23.4	23.4	23.4	23.4	23.4	23.4	23.4
IAP and commercial forestry	9.1	9.1	9.1	9.1	9.1	9.1	9.1
TOTAL	**644.4**	**666.8**	**717.7**	**771.0**	**824.6**	**862.9**	**880.4**

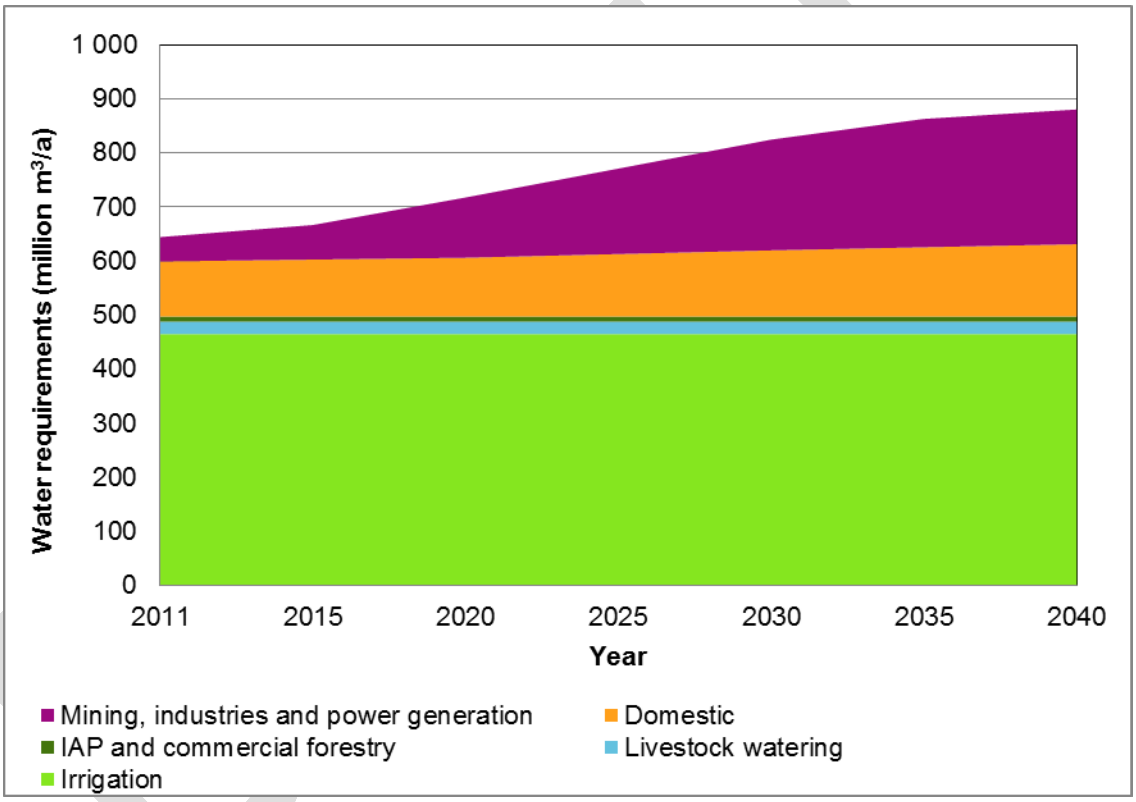

Figure 2.1 Total water requirements in the Limpopo North WMA

3 WATER QUALITY

3.1 INTRODUCTION

A surface water quality assessment was conducted as part of this Study (*Water Quality Assessment Report, P WMA 01/000/00/02914/5).* The assessment focussed on the following:

- Current situation description of the study area, the existing water uses and potential sources of pollution;
- Water quality assessment of data sourced from the DWS national database to show trends of non-compliant determinants; and
- Outlining mitigating measures to ensure the water quality is of an acceptable level to maintain a healthy ecosystem.

The groundwater quality was assessed as part of the groundwater assessment, reported on in the *Groundwater Assessment and Utilisation Report (P WMA01/000/00/02914/6).*

3.2 CATCHMENT WATER QUALITY STATUS

A brief description of the surface water quality issues and possible sources of pollution in each of the catchments is given below.

3.2.1 Matlabas catchment

The Matlabas catchment is a dry catchment with no significant dams and low growth potentials. Agricultural activity could lead to the deterioration of the groundwater quality. The runoff produced from the irrigation of farmlands and effluent from livestock can lead to surface and groundwater pollution. Pesticides, herbicides and fertilizer used in agricultural activities are the main pollutants responsible for the deterioration of water quality.

3.2.2 Mokolo catchment

The Mokolo catchment is dominated mainly by agriculture and game farming. The river flow is highly regulated from the Mokolo Dam with sporadic flows being released for the farming community. Pulsed releases from Mokolo Dam may interfere with water temperatures within the lower reaches of the river, and the unseasonal flow patterns may also adversely affect the lower river system (*State of River Report, Mokolo River, 2006*).

The urban centres of Lephalale and Vaalwater are of possible concern to the water quality due to the informal settlements that are located in the vicinity of these towns. The use of pit latrines can lead to nearby watercourses being contaminated with E.coli and nitrate.

Matimba and Medupi Power Stations and the Grootegeluk Coal Mine, may have a negative impact on the water quality of the catchment. Acid Mine Drainage (AMD) is also a possible threat associated with the Grootegeluk Coal Mine. The potential problems also include an increase in metal content, total dissolved solids (TDS) or salinity, pH and sediment load.

A number of new developments are expected in the Mokolo catchment, including possible extension of existing mines, development of gas fields and the development of petrochemical industries, which may negatively impact on the water quality in this catchment.

3.2.3 Lephalala catchment

The dominant land use in the upper and lower parts of the Lephalala catchment is cattle and game ranching with irrigated agriculture. The Lephalala River is largely undeveloped and the Lephalala Wilderness area is in the middle reaches of this catchment. This is important from an ecological perspective due to the large number of red data species found in this river. Numerous wetlands occur in this area as well.

Water quality in the middle reaches of the Lephalala River is good, although return flows from upstream irrigated agriculture contains pollutants such as pesticides, herbicides and fertiliser (potassium, nitrate and ammonium nitrate) posing potential risks to water quality.

There are a number of game lodges and hotels situated in this catchment which serve as the main tourist attractions. This industry is likely to increase in the future. The effluent from these establishments could become a problem if not treated properly and can lead to contamination with E.coli and nitrate.

3.2.4 Mogalakwena catchment

The Mogalakwena catchment has a large potential for growth, but has insufficient water supply to meet current needs. The Doorndraai Dam is over-allocated and all water resources in the Mogalakwena catchment have been fully developed.

The middle of this catchment is densely populated with informal settlements that are mainly supplied from groundwater. This poses a risk for surface water quality, as well as groundwater quality due to the high concentration of pit latrines. This can lead to long-term contamination of underlying aquifers with E.coli and nitrate as well as unsafe concentrations of bacteria, viruses and chemicals.

Groundwater is also threatened by mine water decant and naturally occurring fluorides emanating from the underlining granite in some areas. As mining is set to increase in future, the potential of more mine water decant is a high risk. Additional water quality determinants associated with the gold and base-metal mines as well as smelters are antimony, pH, TDS, total suspended solids (TSS) and tin.

Large scale irrigation around the dams in this catchment can lead to deterioration of water quality due to runoff of potential agro-chemical pollutants into the water source.

3.2.5 Sand catchment

The Sand catchment is the driest area in the WMA. The surface water is very limited and most of the dominant irrigation sector water requirements are met with groundwater extraction, which are possibly over-exploited. There is an uncontrolled use of fertilizers in the Vivo and Mogwadi (previously Dendron) areas, which can lead to infiltration of nitrates into the groundwater. This can be a serious risk to the population who rely on groundwater for domestic use.

Mining is an important economic driver in this area with a silicon mine and a Platinum smelter near Polokwane, which can have the potential to negatively affect both surface and groundwater sources. Potential mining developments and other industrial developments, such as the Musina SEZ and LEIP, may increase pollutants in the catchment. Water quality determinants associated with the industries and mines in this catchment include copper, mercury, nickel, TSS, TDS, and Zinc.

The location of the WwTW within a catchment can have a major impact on water quality if the discharged effluent does not comply with license requirements. Untreated or partially treated effluent can lead to an increase in nitrates, phosphate, ammonia and E.Coli in the receiving environment. This is of particular significance to this catchment, due to two of the seven large (> 6 Mℓ/d) WwTW in the study area that are located in this catchment.

3.2.6 Nzhelele catchment

Water use in the Nzhelele catchment is dominated by irrigation, which is supplied from river runoffs in the upper reaches of the catchment and the Nzhelele Dam in the lower reaches of the catchment. Much of this water for irrigation is allocated to commercial farmers downstream of Nzhelele Dam. The area is in deficit due to the over-allocation and over development of irrigation, which can negatively impact on water quality due to agro-chemical determinants. Domestic and small industrial requirements are mainly supplied by the Mutshedzi Dam and from groundwater.

The location of two large WwTW in the Makhado town area can have a major impact on the quality of water if the effluent is not treated to acceptable standards as per license requirements.

3.3 POSSIBLE POLLUTANTS

Table 3.1 summarises the possible pollution sources, associated water quality determinants and the water quality problems in the study area.

Table 3.1 Summary of water quality problems in the study area

Pollution source	Associated determinant	Water quality problem	Catchment
Agricultural activities	Pesticides, nitrate, phosphate, ammonia, E.Coli, Suspended Solids (SS)	Eutrophication: algal blooms, Microcystin, low oxygen levels, bad taste and odour, increased water treatment cost and impact on aesthetics and recreational water users Poor microbiological quality: danger to human health, increased turbidity due to erosion	Matlabas, Mokolo, Sand, Lephalala, Nzhelele
Mining	Heavy metals, sulphates, pH	Occurrence of AMD in surface and groundwater leading to number of effects including mobilisation of metals, fish and crocodile kills and bioaccumulation	Mokolo, Sand
Power stations	Hardness, turbidity, temperature, Suspended Solids (SS)	Decrease in biodiversity Increase hardness of water	Mokolo
Informal settlements	Chemical Oxygen Demand (COD), Nitrate, phosphate, ammonia, E.Coli	Danger of nitrate poisoning: Blue baby syndrome Danger to human health	Mokolo, Mogalakwena, Sand
Hotels and lodges	COD, nitrate, phosphate, ammonia, E.Coli	Danger of nitrate poisoning: Blue baby syndrome Danger to human health	Lephalala
Geology of area	Fluoride, calcium, sodium, magnesium	Negative impact on human health Affects aesthetic quality of water Salinization of soils	Mogalakwena
WwTW	COD, Nitrate, phosphate, ammonia, E.Coli	Danger of nitrate poisoning; Blue baby syndrome Danger to human health through recreational and domestic use - washing and bathing Negative impact on ecosystem: low oxygen, eutrophication, effect of ammonia on invertebrates and fish.	Mogalakwena, Sand, Nzhelele

3.4 SURFACE WATER QUALITY ASSESSMENT

As mentioned, a surface water quality assessment was conducted to identify non-compliant determinants and possible deteriorating trends. Resource Water Quality Objectives (RWQOs) were determined per catchment using *RWQOs Model Version 4.1*. Water quality data from the DWS National Water Quality Monitoring Programs were assessed against the RWQO limits for the individual catchments to show compliance and possible trends.

Although the RWQO limits have four levels (ideal, acceptable, tolerable and unacceptable), only the Ideal and Acceptable levels have been used in this assessment. The percentage compliance for each applicable determinant was determined for each catchment.

The results for both Ideal and Acceptable limits are summarised in **Table 3.2**. The following should be noted when interpreting the results:

- Phosphates are a problem determinant in all the catchments; there are no samples which comply 100% with the Ideal or Acceptable limit. In the Sand catchment, the percentage compliance is only 77%. These findings have major implications for water quality as increased phosphates can lead to eutrophication.
- A number of samples in all catchments do not comply with Ideal limits for Electrical Conductivity (EC), Sodium, Sulphates and Chloride. It should be noted that the RWQ limit for these determinants is much stricter than the health limit for these determinants as per SANS 241. Therefore although the water in the study area is not compliant for these determinants, it does not pose a health risk to the community if used as potable water. If the compliance for these determinants decreases further as per the RWQ limits, it will negatively impact on other users; especially the agriculture sector which is affected by increased salts in the water.
- The results indicate failure for COD in the Sand catchment based on two samples, and failure for faecal coliform in Lephalala catchment, also based on two samples.

Figure 3.1 shows the surface water monitoring stations in the study area along with the determinants at each station that is non-compliant.

Table 3.3 provides a summary of the water quality issues, possible reasons for the non-compliance and the proposed mitigation measures.

Table 3.2 Summary of percentage compliance of determinants per catchment

Determinant	Units	Bound	Matlabas	Mokolo	Lephalala	Mogalakwena	Sand	Nzhelele
TSS	mg/l	Upper						
Ammonia (NH3-N)	mg/l	Upper						
Calcium (Ca)	mg/l	Upper	100	100	100	96	98	100
Chloride (Cl)	mg/l	Upper	100	100	100	100	84	100
EC	mS/m	Upper	100	99	99	100	89	100
Fluoride (F)	mg/l	Upper	100	100	99	92	98	92
Magnesium (Mg)	mg/l	Upper	100	100	100	100	100	99
NO2 and NO3	mg/l	Upper	100	100	100	98	100	100
pH	units	Lower	100	95	94	97	100	99
		Upper	100	100	80	97	54	99
Potassium (K)	mg/l	Upper	100	100	100	94	98	93
PO4-P	mg/l	Upper	82	98	97	91	77	91
Sodium (Na)	mg/l	Upper	100	100	98	100	85	100
SO4	mg/l	Upper	100	100	99	100	100	100
Al	mg/l	Upper		100				100
Fe	mg/l	Upper			67		100	
Pb soft	mg/l	Upper		100	100	100	0	17
Mn	mg/l	Upper		100		100		100
Si	mg/l	Upper	100	100	100	98	98	100
COD	mg/l	Upper		100	100	100	50	100
Faecal coliforms	per 100 mℓ	Upper			0		100	

100% Ideal
100% Acceptable
80-99% Acceptable
<79% Acceptable

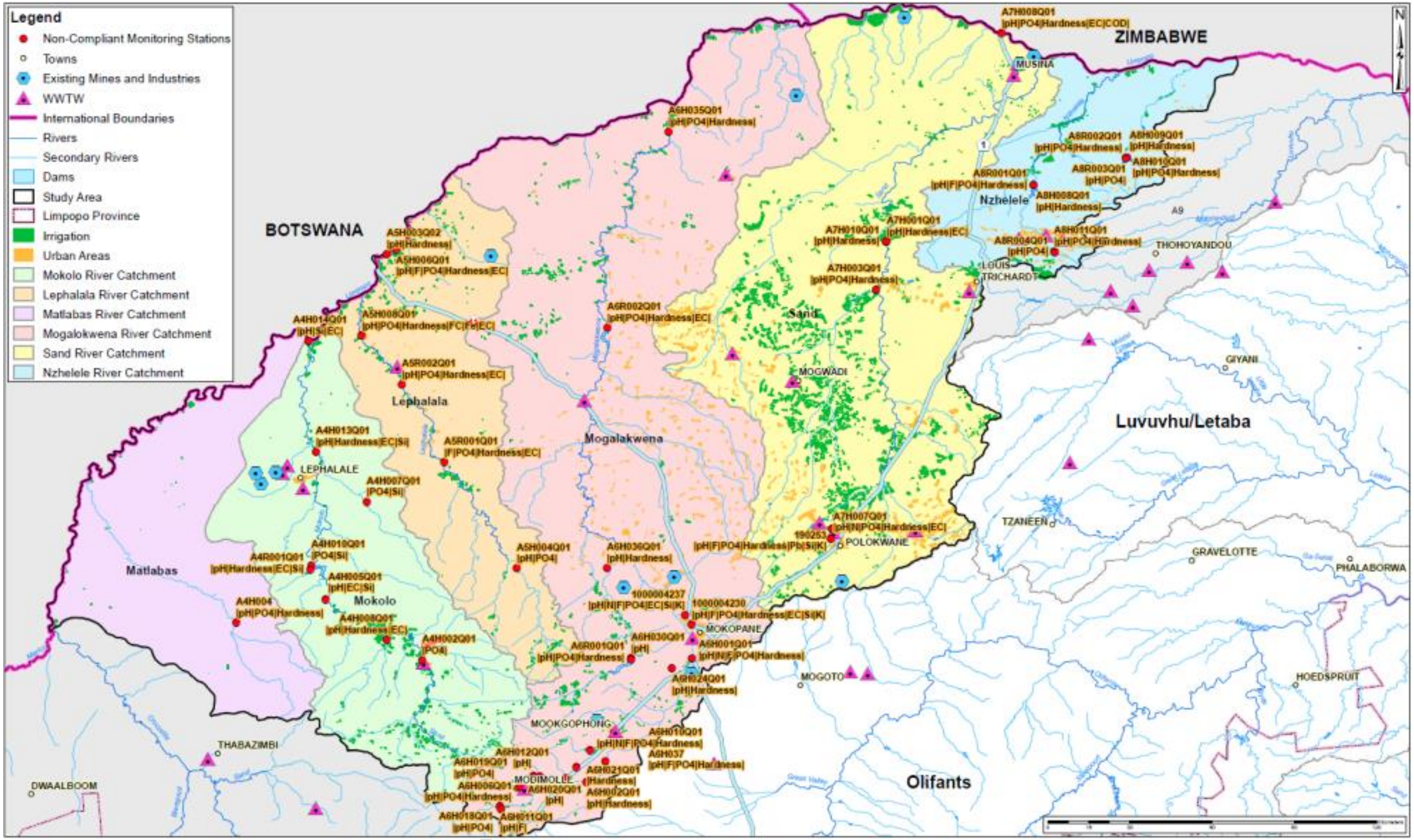

Figure 3.1 Surface water monitoring stations and associated non-compliant determinant

Table 3.3 Summary of water quality issues and mitigation measures

Water quality issue	Possible reason for non-compliance	Mitigation measures
Urban centres such as Polokwane, Mokopane, Mookgopong, Modimolle, Lephalale and Musina are non-compliant for determinants which are associated with untreated or partially treated sewage effluent, i.e. phosphate, nitrate, COD and faecal coliform bacteria.	Urban centres are located downstream of WwTW. It is possible that discharged effluent might be untreated or insufficiently treated.	The correlation between WwTW performance and the water quality downstream of the facility must be further investigated. Every Water Services Authority (WSA) is required to undertake monthly monitoring of the final effluent, at upstream and downstream points for nine determinants and provide this information to the regulator via the Green Drop systems. Evaluation of this data against the national database will show if the WwTW is indeed responsible for non-compliances observed. Mitigating measures can then be implemented by the WSA to ensure the WwTW is functional and effluent is compliant.
Non-compliance for faecal coliforms in the Lephalala catchment presents a serious health risk to humans who may use the water as a potable source.	Lack of adequate chlorination at the WwTW located upstream of the monitoring point.	Increase monitoring of chlorine to every four hours as well as weekly monitoring of faecal coliforms to ensure compliance.
Some monitoring points located in rural areas around Mogalakwena LM and Polokwane LM are non-compliant for nitrate.	Possible seepage from pit latrines from informal settlements.	Increase monitoring of nitrate at boreholes where water is used for human consumption.
Excluding the Matlabas and the Nzhelele catchments, all other areas show an increase in EC and salts.	Agricultural activity	Increase monitoring at all large farms to evaluate levels of runoff.
The Lephalala and Mogalakwena catchments are non-compliant for fluoride, in particular the area around Mokopane and Modimolle.	Elevated levels of Fluoride are associated with the geology in that area.	Increased monitoring of Fluoride in these areas on a weekly basis and blending with other sources when Fluoride levels exceed the allowable limit for the specific user.
The occurrence of Iron in Lephalala catchment, Lead in the Sand and Nzhelele catchment, and Silica in the Mokolo catchment.	Occurrences are associated with geology in the area.	Increase frequency of monitoring for these determinants at the relevant monitoring stations and surrounding areas to ensure maximum allowable limit for these determinants is not exceeded.
Calcium occurs in all of the catchments and is present at most of the monitoring stations.	Calcium is a naturally occurring element in the earth's crust and does not present health risks if consumed.	No mitigating measures required to reduce Calcium.
Lack of adequate monitoring data for Iron and Lead in the following catchments: Lephalala: Only three samples recorded for iron of which two are non-compliant Nzhelele: Only two samples recorded for lead and both are non-compliant Sand catchment: Only one sample recorded for lead and it is non-compliant		Increase frequency of monitoring for these determinants at the relevant monitoring stations and surrounding areas to ensure the maximum allowable limit for these determinants is not exceeded.

3.5 GROUNDWATER QUALITY

Groundwater chemistry data was obtained from the Water Management System (WMS) data base, GRIP Limpopo data base, as well as from various consultancies. The electrical conductivity (EC) values were contoured using a 1 km x 1 km grid along with the fluoride and nitrate concentrations at various monitoring points to give a regional overview of the groundwater quality of the study area. These maps are shown in **Figure 3.2** and **Figure 3.3**.

As with the surface water, high fluoride concentrations within the study area relate mostly to granitoid intrusive rocks, like at Mookgopong where fluorspar (commercial name for the mineral fluorite) was mined in the past. Higher nitrate concentrations are natural in certain areas due to underlying geology, but can also relate to irrigation and human settlements. In densely populated rural areas and large irrigation schemes higher nitrate concentrations are prevalent.

Interventions to limit possible nitrate pollution in human settlements will be to use sealed environmentally friendly toilets in the rural areas.

3.6 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The following were concluded from the surface water quality assessment:

- With the exception of the Matlabas catchment, all other catchments in the study area have water quality issues which indicated deterioration over time;
- Anthropogenic activities such as WwTW, pit latrines and agricultural activity are the main contributors to the deterioration of the water quality. The major concern in the urban areas is non-compliance to phosphates and changes in pH, while increase in EC (salts) is the main concern in the rural areas; and
- Geology also plays a part in this study area with several determinants present in the surface water which are not tolerated by some of the users. These include iron in Lephalala, fluoride in Mogalakwena and lead in Sand and Nzhelele catchment.

The following mitigation measures are recommended:

- For all problem determinants, the frequency of monitoring at the monitoring station as well as upstream and downstream points should be increased;
- Improve the management and monitoring of WwTW to ensure that discharged effluent comply with standard and licence requirements;
- Increase monitoring frequency of diffuse sources of pollution, such as monitoring at large farms to determine the impact of the agricultural activity on increased salinity; and
- In places were geology negatively affects water quality, monitoring must be increased and users must identify alternative water resources that can be used when levels are exceeded.

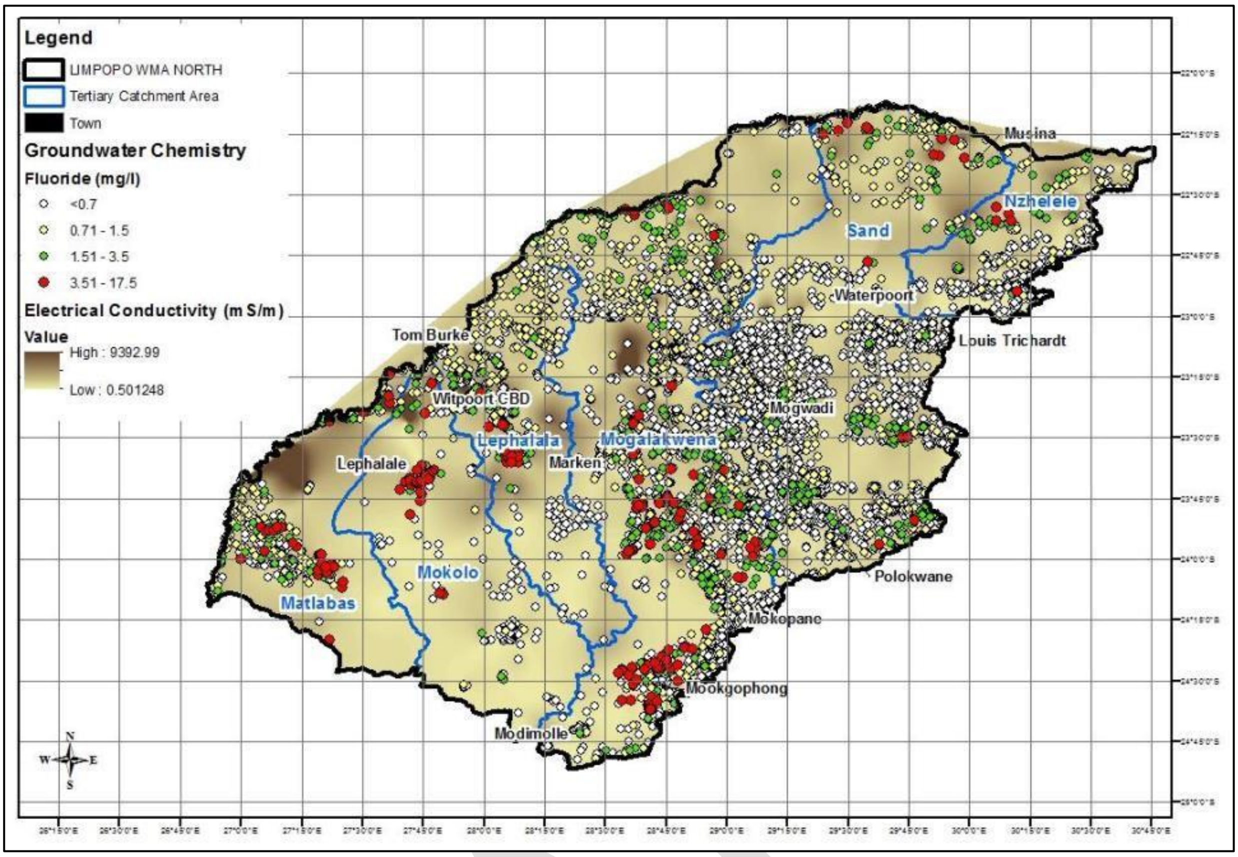

Figure 3.2 Groundwater quality: Contoured electrical conductivity and fluoride

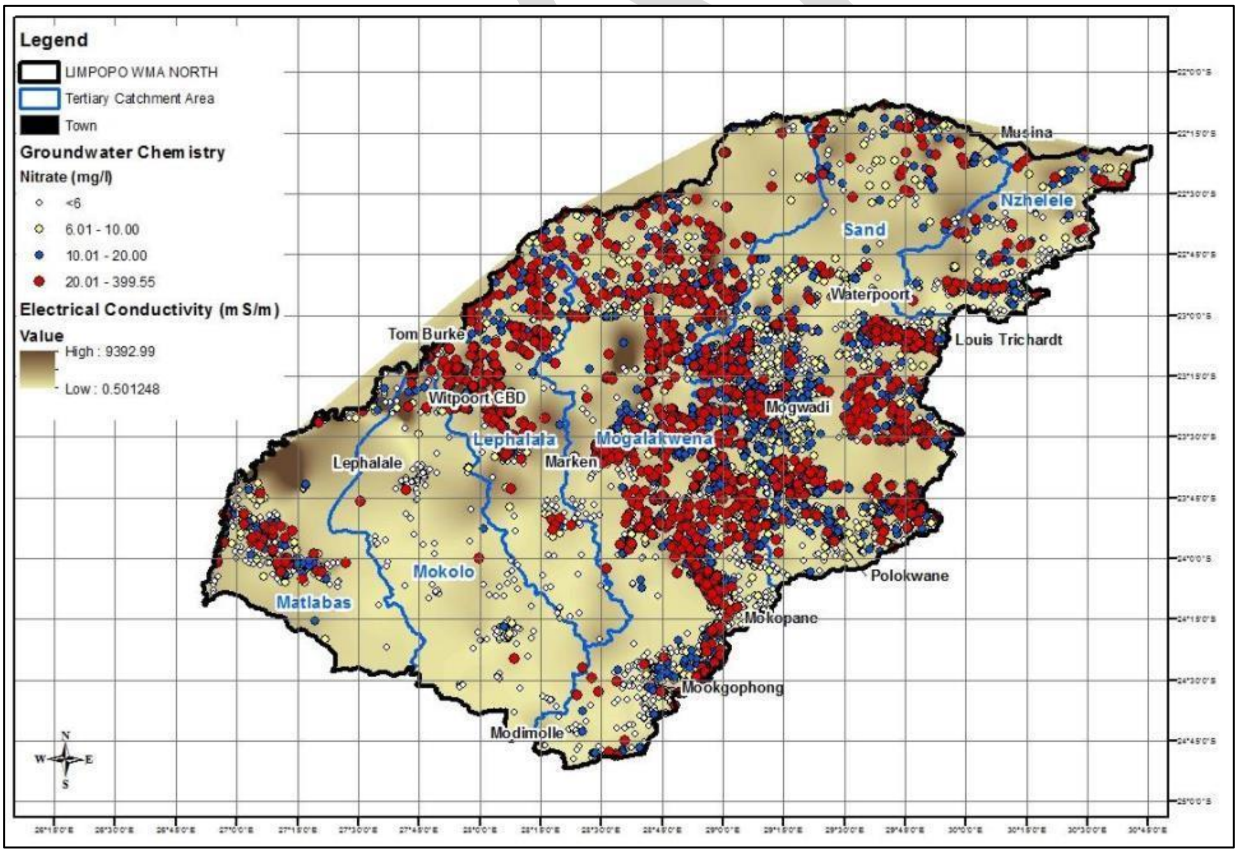

Figure 3.3 Groundwater quality: Contoured electrical conductivity and nitrate

4 WATER RESOURCE AVAILABILITY

The water resources, especially surface water resources, are stressed due to extensive development in most of the six catchments. Several large dams are located in the study area, including the Mokolo Dam, Doorndraai Dam, Glen Alpine Dam, Nzhelele Dam, Mutshedzi Dam, and the Nwanedi and Luphephe twin dams. Groundwater contributes approximately 40% towards the yield from local resources and is the only dependable water source for the majority of rural domestic users in the WMA. Transfers from the Olifants, Luvuvhu/Letaba and the Crocodile (West) and Marico WMAs augment supply to Mokopane, Polokwane and Louis Trichardt.

4.1 SURFACE WATER

The surface water availability and requirements were analysed per catchment as part of the hydrological and yield analyses conducted for this Study. Detail of the hydrological and yield analyses are discussed in the *Hydrological Analysis Report (P WMA 01/000/00/02914/3)*, and *Yield Analysis (WRYM) Report (P WMA 01/000/00/02914/7),* respectively.

The surface water resources in the study area are considered to be almost fully developed. Due to the arid climate, unfavourable topography, sandy rivers and important conservation areas, the scope for future surface water development is limited.

4.1.1 Large dams

Major dams are mainly located within the higher rainfall regions of the study area. These large dams were constructed to supply irrigation and larger towns. The largest dam in the study area is the Mokolo Dam, followed by Nzhelele Dam and Doorndraai Dam.

The Mokolo Dam supplies water to the Matimba Power Station, Grootegeluk Coal Mine (operated by Exxaro), Lephalale, Marapong and downstream irrigation. The allocations of the dam have recently been revised to accommodate the first phase of MCWAP. The old and the new allocations are summarised in **Table** 6.2 in **Section 6.3.2a)**.

Donkerpoort Dam is a small dam located in the upper Mogalakwena catchment. The dam was initially constructed to supply Modimolle (0.93 million m^3/a). However, due to the high water tariff pertained to using Donkerpoort Dam compared to the Roodeplaat Dam Transfer Scheme, water use has reduced, resulting in the dam being under-utilised.

Doorndraai Dam supplies the Mokopane LM (4.4 million m^3/a allocation) and downstream irrigation (3.7 million m^3/a allocation). Lepelle Northern Water has bought some of the irrigation allocation from the Doorndraai Dam in 1990. Mining companies, such as Lonmin has applied to buy the remainder of the irrigation allocation as no growth in irrigation water requirements from the Doorndraai Dam has taken place in recent years.

The Glen Alpine Dam was constructed to supply irrigation water requirements. Approximately 7.3 million m^3/a is supplied to irrigation via releases from the dam into the river – no canal or other formal conveyance system exists. It is estimated that 78% of the water released from the dam is lost, resulting in a total demand of approximately 13 million m^3/a. Each downstream irrigator was allowed to construct a storage weir with a set capacity. Water is released form the dam a few times a year based on the requirements of downstream irrigators, managed by a steering committee, to fill these weirs. Due to this operation approach, weirs of upstream framers fill first, but should they not use their allocation the water is lost. Furthermore, these weirs may become evaporation/siltation ponds.

The Turfloop and Houtrivier dams are small dams located in the Sand catchment that supply mainly rural requirements. The Houtrivier Dam supplies approximately 0.2 million m^3/a to the Houtrivier Regional Water Supply Scheme (RWSS), located just North of Polokwane. The yield and subsequent use from Turfloop Dam is almost negligible.

The Mutshedzi Dam was built for the purpose of supplying domestic water to the surrounding communities in the vicinity of Makhado Town. The domestic allocation from the dam is 3.67 million m^3/a. Run-off-river abstractions for irrigation occur downstream of the dam utilising the dam releases. The allocation for these abstractions are 1.41 million m^3/a.

The Nzhelele Dam, as well as the Nwanedi and Luphephe twin dams, was constructed to mainly supply irrigation. The Nzhelele Dam has an irrigation allocation of 29 million m^3/a – more than the 95% assurance of supply yield. Additionally, 0.5 million m^3/a is supplied from the Nzhelele Dam to the Tshipise Holiday Resort. The dam is thus over-allocated, even without the implementation of the EWRs. Weirs constructed downstream of the Nzhelele Dam are used to abstract water released from the dam for irrigation purposes. Water losses, due to illegal connections, aged infrastructure and reticulations leaks are a major concern. A significant amount of water, estimated up to 60% of the water released from the dam, is lost along the Nzhelele Canal.

The Nwanedi and Luphephe twin dams are situated inside the Nwanedi Nature Reserve, at the confluence of the Nwanedi and Luphephe rivers. These dams provide water for wildlife, irrigation and limited domestic usage in the surrounding areas. The combined allocation from the Nwanedi and Luphephe dams is 5.31 million m^3/a for irrigation.

The licence to supply domestic water requirements from the twin dams to the Luphephe Nwanedi Regional Water Scheme (RWS) have been granted – the allocation is 1.135 million m^3/a. There is also a pipeline from the dams which supplies a camp in the Nwanedi Nature Reserve. Water is released from the dams into a canal system which distributes the water to the irrigators. Cross Dam, situated downstream of these dams is primarily used as a balancing dam to regulate the water releases for irrigators downstream.

The characteristics of the major dams in the study area, including the historic firm yield (HFY) and the long-term stochastic yields, are provided in **Table 4.1**.

The yield with and without the implementation of EWRs are included in the table. Note that the only a first level desktop assessment was carried out to determine the EWRs for catchments other than the Matlabas and Mokolo catchments.

Figure 4.1 shows the historical and stochastic yield of the dams that were analysed in the study area. The corresponding yields with the impact of releasing the desktop EWRs (with pattern in the same colour as yield) are included to show the impact of the EWRs on the yield.

The considerable impact of releasing the desktop EWR from the major dams selected for yield analyses is shown in **Figure 4.2**. It is shown that there is a reduction in yield of 80% at Glen Alpine Dam, 46% at Doorndraai Dam and a 44% at Nzhelele Dam.

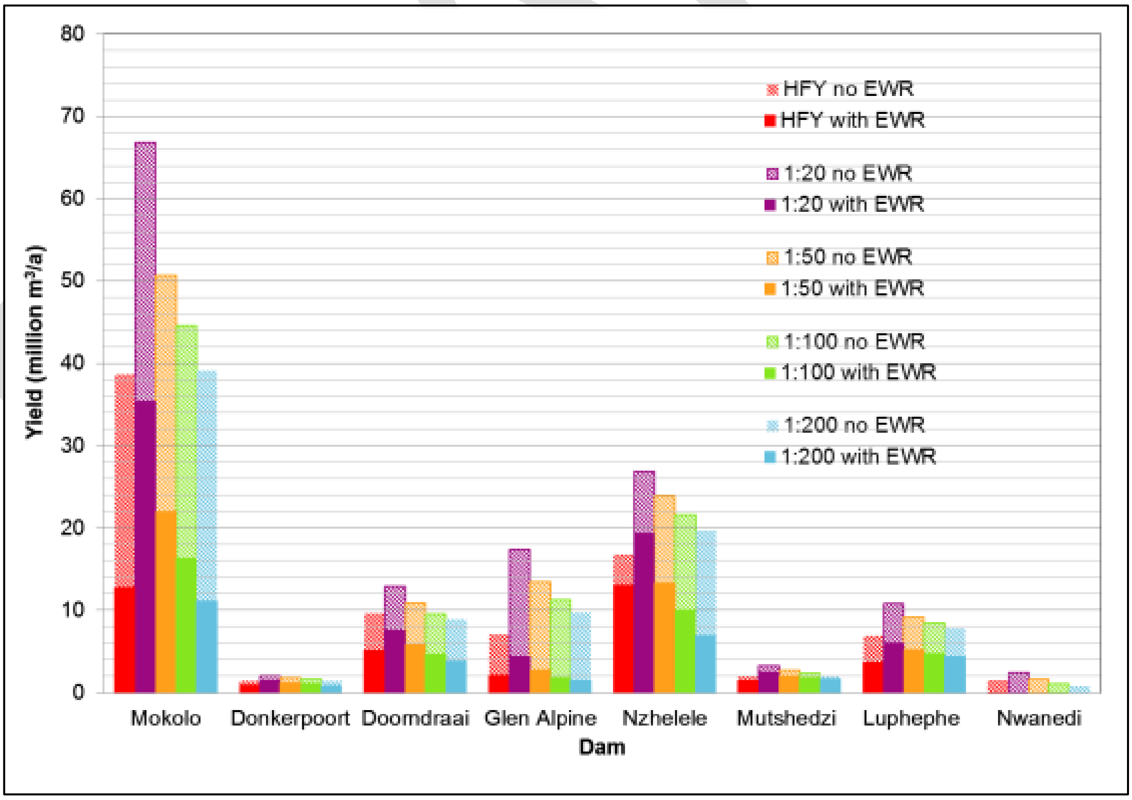

Figure 4.1 Overview of historic and stochastic yields with and without EWR

Table 4.1 Characteristics of major dams in the Limpopo WMA North with no EWR

Dam	Catchment	Quaternary	MAR[1] (million m^3/a)	FSC (million m^3)	HFY[2,4] (million m^3/a)	Stochastic yield[3,4] (million m^3/a), at indicated annual assurance of supply			
						1:200 (99.5%)	1:100 (99%)	1:50 (98%)	1:20 (95%)
No EWR implemented									
Mokolo	Mokolo	A42F	209.4	145.9	38.7	39.10	44.60	50.70	66.80
Donkerpoort	Mogalakwena	A61A1	5.3	2.4	1.44	1.49	1.64	1.83	2.11
Doorndraai		A61H	38.1	44.2	9.64	8.87	9.55	10.89	12.87
Glen Alpine		A62J	204.0	18.9	7.09	9.75	11.30	13.45	17.40
Turfloop	Sand	A71B	0.6	3.3	0.01	-	-	-	-
Houtrivier		A71E	0.4	7.5	0.06	0.01	0.04	0.13	0.26
Nzhelele	Nzhelele	A80C	73.4	51.2	16.81	19.68	21.64	23.92	26.91
Mutshedzi		A80A	15.5	2.2	1.98	2.12	2.35	2.69	3.30
Luphephe		A80H1	21.4	14.8	6.87	7.77	8.42	9.17	10.78
Nwanedi		A80H2	9.5	5.3	1.54	0.81	1.11	1.62	2.43
With full EWR implemented									
Mokolo	Mokolo	A42F	209.4	145.9	12.8	11.1	16.3	22.0	35.4
Donkerpoort	Mogalakwena	A61A1	5.3	2.4	0.93	0.90	1.10	1.26	1.54
Doorndraai		A61H	38.1	44.2	5.1	3.82	4.72	5.89	7.55
Glen Alpine		A62J	204.0	18.9	2.1	1.51	1.88	2.74	4.42
Turfloop	Sand	A71B	0.6	3.3	-	-	-	-	-
Houtrivier		A71E	0.4	7.5	-	-	-	-	-
Nzhelele	Nzhelele	A80C	73.4	51.2	13.06	6.99	10.03	13.33	19.35
Mutshedzi		A80A	15.5	2.2	1.46	1.67	1.86	2.05	2.49
Luphephe		A80H1	21.4	14.8	3.72	4.42	4.81	5.23	6.08
Nwanedi		A80H2	9.5	5.3	0.01	-	-	-	-

Notes: (1) *MAR simulated in the WRSM2000 model with active groundwater abstractions.*
(2) *HFY based on an analysis of 91 years from the 1920 to the 2010 hydrological years.*
(3) *Yield based on a long-term stochastic yield analysis of 201, 91 year generated streamflow sequences.*
(4) *Yields are before meeting the EWR water requirements.*

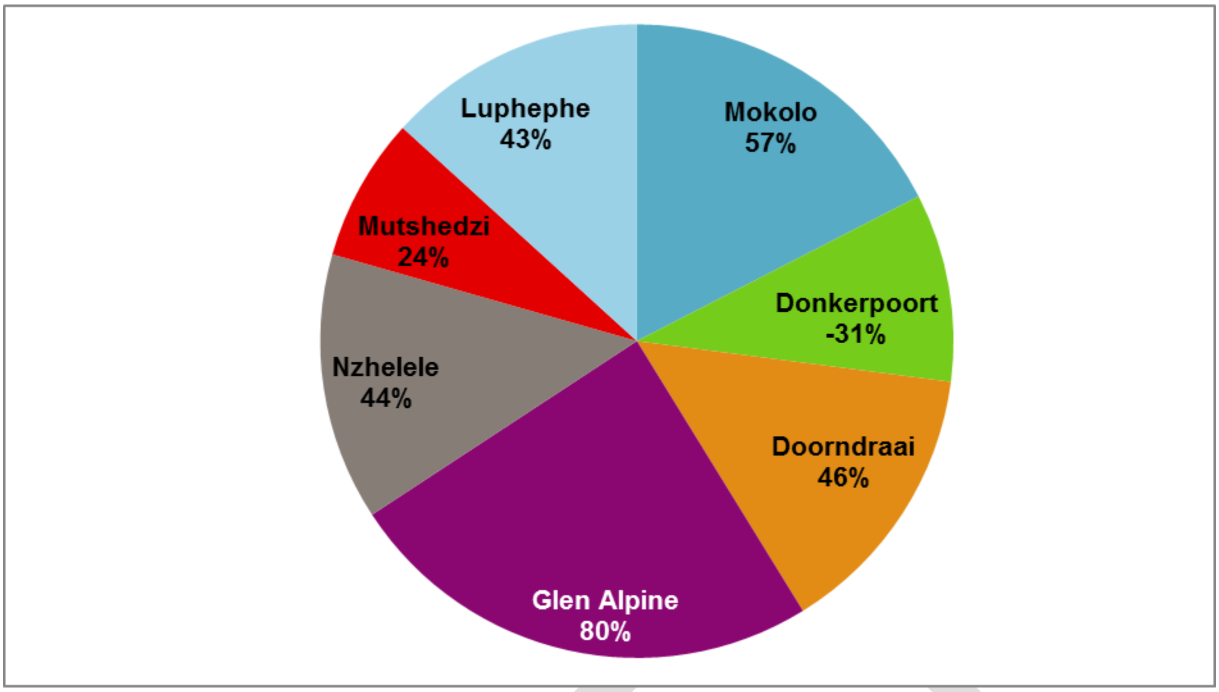

Figure 4.2 Reduction of the 1:50 year yield as a result of the EWR

From **Figure 4.1** and **Figure 4.2** it is evident that the impact of implementing EWRs has an adverse effect on the available yield. Almost all of the major dams within the study area will not be able to meet their current allocations if the desktop EWR are implemented. More detailed studies have to be conducted to better quantify the EWRs and subsequent impact on the yield of large dams for the following phases of the Reconciliation Strategy. It might be that a compromise can be made between the EWR and the impact on the available yield.

4.1.2 Diffuse water availability

Diffuse water resources refer to other small storage dams and river abstractions that contribute to the yield of the system. A significant number of small dams are also located within the study area, of which the majority are small storage dams used as a source of water for irrigation, stock watering and game farming, as well as for recreational purposes. Farmers and some rural communities' also abstract water directly from rivers and are referred to as run-off-river users.

The yield related to these diffuse water resources is more difficult to quantify compared to that of large dams. For the purpose of this Study, the actual water supply from farm dams and run-off-river abstractions were quantified by modelling the water bodies in the WRMS2000 rainfall-runoff model and assuming that the modelled supply (or water requirement) is equal to the available surface water, i.e. the diffuse water use is therefore in balance with the available diffuse water. The assurance of supply to the associated users varies throughout the study area, but in general it is considered to be high in the upper reaches of the catchments and low in the middle and lower reaches. **Table 4.2** summarises the diffuse water resources and availability in the study area.

Table 4.2 Summary of diffuse water resources availability

Catchment	FSC (million m^3)	Available supply from dams and run-off-river (million m^3/a)
Matlabas	4.0	4.7
Mokolo	23.4	28.7
Lephalala	18.3	46.5
Mogalakwena	59.1	39.9
Sand(1)	44.2	56.3
Nzhelele	2.5	15.9
Total	**151.5**	**192.0**

Note: (1) This includes an allocation of 10.96 million m^3/a from the sand aquifers along the Limpopo River near Musina.

4.1.3 Transfers into the study area

Due to the arid nature of the study area, and the limited surface water available, a number of transfers from neighbouring catchments and WMAs into the study area exist. No transfers are made from the study area to other catchments or WMAs. **Table 4.3** provides a summary of all the current transfer schemes and allocated volumes into the study area. A schematic of the transfers into the study area from neighbouring WMAs are illustrated in **Figure 4.3**.

Table 4.3 Summary of existing water transfer schemes

Transfer scheme	Source catchment	Recipient catchment	Volume allocated/agreed (million m^3/a)
Ebenezer-Polokwane	Luvuvhu and Letaba	Sand River	12.00
Dap Naude-Polokwane	Luvuvhu and Letaba	Sand River	6.53
Olifantspoort-Polokwane	Olifants	Sand River	11.30
Albasini-Louis Trichardt	Luvuvhu and Letaba	Sand River	2.40
Roodeplaat-Modimolle	Crocodile West	Mogalakwena	1.93
Total			**34.16**

Water use records indicate that 17 million m^3/a is transferred from the Ebenezer Dam to the Polokwane LM – significantly more than the allocated volume. However, only 5.64 million m^3/a is transferred from Dap Naude Dam to the Polokwane LM. The total allocation from the Olifantspoort Weir is 14.6 million m^3/a, of which 3.3 million m^3/a is supplied to Lebowakgomo, outside of the study area.

The yield of the Albasini Dam has reduced due to the extensive irrigation development upstream of the dam and resulting in the dam being over-allocated. The supply from Albasini Dam to the Louis Trichardt area is planned to be supported by the Nandoni Dam on the Luvuvhu River. The main supply pipeline from Nandoni Dam to Louis Trichardt, as well as other supply areas, is still under construction. The water supplied from Nandoni Dam will only be used to support the urban/industrial and rural domestic sectors and not to augment irrigation requirements (DWS, 2015b).

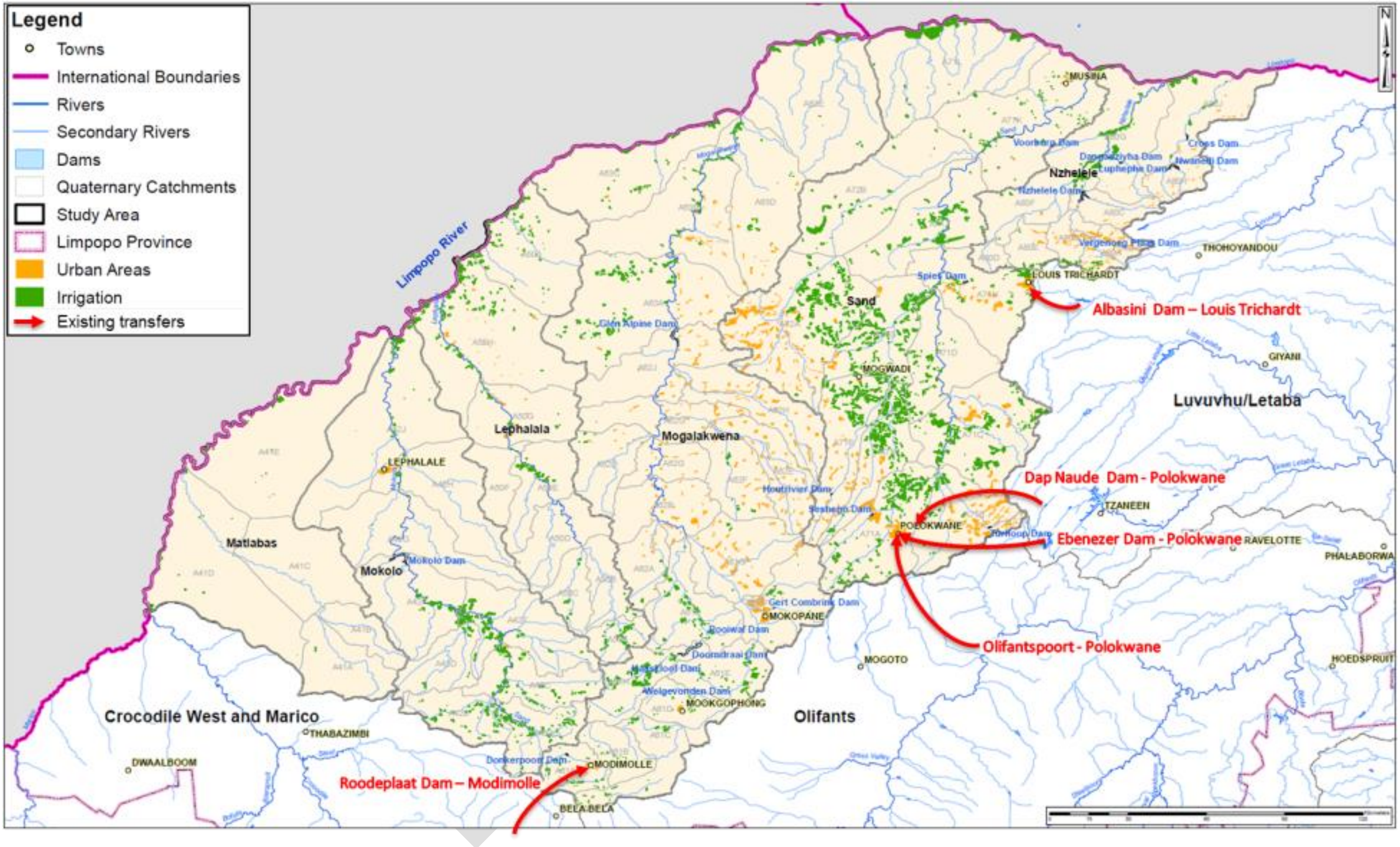

Figure 4.3 Schematic of current transfers from neighbouring WMAs into the study area

Furthermore, a number of future transfers scheme is currently being planned or constructed. This includes the following schemes which are discussed in more detail in **Section 6.3.2**:

- MCWAP-2A transfer from the Vlieepoort abstraction works on the Pienaars River (Crocodile River (West) catchment) to the Lephalale area (Mokolo and Matlabas catchments);
- ORWRDP-2B and 2G transfer from Flag Boshielo Dam (Olifants River catchment) to the Mogalakwena municipal area; and
- Transfer from the Nandoni Dam (Luvuvhu/Letaba River catchment) to Louis Trichardt and Matoks (Sand catchment).

4.2 GROUNDWATER

Groundwater contributes approximately 40% towards the water supply from local resources and is the only dependable water source for the majority of rural domestic users in the study area. Since surface water resources are fully developed, groundwater might be the only possible local water source to augment supply in some areas. However, it should be noted that groundwater resources in the Mogalakwena and Sand catchments have been extensively utilised, and possibly over-exploited by the dominating irrigation sector.

A groundwater assessment was conducted as part of this Study to assess the occurrence, quantity, quality, utilisation and abstraction availability of groundwater at a desktop level. The main aspects of groundwater in the study area are discussed in the sub-sections below, however, more detail is included in the *Groundwater Assessment and Utilisation Report (P WMA 01/000/00/02914/6).*

The availability of groundwater resources available for abstraction is controlled by the aquifer characteristics, such as permeability and storage.

4.2.1 Geology and geohydrology

The regional geology of the study area mostly consists of granites, gneisses, schists and sandstones. These influence the morphology, which in turn influences the surface water run-off and its contribution to the recharge of the aquifers (underground water storage areas) in the study area.

The 1:500 000 hydrogeological map series used the major stratigraphic units as basis for the delineation of the hydrological units that were chosen according to geohydrological similarities.

The aquifers in the study area are characterised by the lithology and structural geology of the area in which they occur. The major stratigraphic units that were used as a basis for the delineation of the hydrological units with geohydrological similarities, as well as the associated aquifer characteristics, are briefly listed below:

- Basement complex - Most of the hydrological units are poor to moderate in terms of quality and quantity, however, the Goudplaats and Hout River Gneisses are considered good to very good aquifers.

- Granite intrusives - Generally poor aquifers with the Matlala granite having slightly better yields.
- Transvaal Supergroup - The Weenen and Planknek wellfields (in dolomites) that supply Mokopane are of significance.
- Bushveld Complex - The mafic unit of the complex is regarded as a moderate to good aquifer while the granitic units are poor.
- Soutpansberg and Waterberg Groups - Numerous faults and dykes in the Soutpansberg Group, combined with higher rainfall in the area, contributes to moderate to very good aquifers, while the Waterberg group is considered a poor aquifer due to limited faulting, but where dykes and sills occur higher yields can be found.
- Karoo Supergroup - The lower units of the Supergroup are poorer aquifers due to the fine grained nature of the rocks while the upper units, Clarens and Lebombo, are considered good aquifers, with the Lebombo having slightly inferior water quality (TDS and nitrate).

Furthermore, significant to water supply is the shallow alluvium deposits in the major rivers. These aquifers are fully saturated during surface flow. During dry periods, surface flow is limited and the potential abstraction of wells within the alluvial decreases.

As previously mentioned, higher nitrate and fluoride concentrations are natural in certain areas due to underlying geology, but increased nitrate may also be due to human influences like irrigation and sanitation, and therefore is prevalent in densely populated rural areas and large irrigation schemes.

4.2.2 Groundwater recharge, potential and utilisation

Groundwater ***recharge*** is defined as the addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers. Recharge is crucial for the ongoing replenishment of aquifers and is influenced by various factors. On a local scale some can be changed by human activities but on a regional scale nature is the controlling factor. Recharge contours and recharge per quaternary catchment in the WMA are depicted in **Figure 4.4**.

The maximum volume of groundwater that can be abstracted per square kilometre per annum without depleting the aquifers ($m^3/km^2/a$) is referred to as the ***harvest potential***. As it is not possible to abstract all the available groundwater stored in the aquifer due to practical, financial and natural limitations, the ***exploitation potential*** is used when calculating available volumes in an aquifer. The exploitation potential is thus defined as the volume of the harvest potential that can practically be exploited.

The *Groundwater Harvest Potential* (Vegter, 1995) was used as the basis for available storage (harvest potential) and is depicted in **Figure 4.5** along with the exploitation potential per quaternary catchment.

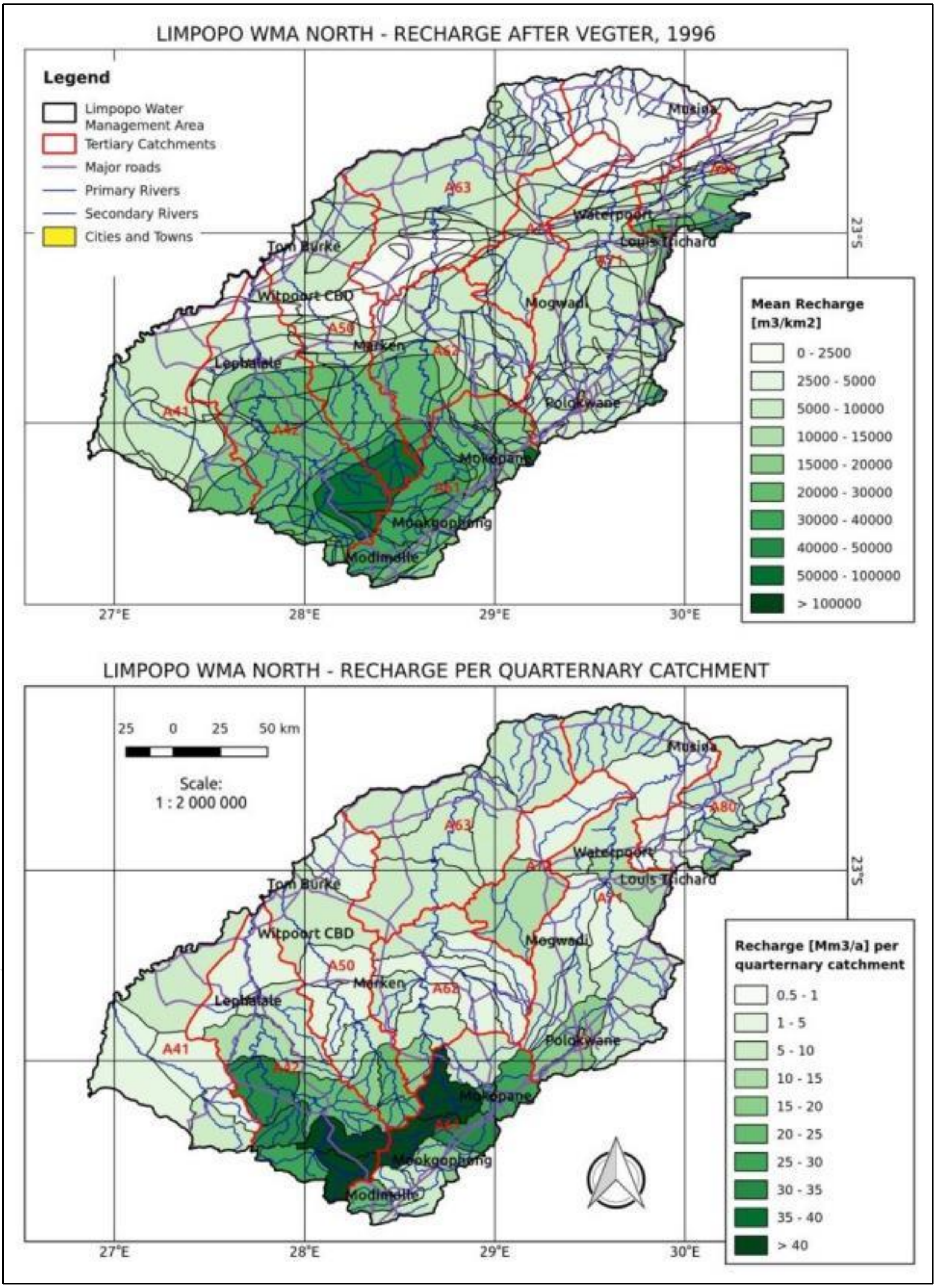

Figure 4.4 Recharge after Vegter 1996 m³/km²/a and recharge volume/quaternary catchment

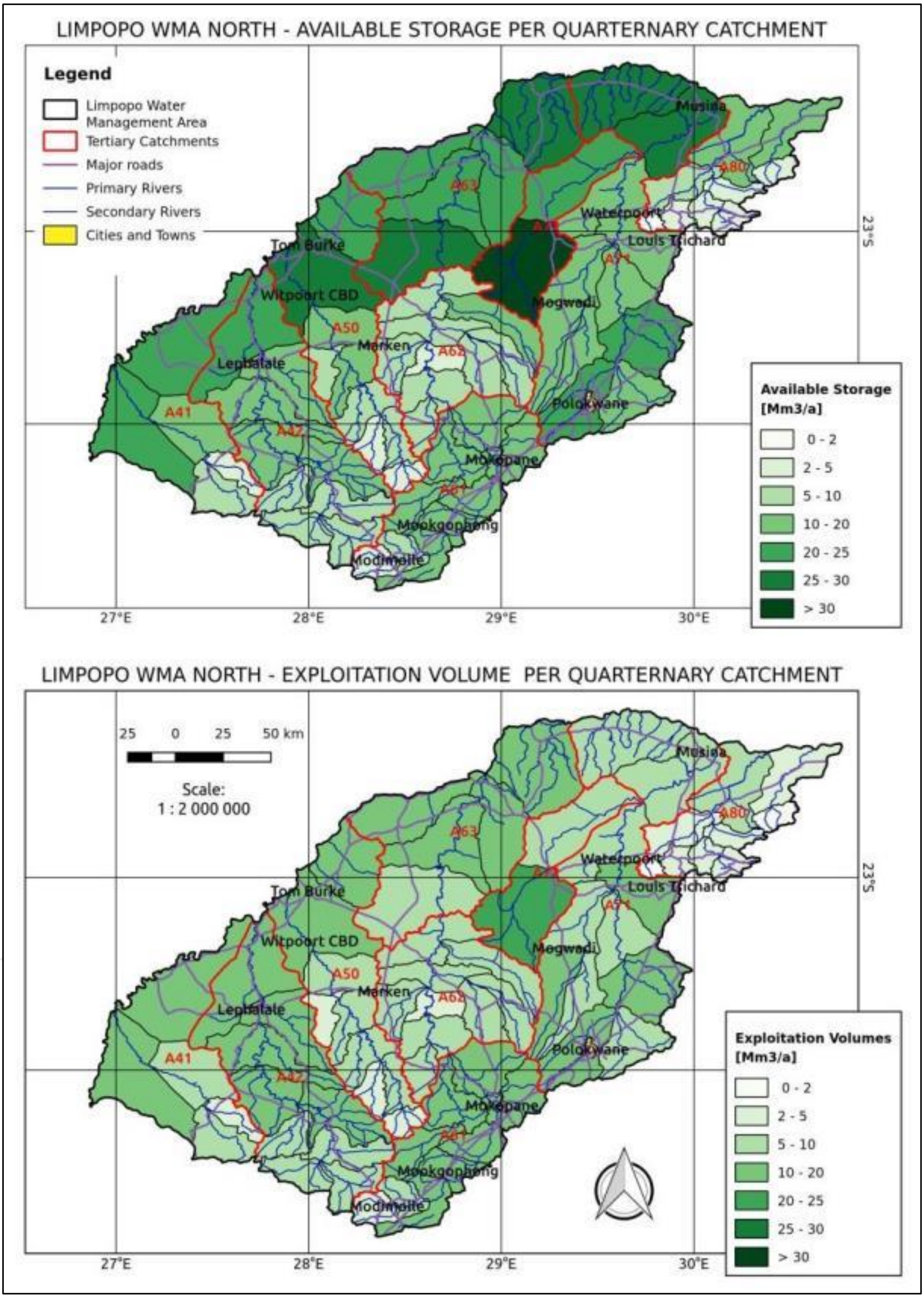

Figure 4.5 Available storage and exploitation volume per quaternary catchment

The highest recharge in the study area occurs in the south western part and the southern border in the north-eastern part, both areas of which are mainly underlain by sandstones with prevalent fracturing/weathering. Although the recharge is high in these areas the available storage (harvest potential) and exploitable volumes are lower than in the northern, central and north-eastern parts of the study area.

The exploitation potential and the groundwater use per catchment, at the 2010-development level, is summarised in **Table 4.4**.

Table 4.4 Groundwater exploitation potential and utilisation

Catchment	Calculated Exploitation Potential from (Baron, Seward & Seymour, 1998) (million m^3/a)	Groundwater use (million m^3/a)	Utilisation of exploitable potential (%)
Matlabas	50.70	2.32	5%
Mokolo	93.74	3.95	4%
Lephalala	65.97	29.70	45%
Mogalakwena	211.34	85.93	41%
Sand	126.28	195.75	155%
Nzhelele	25.15	9.25	37%
Total	**573.19**	**327.90**	**57%**

The percentage utilisation of the exploitable potential, per quaternary catchment, is illustrated in **Figure 4.6**. Green denotes a low percentage utilisation of the exploitable potential, while orange and red denote over-utilisation.

From **Figure 4.6**, it can be concluded that the central and southern central areas (from Polokwane to the north-west and north-east of Mogwadi are over-utilised i.e. using more groundwater than can be safely abstracted without lowering the groundwater levels. However, it should be noted that this provides an overview per quaternary and not per individual aquifer – in areas that show over-utilisation, there might still be some aquifers or boreholes that are not over-abstracted. In light of this, the current developed groundwater resources, as a percentage of the utilisation potential, were evaluated per WSS and are illustrated in **Figure 4.7**. Again green denotes a low percentage utilisation of the exploitable potential, while orange and red denote over-utilisation.

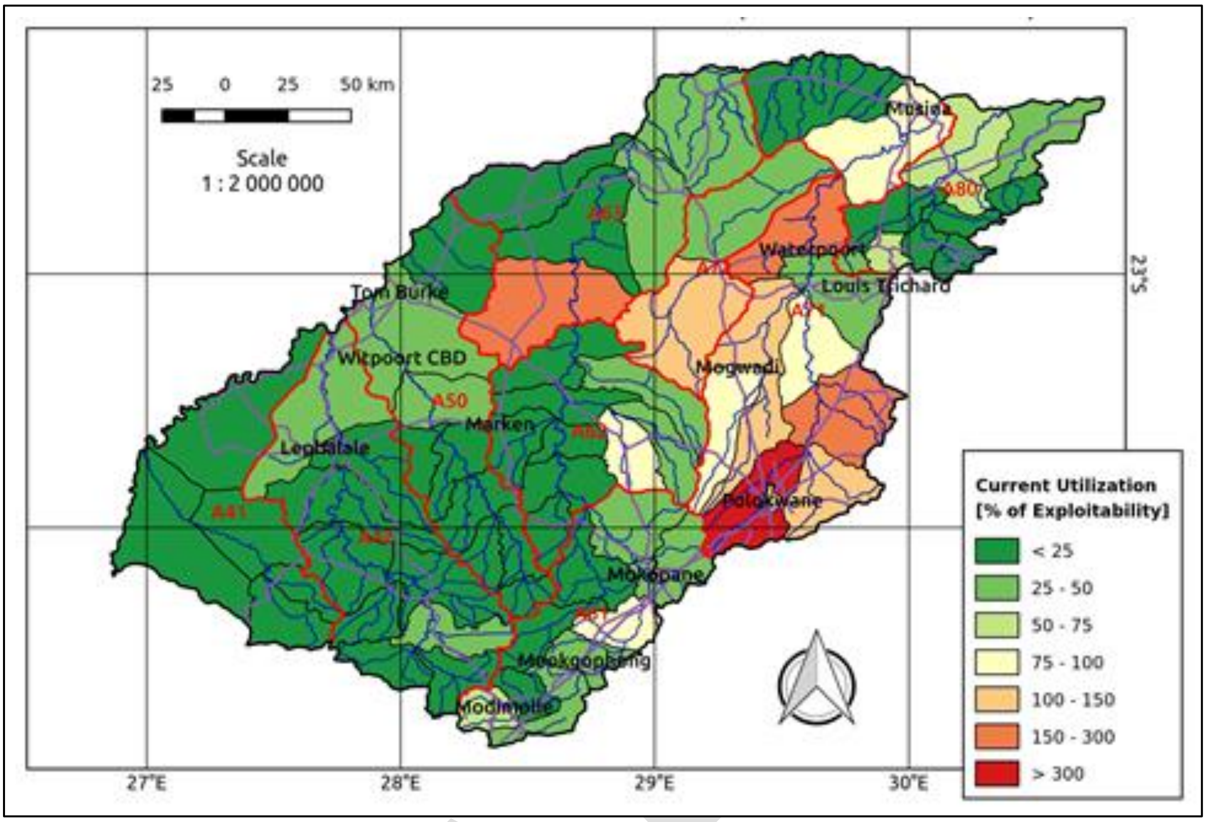

Figure 4.6 2010-development level groundwater utilisation as a percentage of exploitation potential per quaternary catchment

Comparing **Figure 4.6** and **Figure 4.7** it can be derived that the over-abstraction in the Polokwane and Mogwadi areas is possibly not due to the domestic and industrial water requirements but rather irrigation and livestock watering. Furthermore, it can be derived that some potential for groundwater development may exist for some WSS, depending on the associated aquifer or borehole yields and water quality.

From the monitoring of water levels over a long period of time (from 1960 to present) it is evident that these levels have dropped considerably in the last 20 years in the central area of the study area due to increased abstraction for irrigation and water supply to the rural and urban population.

Individually analysed water levels in some of the boreholes on the other hand show rising water levels due to wetter years (increasing recharge) or changed groundwater use (e.g. ceasing irrigation in the area).

Further groundwater development options are discussed in **Section 6.3.1**.

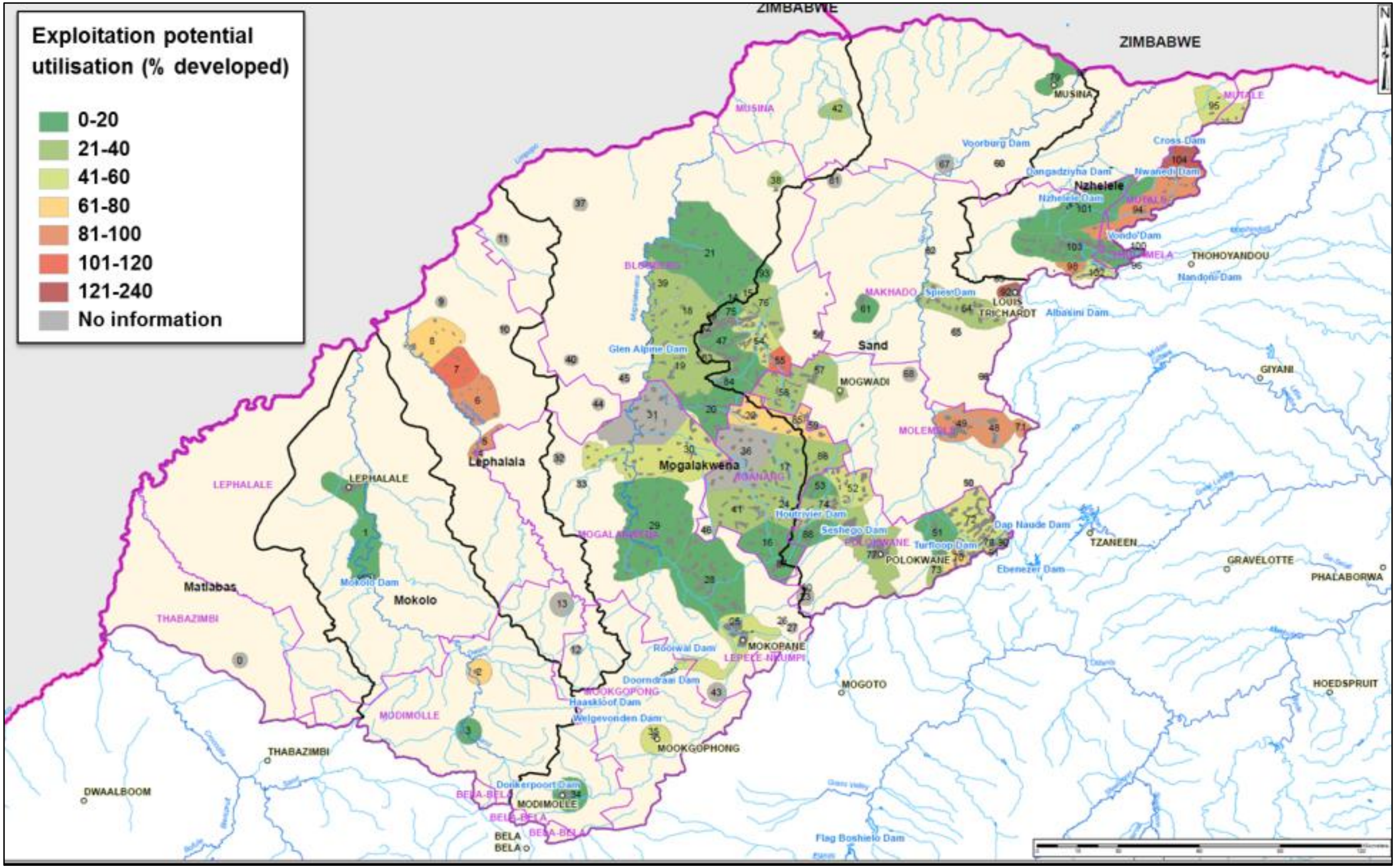

Figure 4.7 2010-development level groundwater utilisation as a percentage of exploitation potential per WSS

4.2.3 Management of groundwater

The main challenge with regard to groundwater, however, is the lack of monitoring and data coalition. Groundwater data capturing on the National Groundwater Archive (NGA), formally National Groundwater Data Base (NGDB) shows a decline in data entry since 1997 on national level, from 2002 data capturing devolved to regions (Review Groundwater Resource Assessment 1 (GRA1) and 2, 2009). This poses serious problems for future groundwater management. Groundwater monitoring and the availability of historic and current data is a key aspect of groundwater management. The following urgent interventions are proposed:

- Enforcement of the compulsory groundwater monitoring as required by law for authorized water users.
- This data as well as all other available groundwater information must be added to the GRIP data base which is the database on a provincial level. The advantages of a good database on provincial level will ensure commitment on all levels of government. The quality of input data reflects the quality of output data, data capturing should thus be done with a high level of accuracy.
- The continuation of the Limpopo GRIP database is an essential tool for future groundwater management.
- The core of groundwater information is the NGA and provincial data must be exported on a regular basis.
- The spatial distribution of the provincial groundwater monitoring network must be constantly improved.
- The evaluation of current available water level data for the strategy was not in depth and further research work must be done.
- Chloride measurements of rainfall and groundwater at static level in the same area must be obtained as these form part of the harvest potential determination. The harvest potential map should then be updated using the same methodology as used in the first map completed in 1996.
- Different methodologies to determine the harvest potential during other studies need to be compared with the chloride methodology.

4.3 Return flows

Return flows refer to water that return to a water resource as surface water after being applied. Domestic or municipal return flows and irrigation return flows have been considered as part of this Study.

4.3.1 Domestic return flows

Municipal wastewater, including domestic and some industrial wastewater, is treated at designated WwTW before the effluent is discharged into existing water resources. The treated effluent released back into water resources is referred to as return flows.

Information on the WwTW within the study area was sourced from the DWS Green Drop System (GDS), available on the DWS website, as well as from published Green Drop assessment reports. There are 24 WwTW in the study area, with the most being located in the more densely populated Mogalakwena (seven) and Sand (eight) catchments. Of these 24, eleven are pond systems and only nine have known river discharges. Most of the WwTW are considered as small plants. Due to the lack of available information from municipalities on the WwTW, the exact design and operating capacity of some plants are unknown. Based on the available DWS Green Drop assessment results, the effluent monitoring, microbiological, physical and chemical compliance of the majority of WwTW in the study area have reduced significantly over the past year and is of major concern. Furthermore, the bulk of the WwTW in the study area have a high risk rating.

Table 4.5 provides a summary of the total capacity and river discharge volume, number of plants per capacity category and the risk level.

Table 4.5 Summary of WwTW in the study area

Description		
Capacity	**Number of WwTWs**	**Design capacity (Mℓ/d)**
Number of WwTW and known design capacity	24	108.0(1)
Matlabas catchment	0	0.0
Mokolo catchment	5	15.1(1)
Lephalala catchment	1	2.0(1)
Mogalakwena catchment	7	17.3(1)
Sand catchment	8	67.0(1)
Nzhelele catchment	3	7.2(1)
Total number of with river discharge	9	52.8(2)
Number of plants < 2 Mℓ/d	11	
Number of plants 2 - 6 Mℓ/d	7	0.0
Number of plants > 6 Mℓ/d	6	0.0
Types	**Number of WwTWs**	
Pond systems	11	
Activated sludge systems	6	
Biological filter systems	4	
Unknown	3	
Risk category as per 2014 Green Drop report	**Number of WwTWs**	
70 - 100% high to critical risk	10	
50 - < 70% medium risk	7	
0 - < 50% low risk	1	
No information	6	

Note: (1) Known capacity

(2) Known discharge into rivers only. The total known effluent discharge, including discharge into open fields, rivers and transfer of treated effluent, is 63.5 Mℓ/d.

A summary of the estimated return flows currently generated and treated in the study area, per catchment, is provided in **Table 4.6**.

Table 4.6 Summary of return flows and WwTW capacities

Catchment	Operating capacity		Percentage of design capacity utilised
	Mℓ/d	million m^3/a	
Matlabas	0.00	0.00	0
Mokolo	9.60	3.50	64
Lephalala	1.50	0.55	75
Mogalakwena	16.30	5.95	94
Sand	54.75	19.98	82
Nzhelele	4.00	1.46	56
TOTAL	**86.15**	**31.44**	**79**

Note: *The operating and the design capacities are as per the GDS, accessed during May 2016, and the 2013 and 2014 Green Drop Assessment Report – whichever has the latest information.*

It is expected that the return flows will increase as the water requirements increase, especially in the Mokolo, Mogalakwena and Sand catchments where major developments are planned. The exact growth in the return flows fall outside the scope of this study, but needs to be considered in the implementation and continuation phase of this Reconciliation Strategy.

It is, however, known that approximately 85 Mℓ/d of wastewater is currently generated in the Polokwane LM area and is expected to increase to 110 Mℓ/d by 2024 and 140 Mℓ/d by 2044 (DWS, 2014a). To accommodate these additional return flows, the development of the Polokwane Regional WwTW (PRWwTW) has recently commenced to serve gravity sewerage generation areas within the Polokwane LM. The facility is located at the confluence of the Sand and Deep rivers at Zandriviers Poort, approximately 28 km North-East of Polokwane.

The project is proposed to be implemented in the three following phases:

- Phase 1: Installation of 20 Mℓ/d, commencing in 2015;
- Phase 2: Installation of 40 Mℓ/d, commencing in 2020; and
- Phase 3: Installation of 40 Mℓ/d, commencing in 2034.

The treated effluent can be re-used either directly or indirectly by various sectors, depending on the treatment process and subsequent effluent quantity and quality. Treated effluent from Mokopane and Polokwane is already re-used in the mining sector in the Mogalakwena catchment. As part of this Study, the opportunities for re-use have been assessed and recorded in the *Opportunities for Water Reuse Report (P WMA 01/000/00/02914/10/1)*. More information on the WwTW within the study area is also available in this report.

The current re-use and the potential for additional future re-use is discussed in **Section 6.3.3** of this report.

4.3.2 Irrigation return flow volumes

The irrigation return flows were determined by simulating irrigation in the WRSM2000 rainfall-runoff model using the WQT-SAPWAT Irrigation Block Module. The irrigation return flows in WRSM2000 are controlled by a return flow factor. These factors were adjusted by the modeller, in an iterative process, until the average annual return flow volumes (as a percentage of supply) as given in the *Validation and Verification Study* (DWS, 2015) were achieved.

The net return flow volumes (direct result of applied irrigation) were determined as 36 million m^3/a, 8% of the total irrigation water requirement. This is reported on in more detail in the *Water requirements and Return Flows report (P WMA 01/000/00/02914/4).*

5 WATER BALANCE

5.1 CURRENT WATER BALANCE WITH NO INTERVENTIONS

Combining the water requirements and water availability of the entire study area into one water balance may be interpreted that the study area is in balance, or has a surplus of water – which is not the case. However, due to the independent nature of some of the catchments and even significant areas, separate water balances have been generated for each catchment, as well as the main urban clusters or focus areas. The water requirements and availability for each WSS were also evaluated.

These water balances are based on the 2010-development level water requirements and available water. Thus, all intervention options post-2010 have not been included.

No detail EWRs determination studies have been done for the study area, except for the Matlabas and Mokolo catchments. For the other catchments, however, and for the purpose of this Study, first level desktop assessments were done to get an indication of the possible effect on the yield of major dams when implementing the EWRs. The actual impact, however, can only be quantified after detailed EWRs determination studies. In light of this, the reduction in the available yield of major dams due to implementing the EWR has been excluded.

The 2010-development level water balance for each catchment is summarised in **Table 5.1**. The water balance for the main urban clusters, were significant development and subsequent increase in water requirements are planned, are provided in **Table 5.2**.

Table 5.1 2010-development level catchment water balances

Catchment	Water requirement[1] (million m^3/a)	Water availability (million m^3/a)	Water balance (million m^3/a)
Matlabas	7.0	7.0	0.0
Mokolo	61.6	61.2	-0.4
Lephalala	75.1	77.3	2.3
Mogalakwena	156.8	152.3	-4.5
Sand	292.6	287.8	-4.7
Nzhelele	39.4	48.1	8.7
TOTAL	**632.5**	**633.7**	**1.4**

Note: (1) Excludes IAPs and commercial forestry which are considered as streamflow reducers.

Table 5.2 2010-development level economic focus area water balances

Cluster area	Catchment	Water requirement (million m^3/a)	Water availability (million m^3/a)	Water balance (million m^3/a)
Lephalale and surroundings	Mokolo	19.3	18.1	-1.2
Mogalakwena and Aganang LMs	Mogalakwena	28.9	28.7	-0.2
Polokwane LM	Sand	54.1	44.2	-4.7
Makhado LM	Sand and Nzhelele	14.8	13.2	-1.1
Musina and surroundings	Sand	6.6	11	4.4

From **Table 5.1** it can be concluded that although the study area seems to be in balance overall, the Mokolo, Mogalakwena and the Sand catchments are in deficit. **Table 5.2** shows that the deficit in the Polokwane LM is significantly more than the overall deficit in the Sand catchment.

The individual WSS water balance information was sourced from either the *All Towns Reconciliation Strategies* (DWA, 2011), or other municipal and DWS sources – whichever is the latest. The 2010-development level water balance for each WSS is illustrated in **Figure 5.1**. The different colours indicate the following:

- Red areas indicate WSS that were in deficit:
- Orange areas indicate WSS that were in balance;
- Green areas indicate the WSS that have a surplus of water; and
- Grey areas indicate WSS of which information is unknown.

Although a number of schemes show to have surplus water, it should be noted that major developments are planned, especially in the Lephalale, Mokopane, Polokwane, Louis Trichardt and Musina areas that will quickly increase the water requirements and causing the schemes to be in deficit if no interventions are implemented.

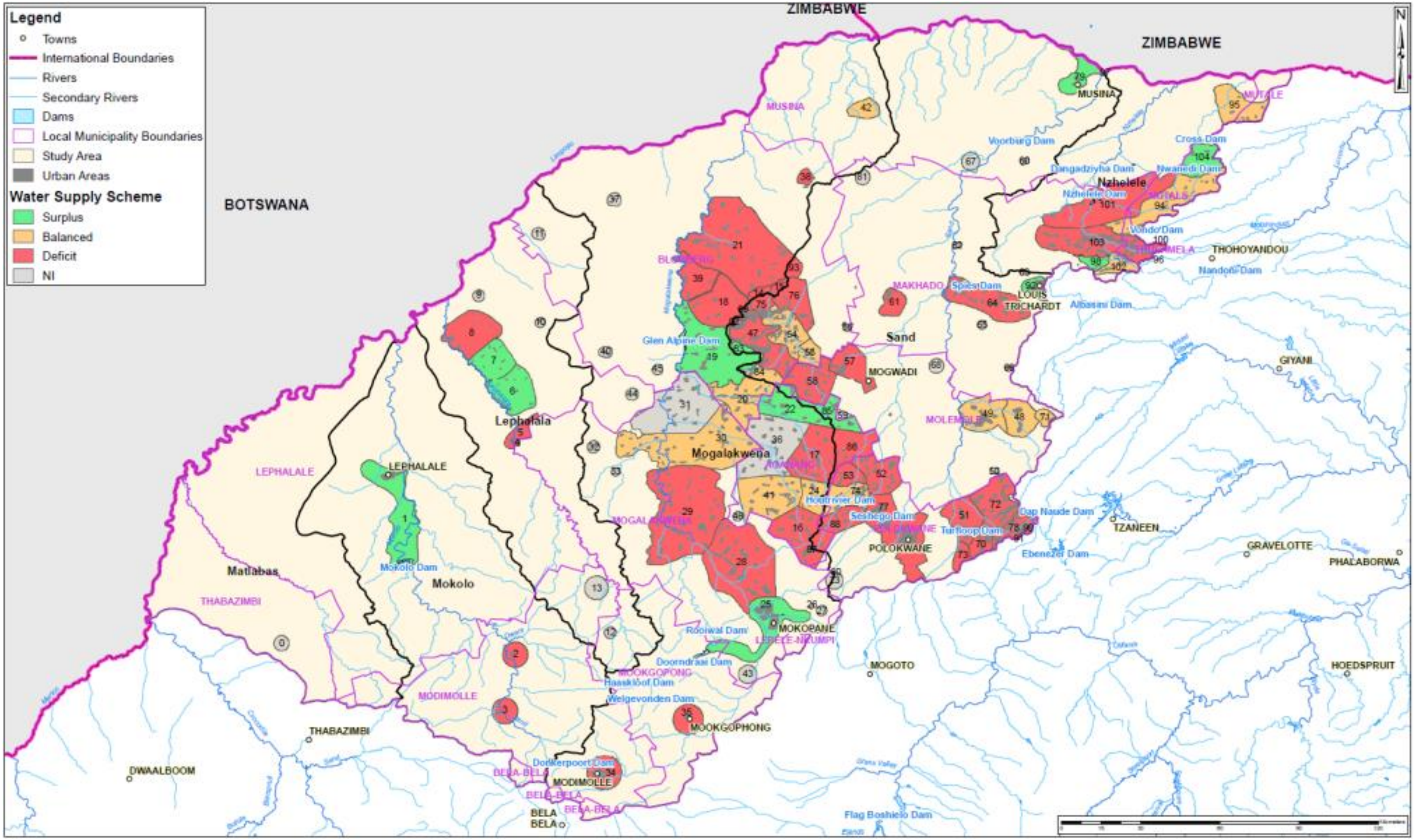

Figure 5.1 2010-development level water balance for each WSS in the study area

5.2 FUTURE WATER BALANCE WITH NO INTERVENTIONS

5.2.1 Matlabas catchment

The current water requirements are limited to irrigation and livestock watering, most of which is supplied by surface water via run-off-river abstractions. Domestic supply is almost negligible. There are no large dams located in the catchment and no transfers in or out of the catchment. The groundwater resources are under-utilised, however, some areas do have high fluoride concentrations.

A number of potential mining and power generation developments exist in the catchment, including:

- Boikarabelo Coal Mine and Power Station;
- Glenover Phosphate Mine;
- Temo Coal Project;
- Thabametsi Coal Mine; and
- Waterberg Joint Venture Coal Mine.

The latter three developments all fall within close proximity to the adjacent Mokolo catchment. The water requirements for these developments are planned to be sourced from the MCWAP-2A and will not have a significant impact on the water availability and requirements of the Matlabas catchment. The water requirements for these developments are thus included in the Mokolo catchment water balance.

The Boikarabelo Coal Mine and Power Station, owned by Resource Generation Limited (ResGen), will require a maximum of 0.3 million m^3/a during construction and during the first phase of the operation (45 MW power station). Phase II will require up to 5.84 million m^3/a. The Glenover Phosphate Mine is an existing platinum group metals mine currently not operating, however, it is projected that the mine will be reopened in future. The Glenover Mine water requirements are not included in this phase of the Reconciliation Strategy, but should be included in the subsequent phases.

No significant growth in domestic water requirements, other than that for, and included in, the mining development requirements is anticipated.

The water balance, with only water available at the 2010-development level, is shown in **Figure 5.2**.

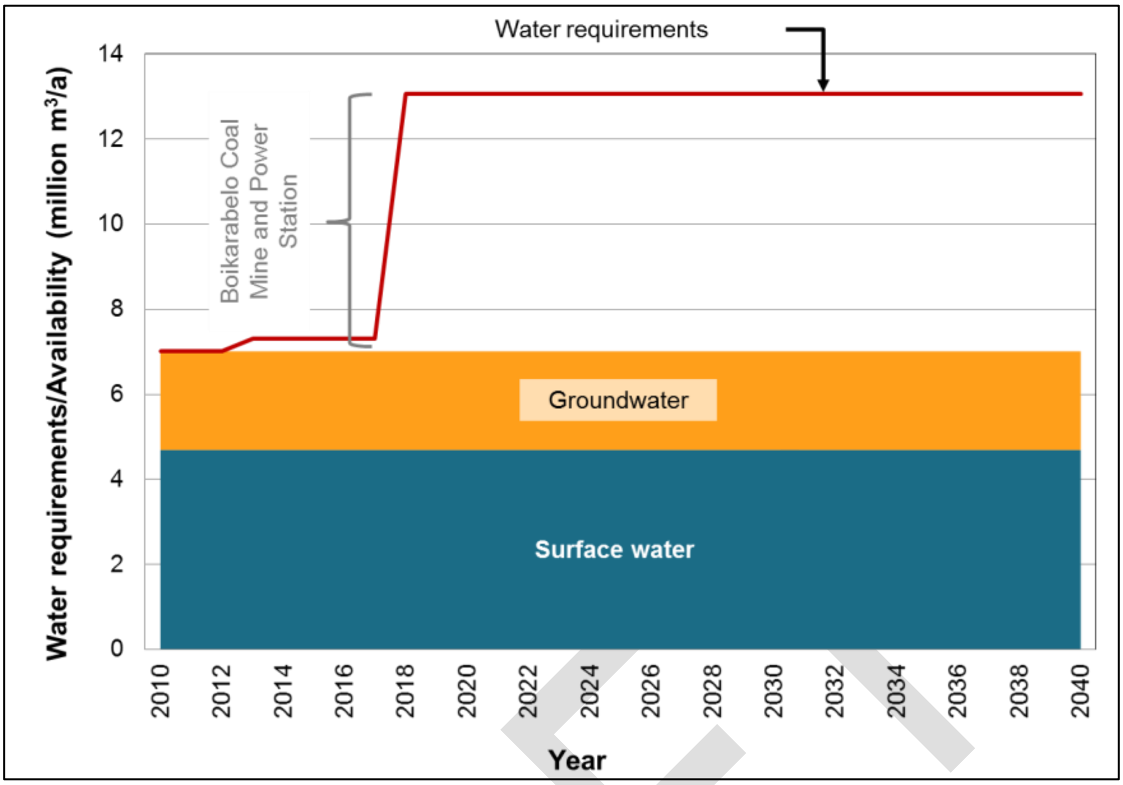

Figure 5.2 Matlabas catchment water balance without intervention options

5.2.2 Mokolo catchment

Irrigation is the major water user in the Mokolo catchment. The catchment is predominantly rural except for the Waterberg Coalfields that exist in the vicinity of Lephalale and Marapong. Other smaller settlements include Vaalwater and Mabaleng (previously Alma). The Matimba Power Station and the associated Grootegeluk Coal Mine, as well as the new Medupi Power Station, located in the lower regions of the catchment, are major water users.

Irrigation water requirements are mainly supplied by surface water, including Mokolo Dam, small farm dams, weirs and run-off-river abstractions. Water to the Matimba Power Station, Medupi Power Station, Grootegeluk Coal Mine, and the Lephalale Local Municipality, including Lephalale town and Marapong, is supplied from Mokolo Dam. The Mokolo Dam, however, is over-allocated and the supply is limited by the distribution infrastructure. The small domestic requirements of Vaalwater and Mabaleng (Alma), situated in the upper reaches of the catchment, are supplied from local groundwater. Boreholes tend to run dry, necessitating water to be supplied to the communities via water tankers.

Extensive future development is planned for the Mokolo catchment, as well as for north eastern area of the Matlabas catchment near Steenbokpan. Potential users and the associated development activities include:

- Eskom - Matimba Power Station, Medupi Power Station, a future third coal fired power station, a potential fourth coal fired power stations as well as two smaller sized Independent Power Producers (IPPs), equivalent of one Eskom power station;
- Exxaro – Grootegeluk Coal Mine and associated new coal mines;

- Other coal mining companies – Allowance for additional coal mines to support power generation in Mphumalanga and coal exportation;
- Sasol – Potential CTL fuel facilities;
- Lephalale and Steenbokpan – Growth in households for construction and permanent workforce.

The total 2040-development level water requirement for these developments are estimated at 100 million m^3/a, additional to the 60 million m^3/a currently required. The water balance, with only water available at the 2010-development level, is shown in **Figure 5.3**.

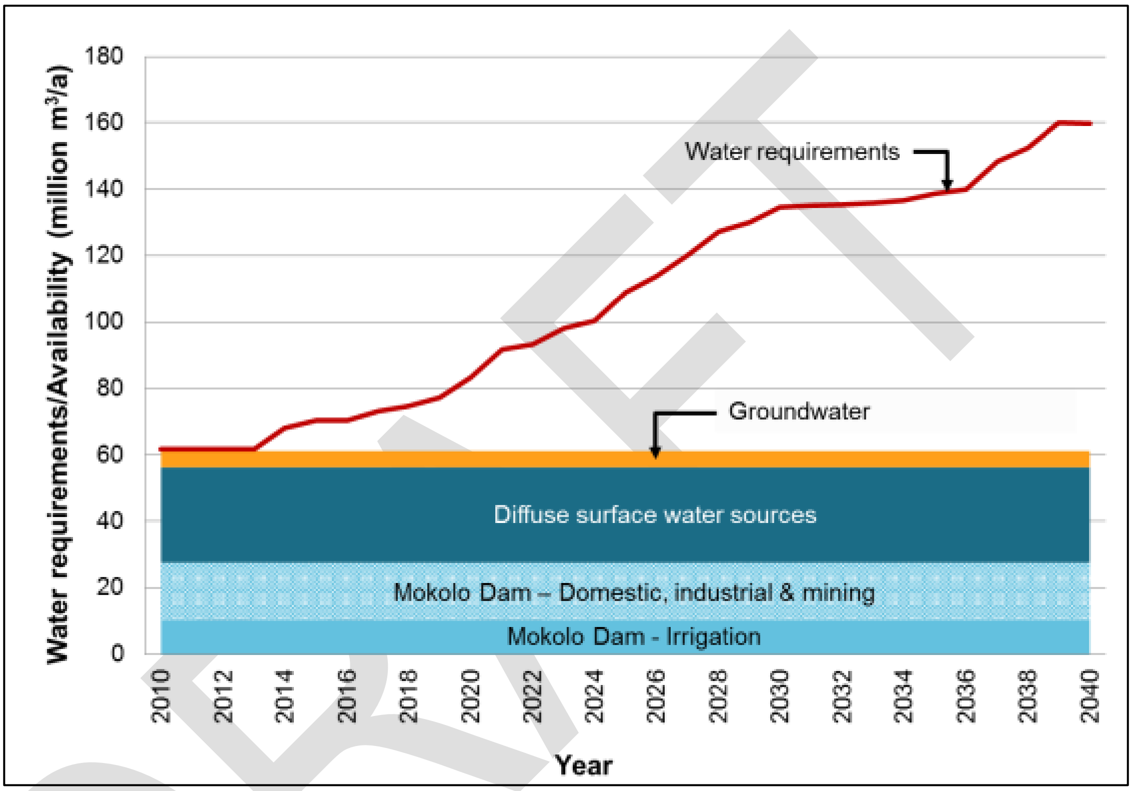

Figure 5.3 Mokolo catchment water balance without intervention options

5.2.3 Lephalala catchment

Irrigation is the major water user in the catchment, accounting for 93% of the water requirement and is supplied mainly from farm dams in the upper reaches, storage weirs in the middle reaches and alluvial aquifers in the lower reaches. A large amount of irrigation (approximately 44%) is supplied by the Limpopo River alluvial aquifer.

The Lephalala catchment has no major towns and smaller settlements, such as Witpoort, are concentrated in the lower reaches, close to the Lephalala River. There are a number of nature reserves and tourist activities in the catchment as well as the Witpoort Hospital. Basic domestic and stock water needs of 38 villages are supplied by five local Groundwater Schemes (GWSs). In total these schemes consist of more than 120 boreholes.

There are no significant developments expected in the Lephalala catchment due to the limited water available and the high conservation importance of the Wilderness area in the middle reaches of the catchment.

The water balance, with only water available at the 2010-development level, is shown in **Figure 5.4**.

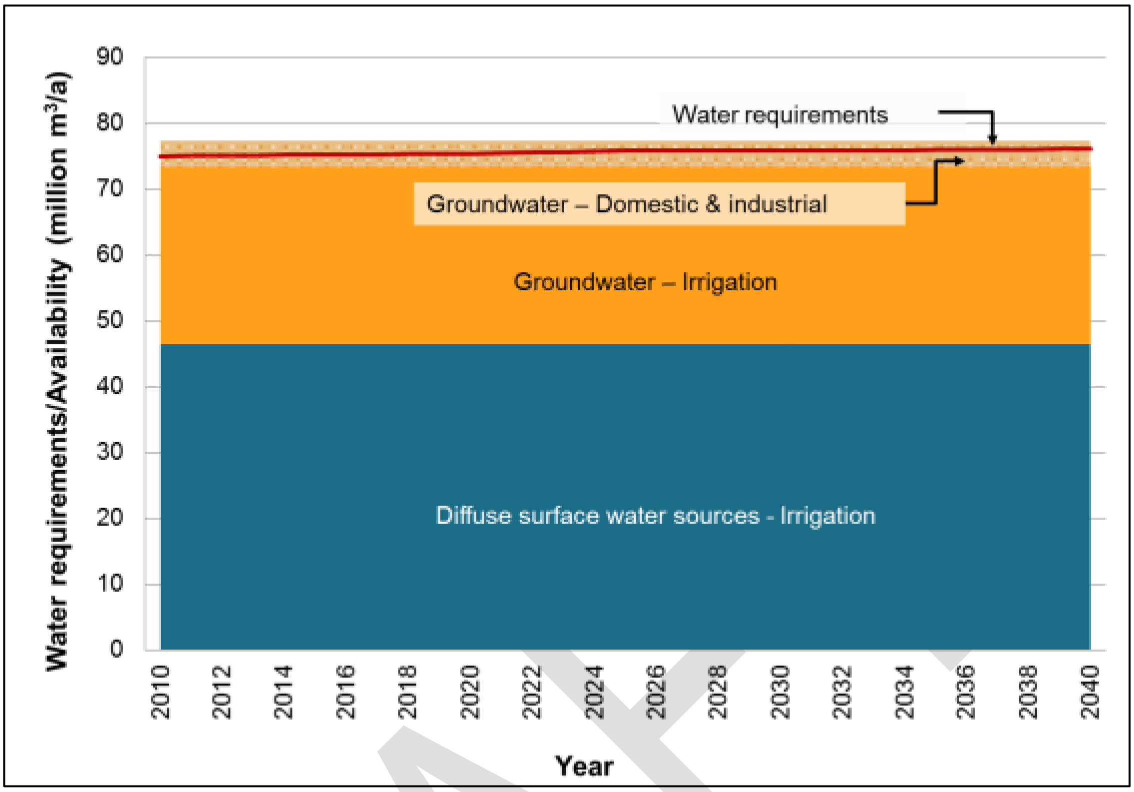

Figure 5.4 Lephalala catchment water balance without intervention options

From the water balance and with reference to **Figure 5.1** it can be concluded that no significant intervention options are required to meet the 2040 water requirement. However, water shortages experienced in the area can be attributed to the significant development and utilisation of the groundwater exploitable potential per WSS (refer to **Figure 4.7**).

Possible intervention options can be identified to reduce the groundwater abstraction.

5.2.4 Mogalakwena catchment

a) Entire catchment

The Mogalakwena catchment is the largest and most densely populated and industrialised catchment in the study area. Major towns include Modimolle, Mookgopong and Mokopane, all situated in the upper regions of the catchment where rainfall is relatively high. The central part of the catchment is densely populated with more than 80% of the population classified as rural.

Surface water resources in the catchment are limited and have been fully developed. The major dams are the Doorndraai, Glen Alpine and Donkerpoort dams. More than 700 farm dams and weirs have been constructed to improve the level of assurance for irrigation. Large groundwater resources exist but have been extensively exploited by the dominant irrigation sector, especially in the upper region of the catchment.

Irrigation accounts for 64% of the 2010-development level water requirements, of which 60% is supplied by groundwater. Surface water irrigation supply sources include the Doorndraai Dam, Glen Alpine Dam and storage weirs, especially downstream of Glen Alpine Dam.

Modimolle is mainly supplied by the Magalies Water pipeline from Roodeplaat Dam (Crocodile West River catchment). Yield is available Donkerpoort Dam, however, users prefer the Magalies Water transfer due to the lower cost. Groundwater resources augment supply during peak demand periods. Water supply to Mookgopong is obtained from groundwater (mainly from the Nyl well-field) and Welgevonden Dam. Mokopane, Mahwelereng and several denser settlements in the Mogalakwena LM are supplied from the Doorndraai Dam and groundwater resources (Planknek and Weenen wellfields). Smaller settlements located in the Blouberg LM area are mainly supplied by groundwater.

Anglo Platinum has been purchasing treated sewerage effluent from the Polokwane LM (7.7 million m^3/a) and Mokopane WwTW (2.7 million m^3/a) to supply the Mogalakwena Platimum Mine (previously the Potgietersrus Platinum or PPL Mine). However, due to the inadequate quality of the treated effluent from Polokwane, Anglo Platinum has stopped with the transfer. The Lonmin mining company has purchased a portion of the irrigation entitlements from Doorndraai Dam but is not using the water yet.

Developments in the catchment expected to increase water requirements include:

- Platinum mining activities – A number of possible new platinum mines were identified in the Mokopane area which is considered to be the platinum growth point of the Limpopo Province;
- Other mining activities – Possible new nickel, vanadium and iron ore mines north of Mokopane have been identified;
- Increased domestic water requirements – Domestic water requirements in the Mokopane area (including the Mogalakwena and Aganang LMs) will increase significantly due to possible future mining activities.

The majority of the new mines and additional water requirements in the Mogalakwena and Aganang LMs will be supplied by the ORWRDP Phase 2B and 2G.

The water balance, with only water available at the 2010-development level, is shown in **Figure 5.5**.

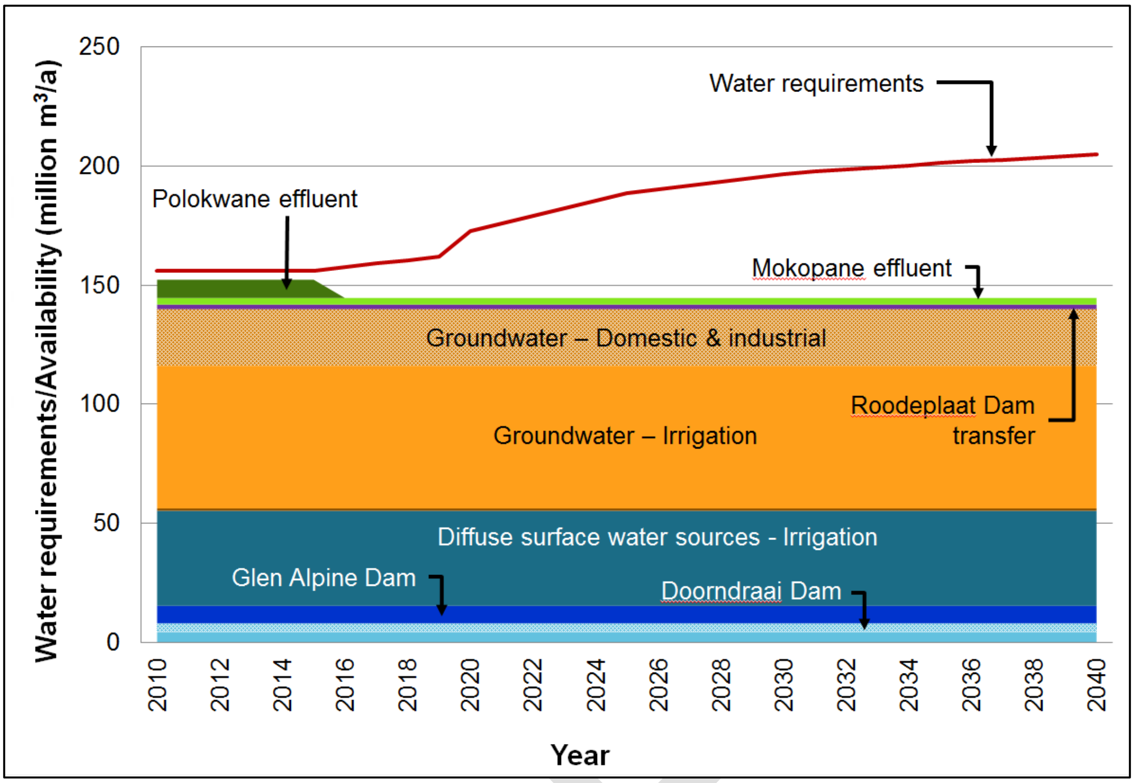

Figure 5.5 Mogalakwena catchment water balance without intervention options

Figure 5.6 shows the catchment's water balance for only the domestic, industrial and mining water requirements. No growth in irrigation water requirements is expected and thus no intervention options were considered to increase the water availability for irrigation in the area. This, however, does not necessarily mean that irrigation will not expand, but rather that farmers may find more efficient irrigation methods and be able to irrigated larger areas with the same amount of water.

From **Figure 5.5** and **Figure 5.6** it can be derived that the 2010-development level water availability does not meet the water requirements, and even more so the projected future water requirements.

b) Mogalakwena LM

The Mogalakwena and Aganang LM areas are considered to be a main economic focus area due to extensive mining development and associated increase in the domestic water requirements. The water balance for the Mogalakwena and Aganang LMs are shown in **Figure 5.7**. The total water requirement for the Mogalakwena catchment is also indicated for reference purposes.

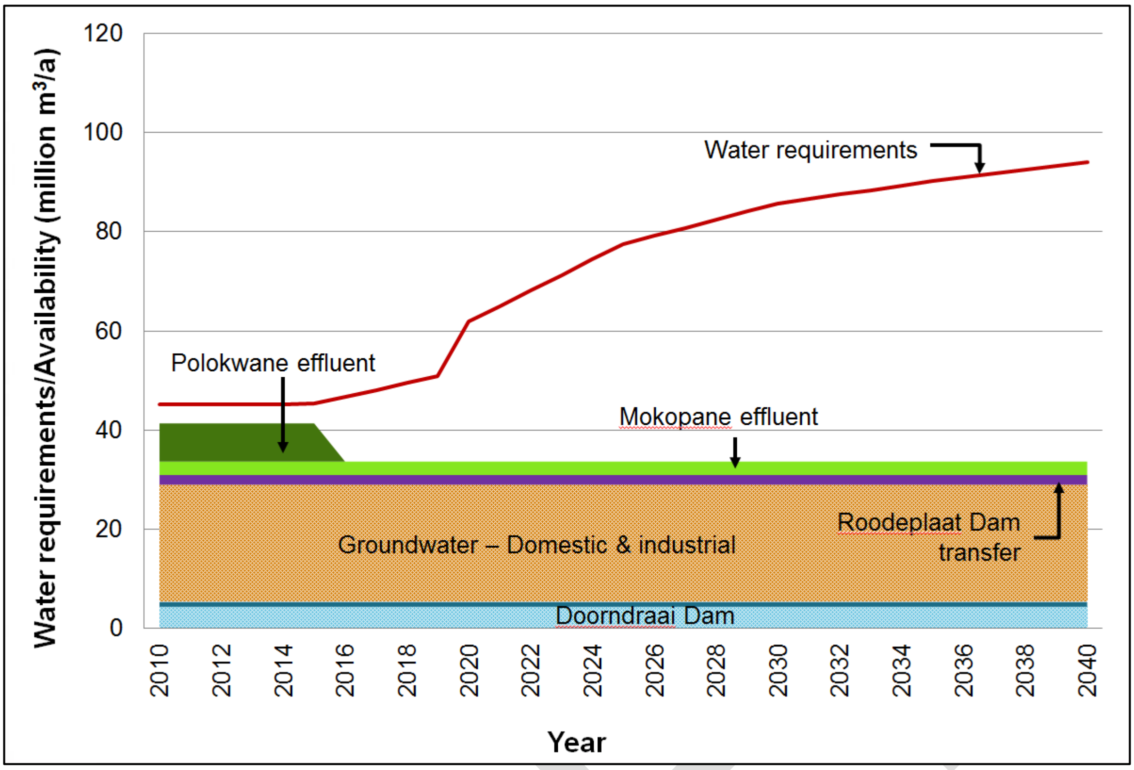

Figure 5.6 Mogalakwena catchment water balance without intervention options

Note: Only domestic, industrial and mining water requirements

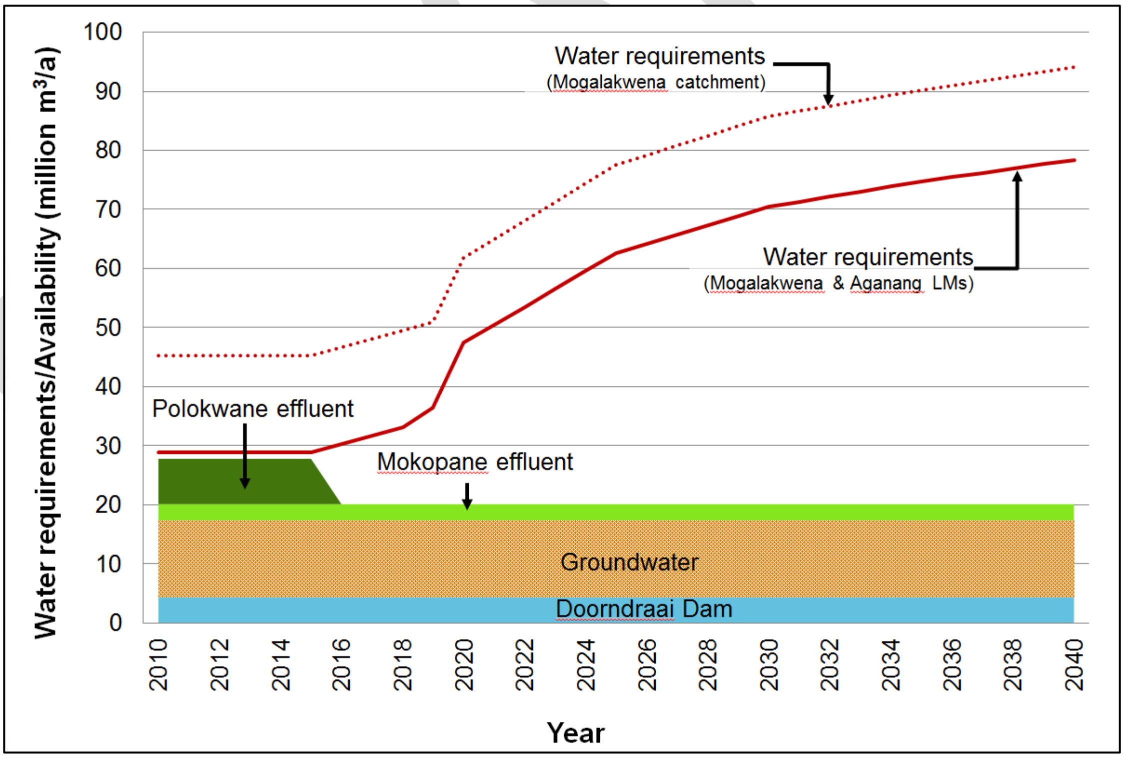

Figure 5.7 Mogalakwena and Aganang LMs water balance without intervention options

Note: Only domestic, industrial and mining water requirements

5.2.5 Sand catchment

a) Entire catchment

The Sand River catchment is the driest catchment in the study area and has the largest water requirement. The main urban centres in the catchment include Polokwane, Louis Trichardt and Musina as well as smaller urban areas such as Mogwadi and Soekmekaar. Major industrial water users include the South African Breweries (SAB) and the Anglo Platinum smelter in Polokwane. Mining industries include the Vele Coal Mine (currently in a maintenance phase), Messina Copper Mine (closed) and the Artonvilla Copper Mine (closed).

Surface water resources in the catchment are limited to the small Seshego and Houtrivier dams and run-of-river abstractions – hence there are no major dams in the catchment. Groundwater is the only dependable water source for many rural settlements and villages. Large quantities of groundwater are abstracted for irrigation, which is the main water user in the catchment. Although exceptional groundwater reserves exist, they have been fully and possibly over-exploited in some areas.

Urban requirements are augmented from transfers from neighbouring WMAs. The Polokwane LM is supplied via the Olifants-Sand RWS by transfers from the Ebenezer Dam (12 million m^3/a allocated) and the Dap Naude Dam (6.5 million m^3/a allocated) in the Luvuvhu and Letaba WMA, as well as the Olifantspoort Weir (11.3 million m^3/a allocated) in the Olifants River catchment. Polokwane LM also recycled effluent water through an innovative artificial recharge scheme and provided it to the Anglo Platinum Mogalakwena Mine near Mokopane. The mine has, however, stopped to purchase the treated effluent due to water quality non-compliances. Louis Trichardt currently receives transferred water from Albasini Dam (2.4 million m^3/a), situated in the Luvuvhu and Letaba WMA. Musina, situated in the northern part of the catchment, receives the majority of its water from alluvial aquifers next to the Limpopo River (10.96 million m^3/a). This is considered as a surface water resource due to the shallow depth of the aquifer. Water to smaller settlements is supplied by one of the 28 regional/rural supply schemes of which the main resource is groundwater.

The catchment has a high coal mining potential, which will significantly increase the water requirements of the catchment if developed. Coal of Africa Limited (CoAL) has identified a number of possible coal mining projects between Musina and Louis Trichardt, such as the Mopane and Chapudi operations. Major expected industrial development in the Musina area includes the Musina SEZ and LEIP. Only a very high level estimate of the projected water requirements of the SEZ was available at the time of compiling this report. However, it is considered that the Musina SEZ refers more to the area that will be occupied by industrial operations, whereas the LEIP refers to the actual industries. In light of this, it is foreseen that some of the SEZ water requirements have been included in the projected LEIP water requirements.

The water balance for the entire catchment and all water use sectors is shown in **Figure 5.8**, with only water available at the 2010-development level. The red line in **Figure 5.8** shows the limit of the groundwater exploitable potential for the entire catchment. Approximately 155% of the exploitable potential is currently abstracted, mainly by the irrigation sector. The water availability from Ebenezer Dam shows the transfer of 17 million m^3/a up to 2016 after which it is reduced to 16.2 million m^3/a (the maximum that can be supplied sustainably by the dam.

Due to the significant water requirements and the various water sources, **Figure** 5.9 shows the catchment's water balance for only the domestic, industrial and mining water requirements.

No growth in irrigation water requirements is expected and thus no intervention options were considered to increase the water availability for irrigation in the area. The over-abstraction of groundwater by the irrigation sector need to be urgently addressed and compulsory licencing might be implemented to alleviate the problem.

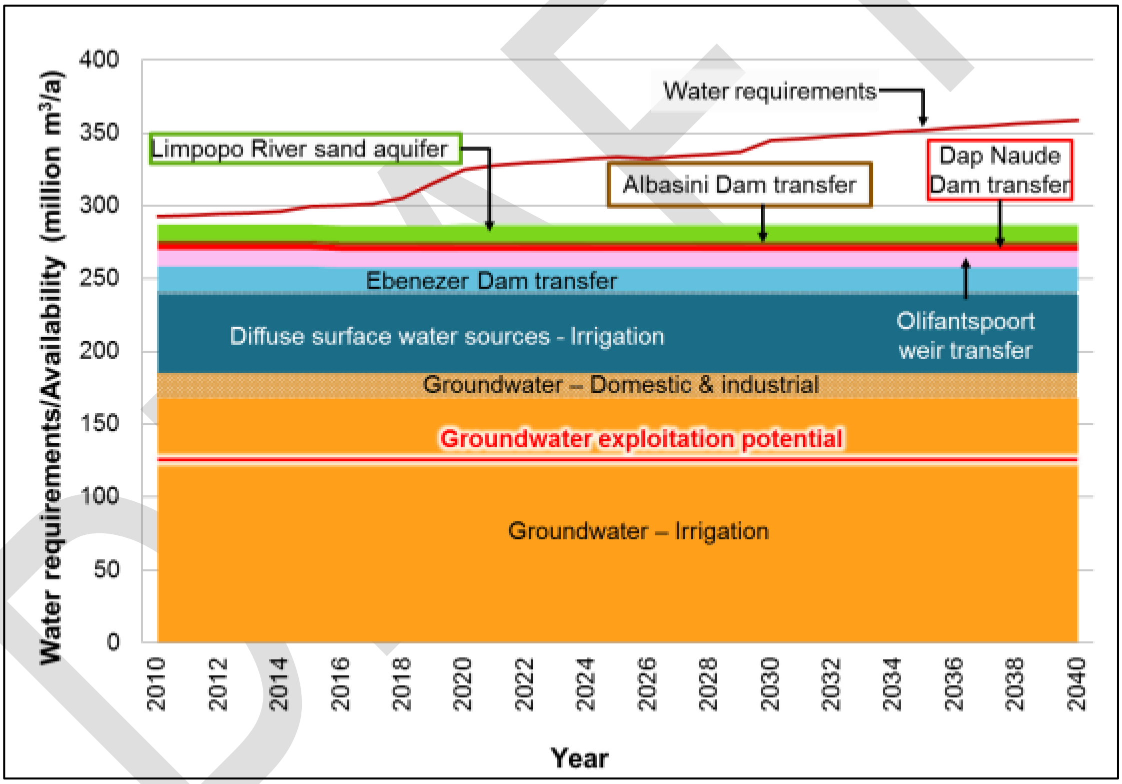

Figure 5.8 Sand catchment water balance without intervention options

Additional to the water balances generated for the catchment, water balances were generated for the domestic, industrial and mining sectors for the economic focus areas, such as Polokwane LM, Makhado LM and the Musina LM, mainly due to their independent water supply systems, spatial distribution and different development plans.

Consideration was also given to the Matoks supply area (located between Polokwane and Louis Trichardt) and the central rural areas near Mogwadi. These areas rely heavily on groundwater, which in some cases are over-abstracted.

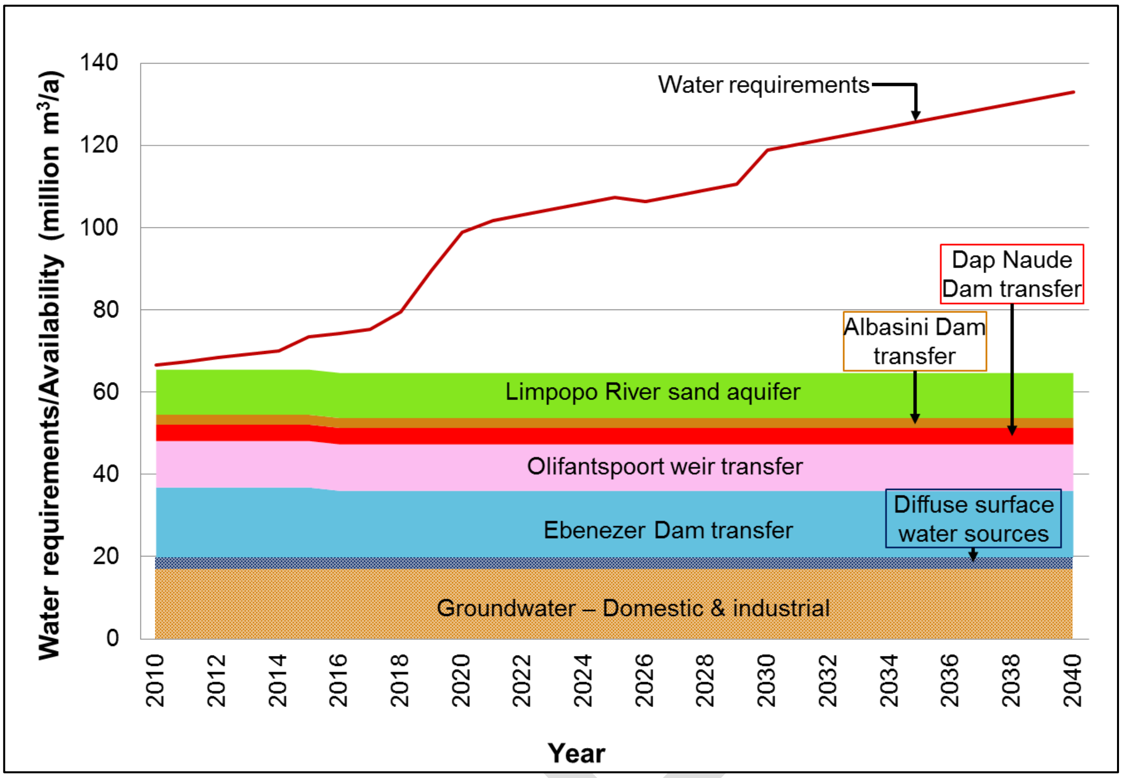

Figure 5.9 Sand catchment water balance without intervention options

Note: Only domestic, industrial and mining water requirements

The split between the water requirements for the aforementioned LMs, were not calculated in detail for the purpose of this Study but were delineated from recently completed studies such as the *Luvuvhu and Letaba Reconciliation Strategy* (DWS, 2015b), the *All Towns Reconciliation Strategy for the Polokwane Cluster* (DWS, 2015a) and other feasibility studies. Careful consideration was given to ensure that the total water requirements for these economic focus areas are in line with the water requirements of the catchment.

b) Polokwane LM

Two water requirement projections were considered for the Polokwane LM – referred to as the “high” and “recommended” projections. The high projection was based on the *Proposed Upgrade of Ebenezer and Olifantspoort Scheme - Socio-Economic Context, Water Consumption Profile and Recommendations* (DWS, 2014c), as part of the ORWRDP studies. This water requirement projection had an accelerated growth which could be motivated. However, the projections were revised to include a lower and more practical growth rate as part of the *All Towns Reconciliation Strategy for the Polokwane Cluster* study (referred to as the “Recommended” water requirement projections).

The water balance for the Polokwane LM is illustrated in **Figure 5.10** with both the high and the recommended water requirement projections. As previously mentioned, Polokwane LM is supplied by groundwater, other surface water sources such as the Houtrivier and Seshego dams, and transfers from the Ebenezer Dam, Dap Naude Dam and the Olifantspoort Weir.

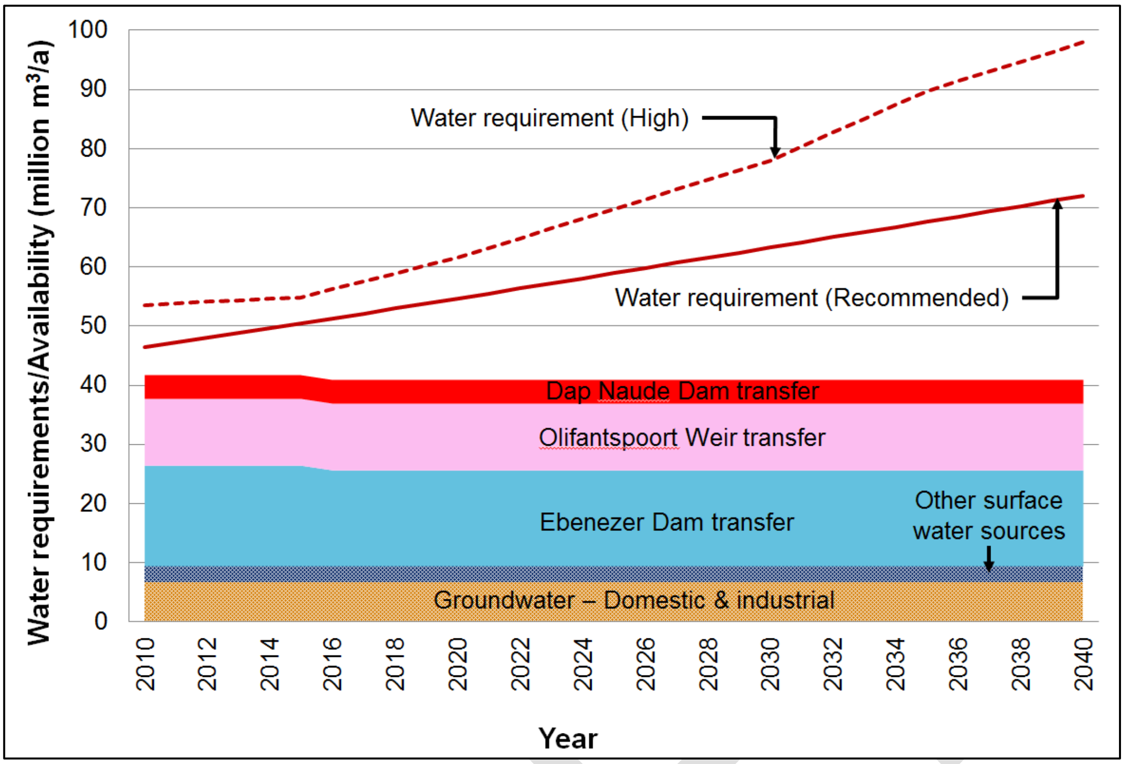

Figure 5.10 Polokwane LM water balance without intervention options

Note: Only domestic, industrial and mining water requirements

The current water use of the Polokwane LM is already exceeding the currently allocated surface water resources and available groundwater resources. The current groundwater water use volume needs to be confirmed as not all the water extracted from the boreholes is metered.

c) Makhado LM

The water requirements for the Makhado LM area were obtained from the *Luvuvhu and Letaba Reconciliation Strategy* (DWS, 2015b) and the *All Towns Reconciliation Strategies* (DWA, 2011). Of note is that this includes the water requirements of WSSs situated in the Sand catchment and some in the Nzhelele catchment, but exclude those located outside of the study area. The WSS included are:

- Makhado RWS (Sand catchment);
- Sinthumule/Katana RWS (Sand catchment);
- Makhado Air Force Base (Sand catchment);
- Buysdorp RWS (Sand catchment);
- Nzhelele RWS (Nzhelele catchment);
- Matshavhawe / Kunda RWS (Nzhelele catchment);
- Nzhelele North RWS (Nzhelele catchment);
- Tshifire Murunwa RWS (Nzhelele catchment); and
- Nzhelele North RWS.

The water requirements include those of the domestic sector, industries and the planned CoAL mines, such as the Makhado Coal Mine (operational from 2018 to 2034), as well as the Chapudi, Mopane and Generaal coal mines operational from 2030. These mining developments account for the majority of the projected growth in the water requirements.

The water balance for the Makhado LM is given in **Figure 5.11**. To show the volume of water required for the CoAL developments, distinction has been made between the total water requirements (solid red line) and water requirements excluding that of the CoAL developments (dotted red line). The noticeable steps in the projected water requirements are due to some of the CoAL mines coming into operation and some closing operations.

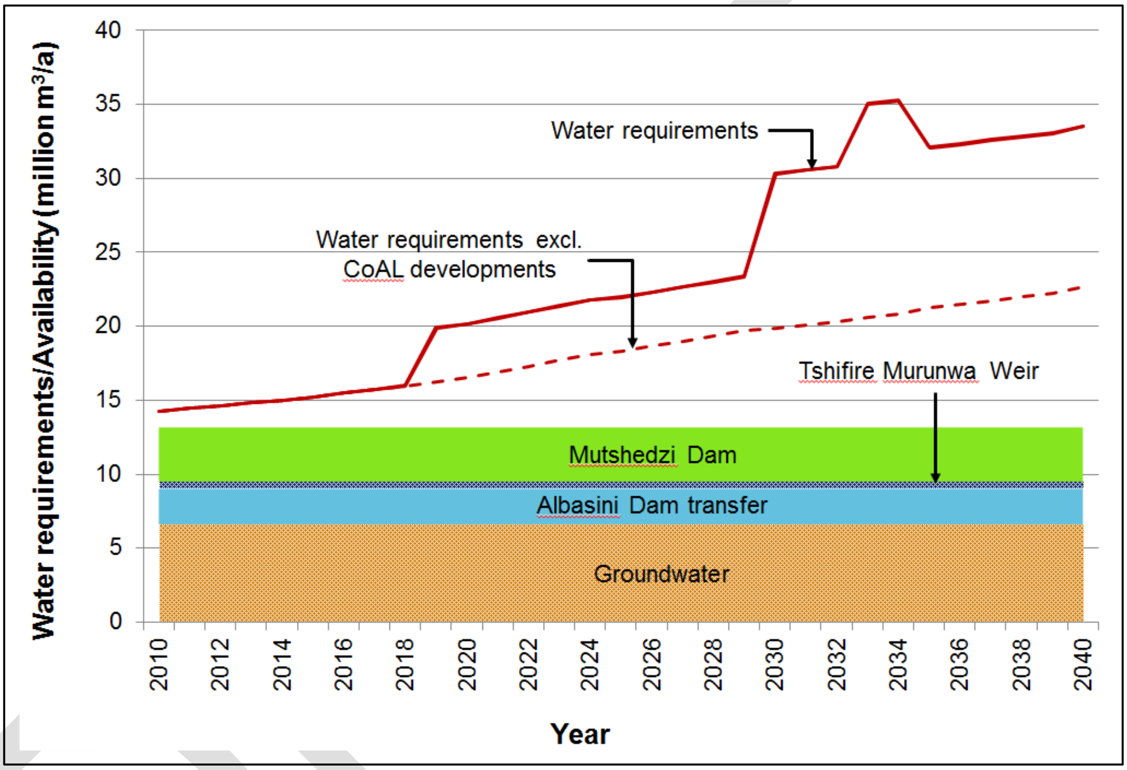

Figure 5.11 Makhado LM water balance without intervention options

Note: Only domestic, industrial and mining water requirements

From the figure, the current water use of the Makhado LM is already exceeding the currently allocated surface water resources and available groundwater resources. Also, the yield of the Albasini Dam has reduced due to the extensive irrigation development upstream of the dam and resulting in the dam being over-allocated. With reference to Figure 4.7, groundwater is already used to its full exploitation potential in the Makhado RWS (Sand catchment) and the Matshavhawe / Kunda RWS (Nzhelele catchment).

d) Musina and environs

Musina is considered to be one of the economical hubs of the study area, with significant development in terms of the LEIP and SEZ. The water requirements for this area were obtained from the *Mutasshi/Musina Corridor Bulk Water Supply Scheme* (DWA, 2013b), the *All Towns Reconciliation Strategies* (DWA, 2011) and through liaison with representatives from LEIP. Two water requirement scenarios were considered – a low water requirement scenario which has lower domestic and small industrial requirements, and a high scenario with higher domestic and industrial requirements. As mentioned, the SEZ water requirements were only determined at a very high level and some are considered to be included in the LEIP water requirements. In light of this, the SEZ requirements, additional to the LEIP requirements are shown as potential extra water requirements.

The water balance for Musina is given in **Figure 5.12**.

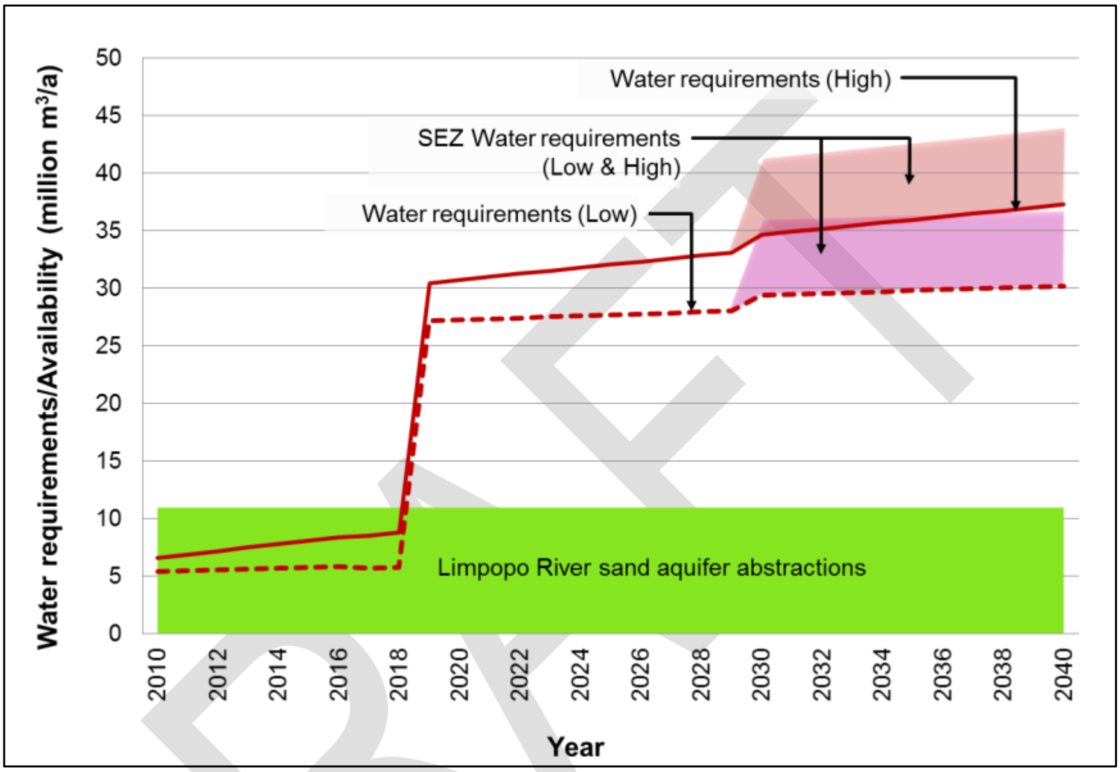

Figure 5.12 Musina water balance without intervention options – Only domestic, industrial and mining water requirements

The current allocation from the Limpopo River sand aquifer (10.96 million m^3/a) can meet the requirements of Musina up to 2018 when the industries as part of the LEIP will start production.

5.2.6 Nzhelele catchment

The Nzhelele catchment is a small rural catchment in the north-eastern corner of the study area. For the purpose of this Study the small Nwanedi River catchment is included as part of the Nzhelele River catchment. There are no large urban centres in the catchment except for a number of settlements in the high rainfall regions, including Makhado Town, Dzanani and Siloam. Small industries include a vegetable processing factory, bakery and furniture factory. A small area of afforestation, equal to 31 km^2, is prevalent in the Soutpansberg area.

Surface water resources in the catchment are developed. Major dams in the catchment include the Nzhelele Dam (the second largest dam in the study area), Mutshedzi Dam and the connected Nwanedi and Luphephe dams. Cross Dam, downstream of the Nwanedi and Luphephe dams serve as a balancing dam. Domestic water requirements are supplied from Mutshedzi Dam, the Tshifiri and Murunwa weirs and from groundwater resources. The Nzhelele Dam supplies irrigation and the Tshipise Holiday Resort. The Nwanedi and Luphephe dams mainly supply irrigation by means of releases. A small volume is abstracted to supply the Nwadeni Reserve camp site, directly downstream of the dam. Furthermore, the licence to supply domestic water requirements (1.135 million m^3/a) from the twin dams to the Luphephe Nwanedi RWS has recently been granted. The RWS, however, extends beyond the boundaries of the study area. In total eight water supply schemes fall within the catchment.

Afforestation reduces the yield of the catchment by approximately 1 million m^3/a and the runoff by approximately 2 million m^3/a.

Due to the high coal mining potential in the catchment, a number of coal mining projects along the Mutamba River have been identified by CoAL. The Makhado Coal Mine is currently past feasibility stage, and the General Project is currently in an exploration phase. The Makhado Coal mine is expected to be operational from 2019 to end 2034 and the Generaal Project from 2030 until after 2040. Should water resources become available, citrus and tomato irrigation in the Nzhelele Valley is expected to expand significantly. However, considering the limited water availability, this is highly unlikely.

The water balance, with only water available at the 2010-development level, is shown in **Figure 5.13**. The allocated volume from Nzhelele Dam is shown. To show the volume of water required for the CoAL developments, distinction has been made between the total water requirements (solid red line) and water requirements excluding that of the CoAL developments (dotted red line). The noticeable steps in the projected water requirements are due to some of the CoAL mines coming into operation and some closing operations.

Although it seems that available water will be able to meet the water requirements up to 2040, it should be noted that the losses from Nzhelele Dam is significant and the assurance of supply is very low. If only the domestic, industrial and mining water requirements are plotted (**Figure 5.14**), the water balance is completely different and a major deficit is evident from 2010.

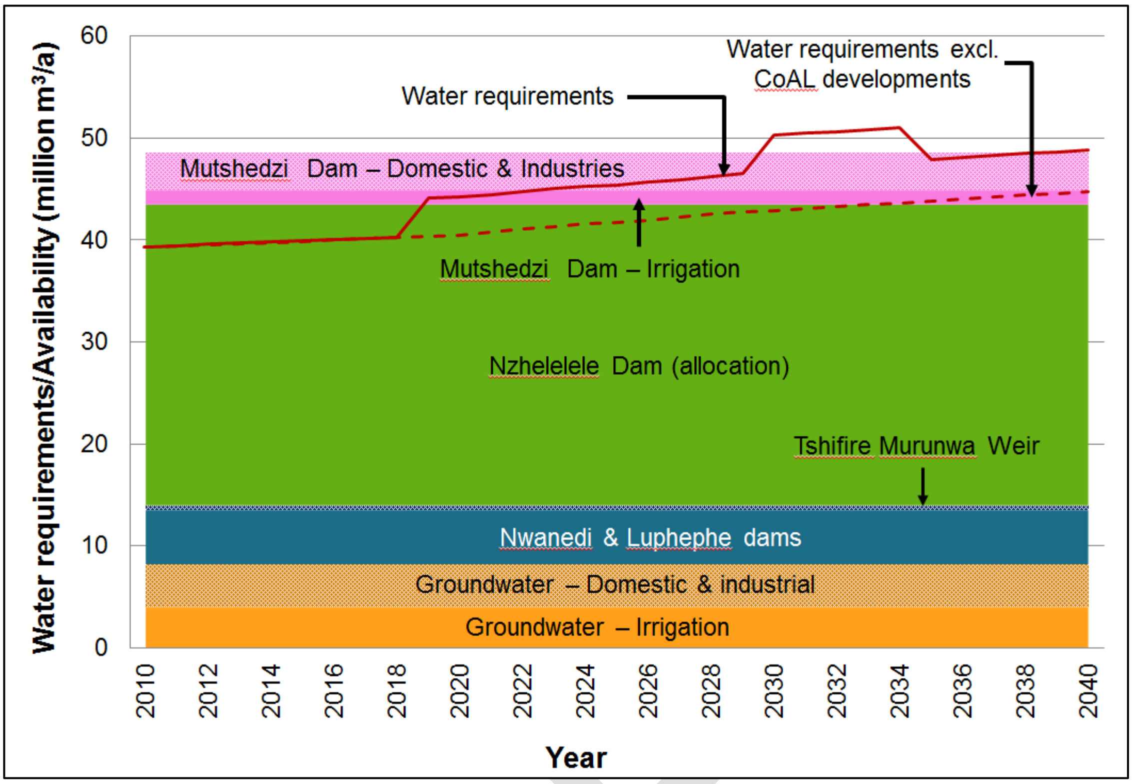

Figure 5.13 Nzhelele catchment water balance without intervention options

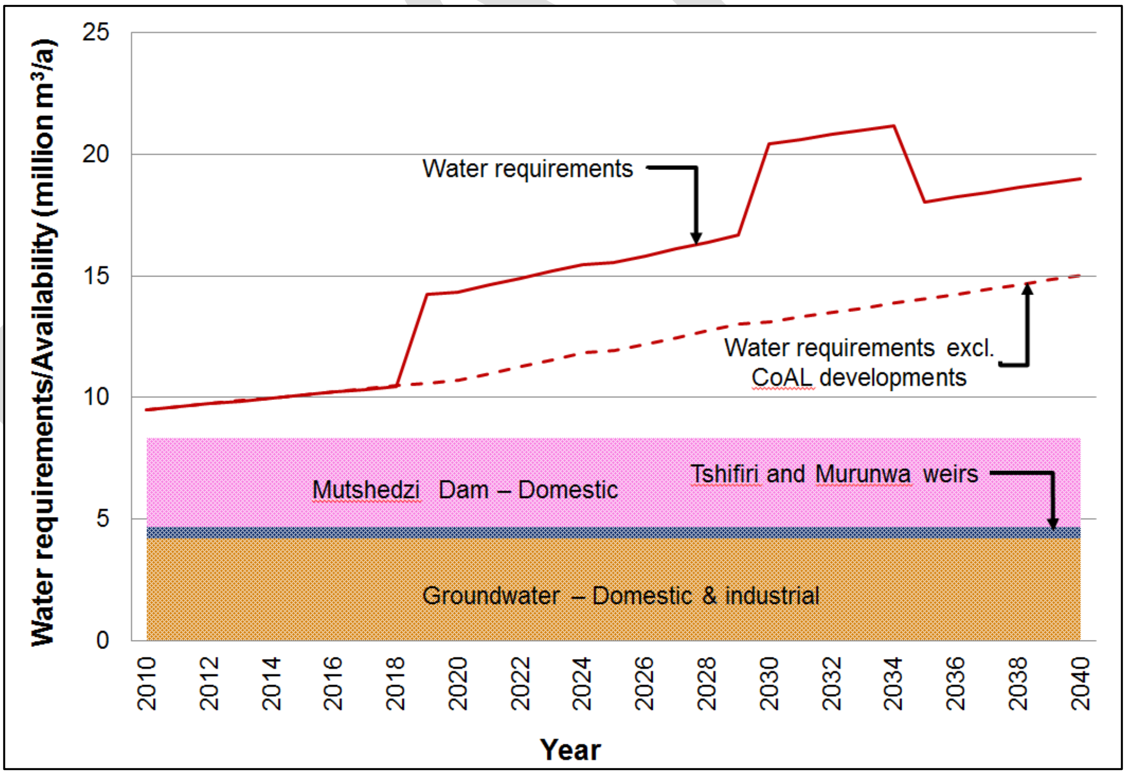

Figure 5.14 Nzhelele catchment water balance without intervention options

Note: Only domestic, industrial and mining users

A significant number of opportunistic users have built weirs and canals from local streams to supply subsistence irrigation or domestic water requirements. These somewhat illegal abstractions reduce the available streamflow to other users and supply sources. As a result some industries in the catchment had to reduce production due to interrupted water supply, and are even considering closing. This will result in a great number of job losses in the area. It is urgent that this matter be addressed.

5.3 SURPLUSES AND SHORTFALLS

Evaluating the catchments as a whole, the 2010-development level water requirements and water availability seem to be in balance for the most. However, certain areas within these catchments are experiencing severe water shortages that should be addressed. Furthermore, significant developments are planned for all catchments, except the Lephalala catchment, which will result in deficits soon after 2010.

6 POSSIBLE INTERVENTION OPTIONS

6.1 INTRODUCTION

Intervention options can be divided into main categories, namely:

- Intervention options that are **water requirement focussed**, with the aim to better manage water resources and to reduce water requirements; and
- Intervention options that are **resource focussed**, with the aim to increase the yield available from existing water resources and the development of new water resources.

6.2 OPTIONS THAT ARE WATER REQUIREMENT FOCUSSED

The intervention options listed in this section does not necessarily aim to reduce water requirements, but also to more effectively manage and monitor water requirements. Furthermore, all possible intervention options considered are described in the following sub-sections, but not all are practical or were assessed in detail as part of this Study.

6.2.1 Water conservation and water demand management (WCWDM)

According to DWS (DWAF, 2004a), **Water conservation** refers to the "*minimisation of loss or waste, the care and protection of water resources and the efficient and effective use of water*". **Water demand management** refers to the "*The adaptation and implementation of a strategy by a water institution or consumer to influence the water demand and usage of water in order to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services and political acceptability*".

The NWRS-2 report has identified the implementation of WCWDM as a core strategy to ensure sufficient water to meet South Africa's needs going into the future. WCWDM strategies for each sector, including agricultural, mining and business, energy generation, local government and the DWS, have been planned.

Implementation of WCWDM in the study area and should be prioritised by municipalities, Water Service Providers (WSPs) and Water Service Authorities (WSAs) as the first line of interventions to improve the water use efficiency. As part of this Study, the following was conducted with regard to WCWDM in the irrigation, domestic, mining and industrial sectors:

- Status quo assessment of the current level of water losses, including physical water losses and Non-Revenue Water (NRW);
- Identification and assessment of current WCWDM initiatives within the study area; and
- Proposed mitigating measures to reduce water losses and ensure sustainable use of water resources.

An overview of the above activities is given below for each of the considered water use sectors – more detail is included in the *Water Conservation and Water Demand Management Report (P WMA 01/000/00/02914/4/2).*

a) Urban / domestic water use sector

Water losses in the urban and domestic sector is based on the concept of NNRW as reported in the *State of Non-Revenue Water Report* (WRC, 2012) and embodied in the DWS *No Drop Certification Program*. Best practise principles for reducing NRW at municipal level include metering of all supply systems to draw up an International Water Association (IWA) water balance to outline source of losses, develop a strategy and implementation plan to address highest losses with baseline, targets, budget and approval from council.

The IWA water balance includes the following components:

- System input volumes: total volume input into systems
- Authorised consumption: this also includes items such as fire-fighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, building water, etc. These may be billed or unbilled, metered or unmetered, according to local practice;
- Water losses, classified as:
  - ***Real losses***: Leakage on transmission and distribution mains, leakage and overflows at storage tanks, leakage on service connection up to point of customer meter.
  - ***Apparent losses***: Unauthorised consumption (i.e. theft of water and fraud) and customer meter inaccuracies and data handling errors.
- Free basic water; and
- Non-revenue water.

The 2012 results indicate a high percent of NRW in rural municipalities estimated at 61% for study area. Vhembe DM demonstrated the most severe water losses with a NRW percentage of 61% in 2010 which increased to 62% in 2012. There is a lower percentage in urban areas where some metering is taking place, e.g. 22% in Musina. There are large gaps in IWA water balance information in the study area as well as low credibility of information due to lack of metering, billings and recordings of information.

For domestic users, the WSA and WSP must comply with No Drop requirements through conducting the following:

- Develop a comprehensive water balance in accordance with the modified IWA water balance guidelines;
- Identify the highest contributor to NRW and address accordingly;
- Develop strategy and implementation plan to address the source of NRW using the *All Towns Reconciliation Strategies* (DWA, 2011) as guideline for savings;
- Obtain council approval and budget for initiatives; and

- Measure targets against baseline and report accordingly.

Implementing WCWDM in the urban areas will have the largest contribution to water saved through WCWDM. The effect of implementing WCWDM in rural areas, however, will have a lesser effect mainly due to the low service levels in these areas. Most rural areas do not have access to water services, and rural communities rely mostly on water obtained directly from streams or boreholes. The opportunity for WCWDM in rural areas will be to contribute to the sustainability of the services once they have been developed. Nonetheless, WCWDM should still be the priority intervention option.

For the purpose of generating water balances for this study, the real water losses in the domestic sector was considered to reduce from 28% in 2010, to 26 % in 2020, 23 % by 2030 and 20% by 2040. Where WCWDM plans or strategies have already been compiled and implemented, these projected water savings were incorporated. Estimates indicate that approximately 3.3 million m^3/a can be saved by the domestic and industrial sector in the Polokwane LM area and between 1 and 4 million m^3/a by the domestic and industrial sector in the Mogalakwena and Aganang LM areas.

WCWDM can be applied immediately after the completion of this Reconciliation Strategy, however, the full benefit thereof on the water balances will only start reflecting after a number of years (five years taken as a benchmark).

b) Irrigation sector

The irrigation sector constitutes for almost 73% of the water requirements within the study area, and can thus also contribute significantly to water losses if not efficiently managed.

Water losses in the irrigation sector can be attributed to three main components:

- Conveyance losses;
- Inefficient irrigation system types; and
- Inefficient operation and management of the system (type of crop selected, scheduling, duration, accurate metering, operating rules, etc.).

The low assurance of supply in the irrigation sector has resulted in farmers to identifying initiatives to maximise efficient use of the limited water resources in the study area. This is especially applicable in the large scale/commercial farming areas, which accounts for approximately 95% of all agricultural activity within the study area. Rural agricultural activity accounts for only 5%.

An evaluation of the irrigation efficiency within the study area indicates that 78% of the total irrigated area uses centre pivot and drip irrigation systems, both of which have 95% system efficiency (Reinders, 2011). This implies that the majority of farmers employ a number of WCWDM measures to reduce losses and wastage, but the exact savings are unknown.

However, the water saved within this sector by individual farmers will not necessarily become available to other sectors, but will rather be applied to either make up for deficits or to expand the irrigation activities.

Furthermore, the bulk of the water losses in the irrigation sector are experienced via the conveyance infrastructure, such as bulk supply canals and reticulation systems. These losses range from as low as 1 or 2% where pipelines are used and where the conveyance distance is short, to as high as 30% where unlined canals are used to transport water over long distances.

With particular reference to this Study, conveyance losses as high as 78% and 60% are estimated from the Glen Alpine and Nzhelele dams respectively. The focus of WCWDM in the irrigation sector should thus be on the maintenance and refurbishment of existing conveyance infrastructure.

c) Mining, industries and power generation

The mining, industrial and power generation sectors account for 7% of the total 2010-development level water requirements and is expected to grow to 23% of the total water requirement by 2040.

Most mining companies have the expertise to implement advance processed to ensure recycle and reuse of all water streams which improved profitability of the operation. In addition to this, mining houses have to comply with strict license conditions for of effluent (and the cost thereof). It therefore pays a mine to recycle its water rather than discharge large volumes of it into the river after use.

There are high levels of efficiency at most mines with on average 5% water losses. However, at some stage, a point of ‘diminishing returns’ is reached where mines and industries have to make substantial investments to obtain relatively small water savings. The concept of water off-setting as outlined in the NWRS2 proposes an opportunity that mines /industries assist other users upstream of water resources to gain larger water saving or assisting to meet effluent compliance specifications, thereby allowing more water to remain in the system.

Typical WCWDM initiatives in industry include undertaking annual water audits, performance and monitoring against industry benchmarks, close loop cooling systems, wash water recovery, water reuse, and effluent reuse. It is also assumed that by increasing the efficiency of manufacturing and operational processes, these industries could decrease water losses even further.

In essence, non-domestic users must comply with water use license requirements, undertake annual water audits and evaluate savings against industry benchmarks as savings will reduce operational cost and allow for expansion of operations

Furthermore, all sectors should align with and achieve targets set out in NWRS2 Implementation plans for WCWDM.

6.2.2 Eliminating unlawful water use

Eliminating unlawful water use in various sectors can result in additional available water capacity to be allocated elsewhere. The DWS is legally bound, in terms of the *National Water Act (NWA), Act 36 of 1998*, to execute this option.

The validation part of the parallel *Validation and Verification Study* (DWS, 2015) for the Limpopo WMA focussed on the current irrigation and the irrigation development during the qualifying period, whereas the verification part focussed on whether irrigation is lawful or not. At the time of compiling this report, the validation process has been completed and the verification process was still in progress. In light of this, it is difficult to estimate how much of the current irrigation developments are unlawful. Preliminary estimates, however, indicate that approximately 23 million m^3/a might be unlawfully used by the irrigation sector in the study area. Approximately 12.9 million m^3/a is supplied from groundwater and 9.7 million m^3/a from surface water. The preliminary estimate of unlawful irrigation water use per catchment is provided in **Table 6.1**.

Table 6.1 Preliminary estimate of unlawful water use for the irrigation sector in the study area

Catchment	Unlawful water use (million m^3/a)			Percentage of irrigation water requirement (%)
	Surface water	Groundwater	Total	
Matlabas	0.8	0.1	0.9	19.1%
Mokolo	1.1	0.6	1.7	4.2%
Lephalala	3.4	1.8	5.2	7.4%
Mogalakwena	3.2	3.0	6.2	6.2%
Sand	0.7	7.0	7.7	3.5%
Nzhelele	0.5	0.4	0.9	3.1%
TOTAL	**9.7**	**12.9**	**22.6**	**4.9%**

It is recommended that as soon as unlawful use is detected, action should be taken, irrespective of the completion status of the *Validation and Verification Study* (DWS, 2015). To eliminate the largest trespassers first will ensure the maximum savings in the shortest possible time. Although the overall unlawful use elimination process is fairly quick, possible protracted court cases may extend the process to approximately four years.

For the purpose of this study water savings due to the elimination of unlawful irrigation use has not been included in the reconciled water balances, mainly because of the level of uncertainty. This intervention option, and the effect thereof on the water balances, should be further investigated during the implementation and continuation phase of this Reconciliation Strategy.

It should be noted that unlawful water use is not only limited to the irrigation sector but also occurs in all other sectors. The unlawful water use in other sectors was not quantified as part of this study, but it is recommended that it be considered in the implementation and continuation phase of this Reconciliation Strategy.

6.2.3 Reduced assurance of supply

In general, reducing the assurance of supply for certain water users can result in additional available water capacity to be allocated elsewhere. The generally accepted assurance of supply for the different sectors is as follows:

- Power generation: 99.5% (1 in 200 years risk of failure);
- Domestic water use: 98% (1 in 50 years risk of failure);
- Industrial water use: 98% (1 in 50 years risk of failure); and
- Irrigation water use: 80% (1 in 5 years risk of failure).

The only sector within the study area which may consider it acceptable to have a lower assurance of supply is the irrigation sector, should there be compensation for consequent losses. It should be noted, however, that the current irrigation assurance of supply in some areas is lower than the recommended 80%, and hence it will be difficult to reduce it even further. Furthermore, the implementation of this intervention option requires extensive negotiations which fall outside of the scope of this phase of the Reconciliation Strategy.

6.2.4 Compulsory licencing

Compulsory licencing, as stated in the *National Water Act (Act 36 of 1998),* is the process where the responsible authority requires that all existing water use be licensed. This enables the responsible authority to assess the current water use and make informed decisions on the allocation of the available water resources to the users within the designated area. The main purpose of compulsory licensing is to correct previous imbalances and inequities in water use. In the case of irrigation, the current water allocation is based on the average water requirement, however, compulsory licensing would set a maximum allowed water use. Although compulsory licencing can reduce water use to a significant amount, it should be considered as the last resort. The implementation process is not as expensive, but is very tedious and may have significant social consequences.

6.2.5 Compulsory levy, purchasing and transfer of water entitlements

a) Partial purchasing of water entitlements

An additional water use charge on all users in the study area can be levied by the Minister, in terms of Section 57 of the NWA, to impose a reduction on the water use. This levy must be in accordance with the pricing strategy which provides for, *inter alia*, setting water use charges for achieving the equitable and efficient allocation of water (Section 56 (c) of the NWA).

The financial contributions of all the water users would be ring-fenced and used to buy out water entitlements from those water users who are willing to sell, e.g. by tender process. This process can then be continued until the necessary water balance is achieved. Alternatively the purchase of water entitlements can be funded from the fiscus.

The purchase of water entitlements can, however, lead to social consequences such as job losses of farm workers. Checks and balances need to be built into the process to mitigate the social consequences. This option should be considered with great caution and necessary checks and balances need to be built into the process to mitigate the social consequences.

Another, more social friendly, option is to allow water users that are willing, to sell water saved through WCWDM to water resource authorities at an agreed price. This option is attractive in the sense that it can be implemented almost immediately and is not dependent on completion of the entire validation and verification processes. It is only those water users who offer a portion of their water use entitlements for sale whose entitlements must be validated and verified and this can be done on an ad hoc basis.

The associated assurance of supply can fluctuate, based on the use and saving of the willing seller. Furthermore, an appropriate policy within DWS needs to be developed and user guidelines need to be prepared. These above options were thus not further considered in this phase of the Reconciliation Strategy, except where allocations have been revised, bought over or are in the process of being revised.

b) Transfer of water entitlements

Some water users, especially irrigators in some regions are not using their full water entitlement and hence surplus water availability can be reallocated to other users. The option to transfer water entitlements is dependent on the administrative processes in terms of Section 25 of the NWA, the compiling of the contract between the buyer and seller, and the issuing of the new water use licence.

The National Water Policy Review, refers to the “Use-it or lose-it” principle (Sections 2.1 and 2.2 of the policy), which entails that any authorised water use, including existing lawful use, which is not utilised productively and beneficially for a certain period, should be reallocated. The NWA, however, does not contain any mandate for this policy to be applied to existing lawful use. The policy has not yet been propagated, and until such time the NWA will take preference. The discrepancies between the NWA and the Policy Review need to be urgently addressed and coordinated by the DWS.

Transfer of water entitlements will not reduce water requirements in the study area necessarily, but will allow water availability and use to be more balanced between the various water users. If implemented, the process needs to be regulated and monitored to prevent social inequity, such as job losses due to a large commercial farming enterprise closing down. The option is recommended only as a short term intervention and only as a last resort. Partial purchase of water entitlements is rather preferred as the long-term option.

The Lonmin mining company has purchased some of the irrigation water entitlements out of Doorndraai Dam to bridge the construction time of the ORWRDP-2B (refer to **Section 6.3.2c)**). Lonmin, however, is not yet using this water.

6.3 OPTIONS THAT ARE RESOURCE FOCUSSED

6.3.1 Groundwater development and management

Groundwater is an important water resource in study area, suppling an estimated 352 million m^3/a, or 55% of the total water requirement at the 2010-development level. The study area has ample groundwater resources of which a large quantity is under-exploited. However, groundwater is over-exploited in the central regions of the study area, especially in the vicinity of Polokwane and Mogwadi. The issue of over-exploitation need to be addressed urgently.

The production ranges recommended for different supply categories are as follows:

- High borehole yields, generally greater than 5 ℓ/s, can be used for urban and rural water supply, industry or large-scale irrigation.
- Moderate borehole yields generally, 2 to 5 ℓ/s, can be used for urban and rural water supply to small towns, industry or small-scale irrigation.
- Low borehole yields generally, 0.5 to 2 ℓ/s, can be used for domestic and livestock watering supply to rural settlements, hospitals and health centres or small-scale irrigation at community vegetable gardens.
- Very low borehole yields generally, 0.1 to 0.5 ℓ/s, can be used for domestic supply to single homesteads, schools, police stations, clinics, small rural villages (250 persons) or livestock watering. Boreholes in this group are mostly equipped with hand, submersible or wind pumps.
- Un-economical borehole yields generally, less than 0.1 ℓ/s. Non-reticulated water supply for isolated households or for monitoring in certain cases. Suitability dependable on factors such as construction, objective of monitoring, location, and geological setting.

In general, new groundwater developments can only be used for domestic supply in small villages and livestock watering. Further groundwater development in rural areas is the main, and in some cases the only intervention option. Although the implementation of WCWDM in these rural areas will have some effect, it not be able to meet the future water requirements. With reference to **Figure 4.7** and **Figure 5.1**, the WSS that are in deficit can potentially be augmented by additional groundwater supply. The *Groundwater Assessment and Utilisation Report (P WMA 01/000/00/02914/6)* contains detail on the intervention potential and cost estimates in terms of groundwater development. The most favourable approach is to develop regional groundwater schemes rather than individual boreholes. This regional approach will allow for sufficient budget for exploration and fewer borehole installations to be maintained as only the highest yielding boreholes will be equipped. This will also prevent over-abstraction within a limited area around villages.

Detailed studies, however, will be required at a local level to determine the future requirements and the additional sustainable groundwater development or yield available. It is recommended that this be further addressed, e.g. as part of the ongoing *All Towns Reconciliation Strategies* (DWA, 2011).

Another groundwater development alternative that can be considered is **artificial recharge**, where water is stored in large underground openings in the subsurface. One old mine in the study area that needs to be investigated as a storage facility is the old copper mine in Musina. The topography in the area is flat and there are no surface dam sites nearby. Possible pollution of the water during storage is a factor to take in consideration although the regional water quality is already poor. The static water level in the area is deep and decanting will not be a problem. Availability of water in Musina during very dry periods will be ranked higher than poor quality. The cost of water purification is linked to power use and research in solar technology can make this a viable option in future. This solution for Musina needs the following feasibility studies:

- The volume of the old dumps will give an indication of the available storage below surface, but this information may already be available from the mine's records.
- The cost to pump water to the mine from the Limpopo River in high flood times, which is the source. The cost of a solar farm to supply power needs to be investigated for this.
- The likelihood and intensity of acid mine drainage (AMD), which takes time, and which is more problematic with the introduction of oxygen and the fluctuation of the water level. The formation of acid water may be reduced by sealing the most problematic walls inside the mine, if at all possible.

Another such storage option is the old tin mine at Modimolle, where previous investigations have suggested a possible natural inflow of 60 ℓ/s into the mine. Modimolle obtains water from the Roodeplaat Dam, and the reuse of treated sewage needs to be ascertained as possible source for storing underground and then used to supply Mokopane and Polokwane. Again, the power source can be a solar farm, which is the largest cost for the treatment and supply.

The third, maybe less controversial, storage option is the area around Mahodi in the Dendron area. It is a large natural aquifer within the gneiss. The aquifer consists of a weathered and fractured zone to approximately 40 m with the natural static water level around 5 to10 m below ground level, and a fractured zone associated with pegmatite and diabase dykes. During pumping tests the inflow into some of the boreholes proved to be more than 20 ℓ/s, which implies that an artificial recharge of around 20 ℓ/s per hole can be added to the aquifer with water that needs to be obtained from outside the catchment. The run-off at Ebenezer Dam, the run-off of the Sand River as near as possible to the Mahodi area and the sewerage treatment works of Polokwane need to be investigated as possible sources. This would recharge the area over time. Irrigation would become an option again and the economy would be revitalized. Water can then be used for all the rural villages in the area of which some have large populations, like Senwarbarwana (Bochum), Mogwadi (Dendron) and Mahodi. Again solar farms as power source must be investigated.

The fourth area to be investigated is the dolomite aquifer at Weenen and Planknek. It is currently pumped at approximately 8 Mℓ/d, although higher abstraction rates had been recommended during previous investigations, which in the end were not sustainable. Higher recharge, e.g. from treated effluent at Mokopane, could make this aquifer an artificial/natural reservoir with higher abstraction rates possible again.

Over and above artificial and natural underground reservoirs alluvial riverbeds can provide substantial water storage areas that obtain regular and large volume recharge. One example is the Mogalakwena River, where caissons (galleries or well points) were built and used. These are very effective as up to 30 ℓ/s can be achieved from these sources. Generally two pumps are installed: A big pump for the rainy season when “unlimited” volumes can be pumped while the river is in flow, and a smaller pump for abstraction of the water that is stored in the sand during dry periods. Again treated effluent could be pumped into the river to artificially keep the river in flow. These sand well points could thus be used at a higher pumping rate for a longer period of the year.

As mentioned in **Section 4.2.3**, the main challenge with regard to groundwater, however, is the lack of monitoring and data coalition. Without proper monitoring, the volume of groundwater abstracted and the volume available for further development is difficult to quantify. Urgent monitoring related interventions are proposed in **Section 4.2.3**.

6.3.2 Transfers in

A number of future transfer schemes from neighbouring WMAs, as well as within the study area, are planned or are currently in the construction phase. A brief overview of these transfers is discussed below.

a) Mokolo-Crocodile Water Augmentation Project (MCWAP)

The MCWAP transfer scheme has two phases. Phase 1 entails a pipeline parallel to the existing pipeline from the Mokolo Dam to the Lephalale area to supply an additional 11.2 million m^3/a to the current supply of 18.2 million m^3/a supply from the dam. Until the commissioning of Phase 2A of MCWAP, Mokolo Dam will be operated at a higher risk in order to meet the growing water requirements. The total water allocation from MCWAP-1 or the Mokolo Dam is 29.4 million m^3/a, excluding irrigation, and has been re-allocated as per **Table** 6.2. The construction of Phase 1 was completed at the end of 2015.

Table 6.2 Old and new allocations from Mokolo Dam

User	Old allocations	New allocations
	million m^3/a	
Exxaro – Grootegeluk Coal Mine	9.9	7.6
Eskom - Matimba Power Station	7.3	3.6
Eskom - Medupi Power Station	0.0	10.9
Lephalale LM (including Marapong)	1.0	7.2
Incidental users	0.0	0.1
Subtotal	**18.2**	**29.4**
Irrigation	10.4	10.4
Total	**28.6**	**39.8**

Phase 2 of the transfer scheme (MCWAP-2) entails a transfer via pipeline from the Crocodile River (West) at Vlieëpoort near Thabazimbi to the Lephalale area. Current indications suggest that the growing water requirements would exceed the available Mokolo River system yield by 2019, by which time MCWAP-2A should be operational. The proposed capacity of MCWAP-2A, ranging from 75 million m^3/a to 100 million m^3/a, is still under discussion and pending funding. However, for the purpose of this phase of the Reconciliation Strategy, MCWAP-2A is expected to transfer 100 million m^3/a into the Mokolo River catchment.

b) *Magalies Water transfer scheme to Modimolle and Mookgopong*

There is currently an operational transfer scheme from Roodeplaat Dam on the Pienars River, via the Klipdrift Water Treatment Works (WTW) located in the Crocodile River (West) catchment, to Modimolle, supplying a maximum of 2 million m^3/a (5.3 Mℓ/d). It is approximated that 8.5 million m^3/a will be required in the Modimolle municipal area by 2040.

Magalies Water is in the process of investigating the Klipvoor Dam Scheme, which will have a capacity of 16.4 million m^3/a (45 Mℓ/d) to meet the increased water requirements of the Moretele, Bela-Bela and Modimolle LMs. The scheme will comprise of a new WTW, or the upgraded Klipdrift WTW, and bulk supply pipelines to the three LMs, including up to Mookgopong. At the time of compiling this report, the source of water has not been confirmed, but will either be from the Roodeplaat Dam or Klipvoor Dam on the Moretele

River. The Klipdrift WTW are in the progress of being upgraded from 18 Mℓ/d to 42 Mℓ/d.

Assuming that the increase in the water requirements in the Modimolle LM (Modimolle and Mookgopong) will be supplied mainly by the Klipvoor Dam scheme, approximately 6.6 million m^3/a will have to be transferred via this scheme to meet the 2040 water requirement.

c) *Transfer from Flag Boshielo Dam to Mogalakwena and Aganang Local Municipalities (ORWRDP-2B and 2G)*

With the significant planned expansion of mining activities and the subsequent population growth in the Olifants River catchment, as well as the Mogalakwena and Polokwane LMs, the ORWRDP has been identified to meet the growing water requirements. The ORWRDP is a two phased project, of which Phase 1 entails the raising of the existing Flag Boshielo Dam (Olifants River catchment) and Phase 2 the construction of the new De Hoop Dam (Olifants River catchment) and associated bulk supply infrastructure.

Phase 2B and 2G entail parallel bulk supply pipelines from Flag Boshielo to supply the growing mining and domestic water requirements of the Mogalakwena LM, as well as a portion of the Aganang LM domestic requirements. The first pipeline, Phase 2B, have a planned capacity of 49 million m^3/a, but will supply approximately 9 million m^3/a to the Lebowakgomo mines (outside of the study area) halfway along the pipeline. Phase 2G have a planned capacity of 16 million m^3/a. However, due to the delay in construction and the steep increase in the projected water requirements, is was recommended that Phase 2B and 2G be combined into a single pipeline and be constructed as soon as possible.

The total required supply capacity to the Mogalakwena and Aganang LMs have also since decreased to 50 million m^3/a.

d) *Transfer from Glen Alpine Dam to Molemole West supply area*

The Glen Alpine-Molemole West supply area transfer scheme has been identified as a potential scheme to augment domestic groundwater supply to the Molemole West Supply Area from the Glen Alpine Dam.

Currently, water is released from the Glen Alpine every six to seven weeks depending on the downstream irrigation demand. However, no formal canals or pipelines exist and farmers abstract water from weirs that are built in the river channel – some of which are unlawful. These releases and abstractions are thus basically uncontrolled and insufficient.

Preliminary estimates indicated that 2.18 million m^3/a (at 98% assurance of supply) is potentially available from the dam to supply the Molemole West supply area. This includes the historical allocation of 1.56 million m^3/a (at 98% assurance of supply) for irrigation to former Lebowa that has never been taken up, as well as the potential volume of 0.62 million m^3/a that can be saved by reducing downstream conveyance losses through installing pipelines or canals (WSM Leshika Consulting, 2014).

In conjunction with possible groundwater development, only 0.6 million m^3/a have to be transferred to meet the future requirements of the Molemole West supply area. The remainder can thus be applied elsewhere in the study area.

e) Nandoni Dam transfer

The Nandoni Dam is situated on the Luvuvhu River and has been completed in 2004. Water from the dam has been allocated to various areas within the study area to augment supply, including:

- Makhado RWS that includes Louis Trichardt and surrounds;
- Sinthumule Kutama RWS;
- Makhado Air force Base; and
- Matoks (between Louis Trichardt and Polokwane).

In total approximately 8.5 million m^3/a will be transferred from Nandoni Dam to the Makhado RWS, Sinthumule Kutama RWS and the Makhado Airforce Base to augment the current groundwater and Albasini Dam supply. The main supply pipeline from Nandoni Dam to Louis Trichardt, as well as other supply areas, is still under construction. The estimated connection date is at the end of 2016, but might be delayed up to 2018. The water supplied from Nandoni Dam will only be used to support the urban/industrial and rural domestic sectors and not to augment irrigation requirements.

Additionally, another 4.7 to 5.5 million m^3/a will be transferred from Nandoni Dam to the Matoks Supply Area (including the Botlokwa, Ramakgopa and the Nthabiseng Groundwater Schemes (GWS)). The Matoks area is currently supplied by groundwater only, however, the current abstraction rate (3 million m^3/a) is unsustainable and needs to be reduced. The supply from Nandoni Dam will replace the over-abstracted groundwater amount (approximately 2.7 million m^3/a) and meet the projected future water requirements up to 2030.

f) Zimbabwe transfer

A transfer from Zimbabwe, is a potential intervention that was considered as part of the feasibility study for the *Mutasshi/Musina Corridor Bulk Water Supply Scheme* (DWA, 2013b). The aforementioned study established that about 30 million m^3/a of raw water can be purchased from the Zimbabwe National Water Authority (ZINWA). However, this volume is only an estimate and need to be confirmed.

Should this scheme be implemented, it is proposed that the water released from Zimbabwe be abstracted from a tributary of the Limpopo River and treated before being transferred to South Africa. This intervention option, however, entails significant negotiations and agreements between South Africa and Zimbabwe to ensure sustainable supply.

g) Summary of potential transfer schemes

A summary of the potential transfer schemes, source and recipient catchments and the expected transfer volumes are reported in **Table** 6.3 and graphically illustrated in **Figure 6.1**.

Table 6.3 Summary of potential transfer schemes

Transfer scheme	Source catchment	Recipient catchment	Volume (million m^3/a)
MCWAP 1	Mokolo	Mokolo	13.0
MCWAP 2A	Crocodile West	Mokolo	100.0
Klipvoor-Modimolle and Mookgopong	Crocodile West	Mogalakwena	6.6
ORWRDP: Flag Boshielo-Mokopane	Olifants	Mogalakwena	50.0
Glen Alpine-Molemole West	Sand	Sand	2.18
Nandoni-Matoks pipeline	Luvuvhu and Letaba	Sand	4.66 - 5.5
Nandoni-Louis Trichardt	Luvuvhu and Letaba	Sand	5.5 - 8.5
Zimbabwe	Umzingwane (Zimbabwe)	Sand	30.0

6.3.3 Reuse of treated sewerage effluent

For the purpose of this Study, the *Opportunities for Water Re-use Report (P WMA 01/000/00/02914/10/1)* have been compiled to provide an overview of the status of WwTW in the study area, an overview of water re-use and considerations, possible treatment technologies, and current and possible reuse opportunities within the study area. The following section provides a summary of the content included in the above report.

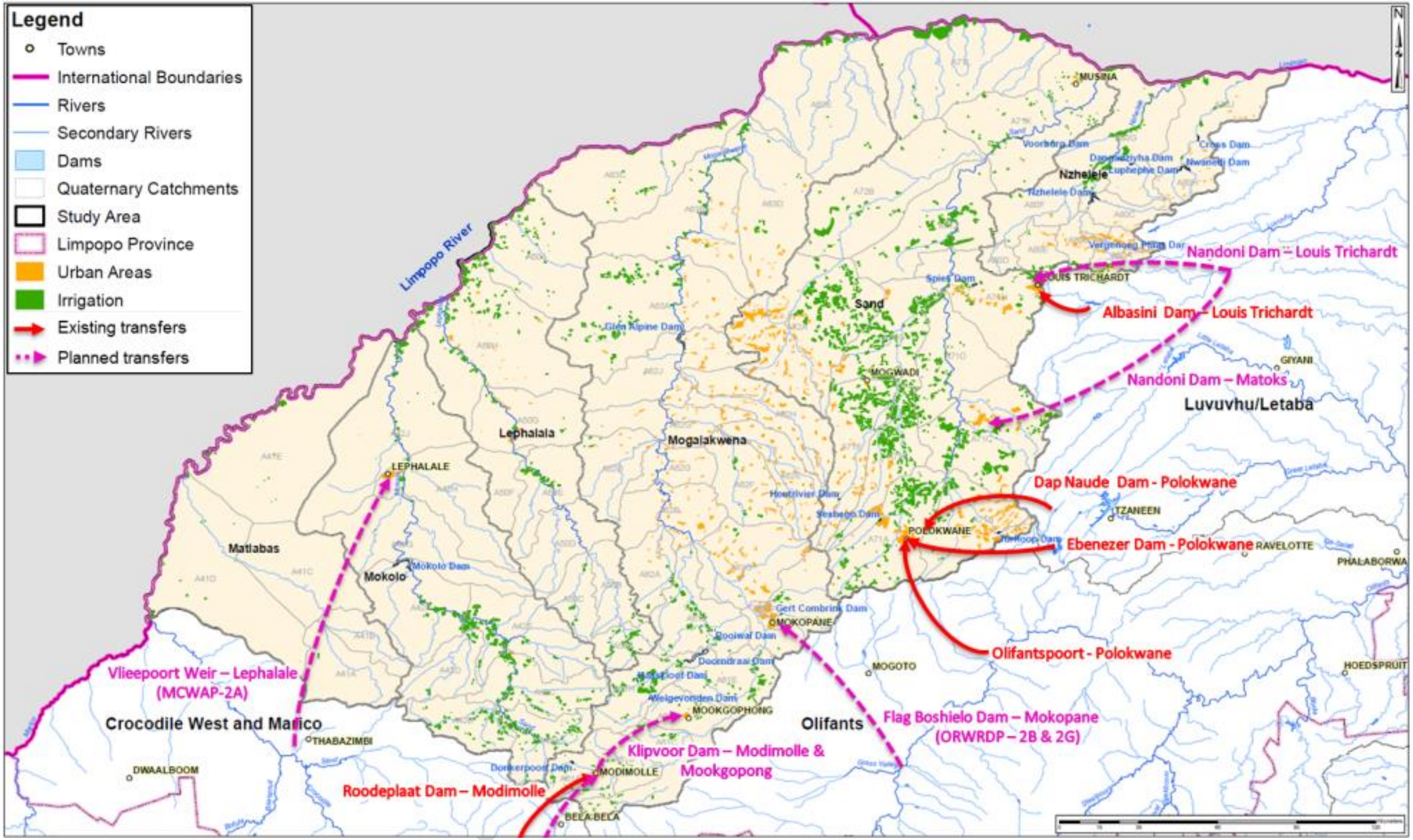

Figure 6.1 Planned and possible transfers into the study area

a) Overview

Re-use of water is defined as the deliberate application of reclaimed water, generally treaded domestic wastewater effluent, for beneficial use. However, water re-use can also refer to the reclamation and recycling of any water, such as water applied in the irrigation and industrial sectors. Treated municipal wastewater can augment water supply to domestic users significantly if the quality thereof is adequate and implementation feasible.

There are a number of benefits as well as potential risks associated with water re-use. The following considerations affect the choices relating to implementing water re-use as an option for water supply and augmentation:

- Water quality and security of supply;
- Water treatment technologies;
- Cost relative to other supply alternatives;
- Social and cultural perceptions; and
- Environmental considerations.

There are various water re-use and reclamation processes or technologies that can be applied in WwTW. each with their associated advantages and disadvantages. The process and unit cost of treating wastewater for re-use is highly dependable on the site conditions e.g. the quality of the raw water source and the water quality of the end product required. If the feed water is of good quality, fewer and less intensive processes are required to enhance the water to a potable water standard. Treating of industrial and mining wastewater to a potable standard is generally more expensive than treating domestic wastewater. Furthermore, the treatment process will also depend on direct potable re-use or indirect potable re-use.

Should water re-use be identified as a feasible option to augment water supply to the study area, it is recommended that larger treatment plants be considered in the case of conventional treatment processes and where settlements are within close proximity of each other. A number of scattered smaller treatment plants are not recommended.

b) Current and future re-use within the study area

Re-use of treated effluent is already being applied in the mining and industrial sectors within the study area. Furthermore, a number of re-use opportunities have been identified as future augmentation options. These opportunities relate to the re-use of return flows generated and treated at mainly existing WwTW that have river discharges.

The Polokwane LM already recycles effluent water through an innovative artificial recharge scheme. Currently treated effluent is transferred from the Mokopane WwTW (2.7 million m^3/a or 7.5 Mℓ/d) and Polokwane WwTW (7.7 million m^3/a or 21 Mℓ/d) to the Anglo Platinum Mogalakwena Mine near Mokopane in the Mogalakwena catchment. The transfer from Polokwane WwTW has, however, been discontinued due to insufficient effluent quality.

The Marapong WwTW in the Mokolo catchment, near Lephalale, has been upgraded to a 16 Mℓ/d plant with the aim to supply treated effluent to the Boikarabelo Mine and Power Station, located next to the Limpopo River in the Matlabas catchment. This scheme is referred to as the MBET scheme. Approximately 5.84 million m^3/a can be supplied to meet the full requirements for the power station and mine. The pipeline has already been constructed and supply can commence as soon as the power station is completed.

The return flows in the Polokwane LM area is expected to increase from the current 31 million m^3/a (85 Mℓ/d) to 40 million m^3/a (110 Mℓ/d) by 2024 and 51 million m^3/a (140 Mℓ/d) by 2044 (DWS, 2014a). To accommodate these additional return flows, the development of the Polokwane Regional WwTW (PRWwTW) has recently commenced to serve gravity sewerage generation areas within the Polokwane LM. The facility is located at the confluence of the Sand and Deep rivers at Zandriviers Poort, approximately 28 km North-East of Polokwane. The three existing WwTW in the Polokwane LM will not be decommissioned once the PRWwTW is in operation. Excess sewerage flows from these three existing WwTW will in future be conveyed to the new PRWwTW. The new PRWwTW will only treat domestic effluent and wastewater, industrial effluent and wastewater will continue to be treated by the Polokwane Pasveer WwTW. With the implementation of the PRWwTW (20 Mℓ/d of additional wastewater treatment capacity by 2020 and 100 Mℓ/d by 2044), the following additional amount of treated effluent can be re-used:

- An additional amount of 4.7 million m^3/a (13 Mℓ/d) of treated effluent can be re-used in the Polokwane LM area by 2020 and 12.7 million m^3/a (35 Mℓ/d) by 2040 (DWS, 2014a);
- Approximately 2.2 million m^3/a (6 Mℓ/d) of treated effluent can be transferred to the Mogalakwena LM by 2020 and 8.8 million m^3/a (24 Mℓ/d) by 2040, additional to the current transfer to the Mogalakwena Platinum Mine; and
- Approximately 2.1 million m^3/a (5.8 Mℓ/d) of treated effluent can be transferred to the Lebowakgomo area (outside of the study area) by 2020 and 2.7 million m^3/a (7.3 Mℓ/d) by 2040.

The Louis Trichardt WwTW has also been recently upgraded. It was identified that 1.3 million m^3/a (3.6 Mℓ/d) of treated effluent can be re-used by 2015, 1.45 million m^3/a (4 Mℓ/d) by 2020, 1.6 million m^3/a (4.3 Mℓ/d) by 2025 and 1.7 million m^3/a (4.7 Mℓ/d) by 2030. At the time of completing this report there was no indication who the intended user will be and how it will be transported (DWS, 2015b).

During liaisons with representatives from LEIP it was also indicated that the industry will re-use some of the treated effluent from the Musina WwTW as well as of their own. The planned total effluent to be re-used is 4.68 million m^3/a.

Other than the re-use opportunities already identified, little scope for further opportunities exist due to the following reasons:

- WwTW are mainly small or medium sized facilities;
- WwTW are located in rural areas, and re-use is more beneficial in denser populated areas;
- The advanced treatment processes that would have to be incorporated into existing WwTW to enable re-use are expensive with regard to construction and operation costs; and
- Re-use of treated effluent for domestic purposes are not well received by communities.

6.3.4 New dams and the raising of existing dams

The construction of new dams can increase the yield of an area significantly. However, the construction of new dams is not considered a feasible option in the study area due to the flat nature of the terrain and the relatively low runoff in most regions. Possible dam sites have been identified in previous studies, but have not been pursued further. These include:

- Groenvley Dam, North West of Mokopane;
- Dam on the Mutamba River (Nzhelele catchment) to supply CoAL mining operations;
- Wylliespoort Dam (Nzhelele catchment); and
- Tshipise Dam (Nzhelele catchment).

If conditions permit, dams can be raised to increase the yield. Raising of the following dams have been considered as part of this Study:

- Mokolo Dam – The raising of the dam was investigated in the *Updating the Hydrology and Yield Analysis in the Mokolo River Catchment Study* (DWAF, 2007). Results showed that if the dam is raised by 12 m the additional yield will be 17 million m^3/a and if raised by 15 m, 22 million m^3/a. Raising the dam however, was omitted due to technical issues and significantly high relative cost.
- Glen Alpine Dam – Raising the dam has been considered, but no yield analysis or cost estimates were conducted as part of this study. It is proposed that the losses from the dam, due to unregulated downstream releases and lack of proper conveyance infrastructure, be reduced before further investigating the possible raising of the dam.
- Nzhelele Dam – Raising of the dam has been considered as part of the *Nzhelele Valley Bulk Water Supply Scheme* but no yield analysis or cost estimated were conducted as part of this study. This should be further investigated. Of note is that the storage capacity of the dam has been reduced by sediment, resulting in a lower yield than initially expected.

- Mutshadzi Dam – Raising of the dam has been considered as part of the *Nzhelele Valley Bulk Water Supply Scheme* but no yield analysis or cost estimated were conducted as part of this Study. The aforementioned study indicated that approximately 10 million m^3/a can be obtained from raising the dam, however, considering the current storage capacity and yield available from the Mutshedzi Dam, it is highly unlikely that 10 million m^3/a will be additionally available if the dam is raised.

Eco-Industrial Solutions (Pty) Ltd (EIS) has proposed off-channel storage dams to supply approximately 18 million m^3/a of the LEIP water requirements by 2022. It was proposed that 20 to 23 million m^3/a is abstracted from the Limpopo River via an infiltration gallery system and pumped to two off-channel storage dams with a combined capacity of 17 million m^3. Water will be abstracted from the river at an average rate of 3 m^3/s over a three month period when the maximum flow occurs in the river (December to February). From the off-channel storage dams, water will be stored in a concrete reservoir and be supplied to the various plants as needed.

Liaison with EIS took place at the end of this Study, and no further investigations on the matter were conducted. It is, however, recommended that a yield analysis of the off-channel storage dam be conducted to determine the optimum storage capacity and river abstraction rate. Furthermore, due to the close proximity of the LEIP, other SEZ developments and Musina town, it is proposed that a holistic approach is followed when identifying possible water resources. Considering the limited existing water resources, limited potential development options, and other financial and institutional processes and regulations to be followed, it is likely that the LEIP, other SEZ developments and Musina town will need to conjunctively develop, operate and maintain additional resources.

Since water is abstracted from the Limpopo River, an internationally shared water resource, international obligations will have to be met and the development can pose a number of international and social challenges

6.3.5 System operating rules

The development of system operating rules is used in long-term planning to maintain a water balance in the system and minimise the risk of the impact of a drought event to an acceptable level. As described in the *Yield Analysis (WRYM) Report (P WMA 01/000/00/02914/7)*, the system operating rules adopted for this Study are similar to the operating rules used for the Mokolo River system (DWAF, 2007). As a rule, no defined system operating rule exists for the dams and other abstractions and they are operated by experience, water availability and practicality. Drought operating rules have been investigated for the following dams as part of the *Drought Operating Rules for Stand Alone Dams/Schemes Typical for Rural/Small Municipal Water Supplies – Northern Cluster* (DWA, 2012).

However, operating rules were implemented in the WRYM configuration of the representative river catchment systems by means of the WRYM penalty structure mechanism. Penalties are dimensionless values assigned by the system analyst and are used by the WRYM as a basis for determining appropriate flow routing solutions. Refer to *Yield Analysis (WRYM) Report (P WMA 01/000/00/02914/7)* for more detail on the specific setup of each catchment's system.

The implementation of operating rules for existing catchments should be reviewed as part of the next (implementation) phase of this Reconciliation Strategy. This should be done to ascertain whether the current operating rules are efficient in ensuring optimal supply and usage of the available water.

6.3.6 Rainfall enhancement

Cloud seeding was found to benefit the yield of farm dams but not the runoff to the Vaal catchment, when practiced in the Bethlehem area of the southern Free State. The programme has since been moved to the escarpment areas of the Eastern Cape, where some measure of success was experienced in increasing the rainfall over commercial tree plantations. (Eales, et. al, 1996).

Such a programme could possibly be replicated for the study area, however, the low annual rainfall in the area must be kept in mind. Furthermore, the possible benefits and costs would need to be properly investigated. This would require a pilot project to assess the benefits and costs.

For the purpose of this strategy this option was not further explored or considered as a result of the possible negative social and environmental impacts that were pointed out.

6.3.7 Rainwater harvesting (RWH)

An underutilized method of water conservation is rainwater harvesting. The term "rainwater harvesting (RWH)" is usually taken to mean the immediate collection of rainwater running of surfaces upon which it has fallen directly. This definition excludes runoff from land watersheds into rivers, lakes and other water bodies.

Rainwater that has fallen on the roofs of household and industrial buildings can be collected in guttering placed around the eaves of the building. The guttering then drains to a down-pipe which discharges into a storage tank. The water collected, after going through the necessary quality checks/treatments, can be used to supplements household, mining or industrial water requirements.

As with all other water storage and supply systems, RWH systems have their advantages and disadvantages. Reported in **Table 6.4** is a brief comparison of advantages and disadvantages associated with RWH systems.

Table 6.4 Advantages and disadvantages of rainwater harvesting

Advantages	Disadvantages
Simple construction: Construction of RWH systems is simple and local people can easily be trained to build these themselves. This reduces costs and encourages more participation, ownership and sustainability at community level.	***High investment cost***: The cost of RWH systems is almost fully incurred during initial construction. Costs can be reduced by simple construction and the use of local materials
Good maintenance: Operation and maintenance of a household system is solely by the tank owner. As such, this is a good alternative to poor maintenance and monitoring of a centralised piped water supply.	***Usage and maintenance***: Proper operation and regular maintenance is a very important factor that is often neglected. Regular inspection, cleaning and occasional repairs are essential for the success of the system.
Relatively good water quality: Rainwater is better than other available or traditional sources (groundwater may be unusable due to fluoride, salinity or arsenic).	***Water quality is vulnerable***: Rainwater quality may be affected by air pollution, animal or bird droppings, insects, dirt and organic matter.
Low environmental impact: Rainwater is a renewable resources and no damage is done to the environment.	***Supply is sensitive to droughts***: Occurrence of long dry spells and droughts can cause water supply problems.
Convenience: It provides water at the point of consumption	***Limited supply***: The supply is limited by the amount of rainfall and the size of the catchment area and storage.
Not affected by local geology or topography: Rainwater collection always provides an alternative whenever rain falls.	
Flexibility and adaptability of systems to suit local circumstances and budgets, including the increased availability of low cost tanks.	

Due to the erratic nature of water availability from RWH systems, this is not the best solution for primary water supply system for industrial activities. However if implemented and maintained adequately, can be used to supplement water requirements. This will not only reduce strain on water resources but could also save users money in the long run.

This intervention option will have to be further investigated in more detail at a local level. It is recommended that this be further addressed, e.g. as part of the ongoing *All Towns Reconciliation Strategies*.

6.3.8 Removal of invasive alien plants

The reduction in runoff due to the prevalence of invasive alien plants (IAP) in the study area is 6.9 million m³/a, of which the majority occurs in the Mogalakwena and Nzhelele catchments as summarised in **Table 2.5**. However, if cleared, the increase in annual runoff may not directly translate into available yield. The available additional runoff must either be abstracted or impounded in a water body. Furthermore, the increase in utilisable yield when implementing the removal of IAP is not viewed as significant when compared to other intervention options and therefore is disregarded from any further evaluation for the purpose of this study.

6.3.9 Desalination of sea water

Considering the location of the study area, and the current cost of electricity, as well as the unsustainability thereof, the option of desalination of sea water and pumping it to the study area has not been considered independently in this Study.

6.4 CONSIDERATIONS FOR SELECTING THE MOST APPROPRIATE RECONCILIATION OPTIONS

6.4.1 Basis for water reconciliation

The following aspects were taken into account and formed the basis for water reconciliation:

- South Africa will meet its international obligations;
- All unlawful water use will be eliminated;
- WCWDM actions must be implemented in all water use sector as applicable;
- Water for strategic users for the benefit of the country must receive priority before any other economic development;
- Water for socio-economic development within the policy parameters of the government will be provided;
- There will be no increase in forestry areas; and
- There will be no increase in total water allocations for irrigation.

Other aspects that should be considered in the continuation and implementation phase of the Strategy include:

- The water for basic human needs will be supplied.
- The Reserve is a priority; environmental water requirements to meet the REC will be maintained.

6.4.2 International obligations

The study area forms part of the Limpopo River Basin and shares the Limpopo River as an international boundary with Botswana and Zimbabwe. The *International Obligations Report (P WMA 01/000/00/02914/12)*, as part of this Study, deals with each of the international treaties and policy documents that impact on water allocation out of the shared Limpopo River Watercourse, with specific focus on the Limpopo WMA North area.

The following legislation, treaties and policy documents have a bearing on international obligations regarding water allocations out of the shared Limpopo River Watercourse:

- Constitution of the Republic of South Africa, 1996.
- National Water Act, Act 36 of 1998.
- Convention on the Law of the Non-navigational Uses of International Watercourses Adopted by the General Assembly of the UN on 21 May 1997.
- The Law on Transboundary Aquifers (UN Resolution 11 December 2008).
- Convention on wetlands of international importance especially as waterfowl habitat (The Ramsar Convention on Wetlands), 1971 as amended 1982 and 1987.

- SADC Revised Protocol on Shared Water Courses, 7 August 2000.
- SADC Regional Water Policy 2005.
- Stockholm Convention on Persistent Organic Pollutants.
- Agreement between the Republic of Botswana, the Republic of Mozambique, the Republic of South Africa and the Republic of Zimbabwe on the Establishment of the Limpopo Water Course Commission (LIMCOM) of 27 November 2003.
- Limpopo Basin Permanent Technical Committee (LBPTC) *Joint Limpopo River Basin Study Scoping Phase*.

The character of these legislation, treaties and policy documents promotes *inter alia* the sustainable, equitable and reasonable utilisation of shared watercourse systems and avoiding causing any negative impact to the neighbouring state. There are specific provisions in terms of which State Parties shall exchange information and consult each other and, if necessary, negotiate the possible effects of planned measures on the condition of a shared watercourse.

Specific to the study area, the LIMCOM agreement advises member countries on the following matters:

- Measures and arrangements to determine the long-term safe yield of the water available from the Limpopo River;
- The equitable and reasonable utilisation of the Limpopo River to support sustainable development in the territory of each member country and the harmonisation of the policies related thereto;
- The extent to which the inhabitants in the territory of each of the member countries concerned shall participate in the planning, utilisation, sustainable development, protection and conservation of the Limpopo River and the possible impact on social and cultural heritage matters;
- All aspects related to the efficient and effective collection, processing and dissemination of data and information with regard to the Limpopo River;
- Contingency plans and measures for preventing and responding to harmful conditions whether resulting from natural causes such as drought or human conduct as well as emergency situations that result suddenly from natural causes such as floods or human conduct such as industrial accidents,
- The investigations and studies, separately or jointly by the member countries with regard to the development of the Limpopo River including the construction, operation or maintenance of any water works;
- Measures with a view to arriving at a settlement of a dispute between two or more of the member countries; and
- Any other matters affecting the implementation of the Protocol.

Furthermore, the *Joint Limpopo River Basin Study Scoping Phase*, initiated by the LBPTC, was conducted to quantify the present and future water balance in the Limpopo River basin in each of the four co-basin states, and to plan future water resource development and management options so as to meet the future water requirements in an optimal, sustainable and equitable way. The study made an estimate of the current water requirements and made a number of recommendations for further work. However, it does not go as far as to make recommendations on a future water allocation amongst the basin states.

6.4.3 Environmental screening of options

Several wildlife and nature conservation areas have been proclaimed in the study area, of which the Nylsvley Nature Reserve, Mapungubwe National Park and the Marekele National Park are probably the best known. The Wilderness area, situated in the middle reaches of the Lephalala catchment, is of high conservation importance. The relatively undeveloped river and tributaries inhabits several flow and pool dependant species, including red data species such as the short fin barb.

Nylsvlei in the south-east of the Mogalakwena catchment is the country's largest ephemeral floodplain and has been declared a RAMSAR wetland site because of its international conservation importance and birdlife.

There are a number of important wetland areas in the Sand catchment which inhabit rare or endangered frog species and plant and red data bird species. Numerous flow dependant species including red data species inhabits the upper reaches of the Nzhelele River. The endangered snake catfish occurs in the Nwanedi River.

The environmental screening focused on the possible schemes considered in the strategy and aimed to:

- Summarise any key environmental or social issues that should be taken in account when considering and comparing options;
- Identify any environmental or social "fatal flaws" or "red flags associated with any of the projects; and
- Identify environmental authorisations that will be required for any of the new projects.

The assessment was based on available documented information, and no site visits, field work or additional data collection were undertaken to verify or update the available information. Implementation of the Reserve (surface water, groundwater and water quality aspects) during construction and operational phases is assumed to be a condition of any proposed scheme. It is assumed that this will ensure that the aquatic ecology and requirements for BHN are adequately provided for and protected.

The construction of bulk water supply infrastructure requires the environmental authorisation impact assessment process that includes a public participation process. This process has been conducted and completed for the bulk water supply major infrastructure developments such as MCWAP, ORWRDP, Nandoni Dam transfer pipelines and the MBET pipeline.

Potential impacts on adjacent groundwater using landowners, surface flow and riverine ecology and groundwater dependent ecosystems could potentially be affected by groundwater development if it is not implemented sustainably. Before any additional groundwater developments are implemented, the required impact assessments should be carried out and mitigation measures, if needed, should be recommended and monitored. It is recommended that groundwater in stressed aquifers must be managed and regulated better to minimise the impact.

Any water transfers into the study area will impact on the receiving streams due to an increase in their flow and loss of natural variability with consequent ecological affects. Organisms from the donor catchment will inevitably be transferred with the water.

Not all effluent generated by a WwTW will be transferred for re-use purposes as some will be required to recharge groundwater contribute to downstream streamflow. All effluent at the WwTW, however, will be treated to comply with the water quality targets as set by the downstream user. These water quality targets are normally relatively high and may result in the surplus effluent discharged in to other water bodies to be of better quality. Implementing re-use will also motivate better and more frequent monitoring. Major industrial or mining effluent users can collaborate with municipalities to upgrade, operate and maintain the producing WwTW, such as with the Boikarabelo Mine and Power Station and the Marapong WwTW (Lephalale LM).

The possible abstraction from the Limpopo River (for three months per year during the high flow season) to full the proposed off-chancel storage dams of the LEIP should be further investigated in terms of the impact on the streamflow and downstream users.

7 RECONCILING THE WATER REQUIREMENTS WITH THE WATER RESOURCE

7.1 INTRODUCTION

Based in the information provided in **Section 5** and **Section 6**, water balances for each catchment and some of the economic focus areas have been developed to illustrate the balance between the current and future water requirements and the proposed intervention options.

The following section provides a description of the proposed intervention options to be implemented as well as the associated water balances.

7.2 WATER BALANCE GRAPHS

7.2.1 Matlabas catchment

The majority of the 2010-development level water requirements are met by the local surface water and groundwater resources. The planned mining developments in the Steenbokpan area form part of the developments that will be supplied by the MCWAP-2A and was thus excluded from the Matlabas catchment water balances.

The Boikarabelo Mine and Power Station will be supplied by groundwater during construction and by the MBET during operation. Resource Generation Limited has a water use licence to abstract up to 2.1 million m^3/a from the boreholes located on the mine and power station property. However, approximately only 0.3 to 0.5 million m^3/a will be abstracted during construction and operation. The MBET entails the transfer of treated effluent from the Marapong WwTW to the mine and power station to meet the both the medium and long term Phase II water requirements. Resource Generation Limited has agreed with the Lephalale LM to upgrade the existing Marapong WwTW from 4 to 16 Mℓ/d, as well as to operate, maintain and provide the financing for the WwTW. The pipeline has already been constructed and supply can commence as soon as the power station is completed.

The Glenover Phosphate Mine and any additional future domestic water requirements, not associated with the Boikarabelo developments, can be supplied from the under-exploited groundwater resources. The additional domestic and Glenover Mine water requirements are not included in this phase of the Reconciliation Strategy, but should be included in the subsequent phases.

WCWDM has not been considered for this catchment since domestic requirements are minimal and the planned mining and power station developments are incorporating the latest water saving technologies.

A summary of the considered intervention options is included in **Table 7.1**. The water balance for the Matlabas catchment is shown in **Figure 7.1**.

Table 7.1 Summary of Matlabas catchment intervention options

Intervention option	Supply area	Volume (million m^3/a)	Implementation time
Approved / definite intervention options			
MBET*	• Boikarabelo Coal Mine and Power Station	5.8	2018
Groundwater development	• Boikarabelo Coal Mine and Power Station	0.2 to 0.5	2012
Other possible intervention options			
Groundwater development	• Glenover Mine • Domestic water requirements	To be further investigated in continuation and implementation phase.	
WCWDM	Not considered to have an impact – very little domestic water requirements and new industrial operations will incorporate efficient water use.		

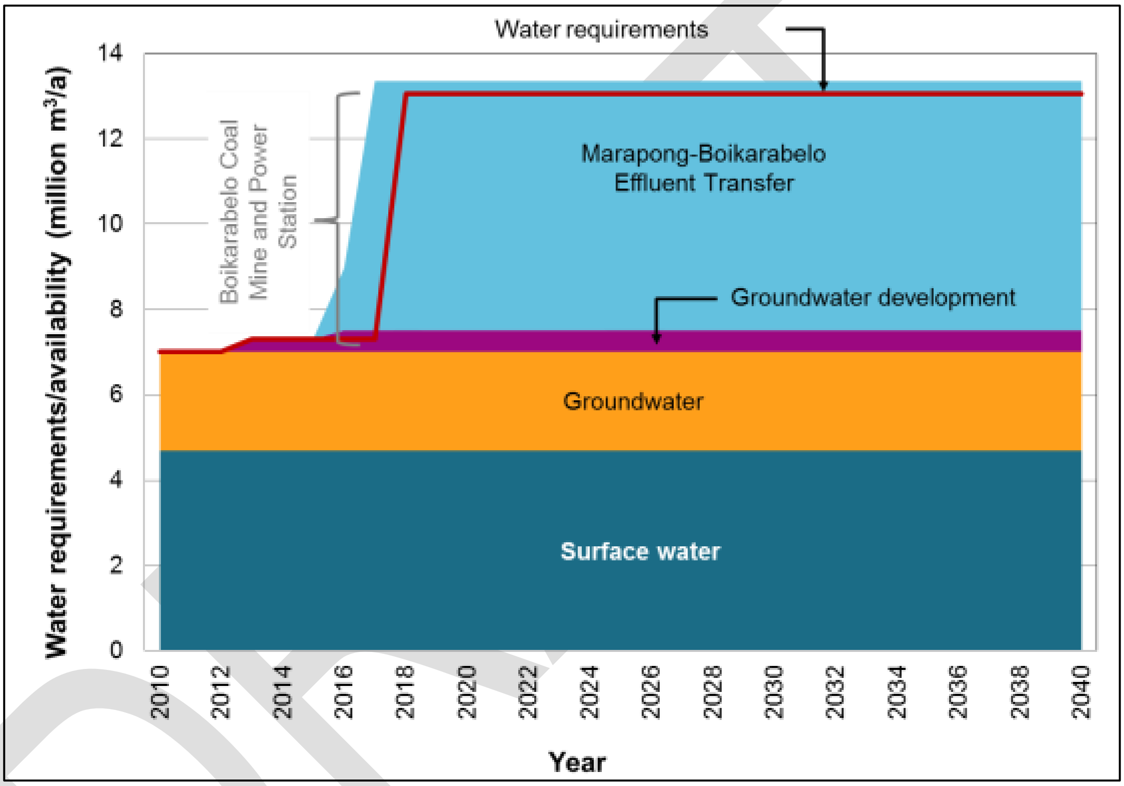

Figure 7.1 Water balance for the Matlabas catchment

7.2.2 Mokolo catchment

The majority of the 2010-development level water requirements are met by the local surface water and groundwater resources.

Due to the extensive developments planned in the vicinity of Lephalale, the Mokolo catchment has formed the basis of a number of water resources studies. Intervention options previously identified include the raising of the Mokolo Dam, groundwater development and transfers from adjacent WMAs. The MCWAP was identified as the preferred option and construction of the first phase has recently been completed (refer to Section 6.3.2a) for more information on MCWAP).

Since the new mining and power generation developments plan to incorporate the latest water saving technologies, no WCWDM measures were considered for mining and industrial sectors. Furthermore, water savings by the irrigation sector were considered to be used for the expansion of irrigated areas. WCWDM were thus considered only applicable to the limited domestic water requirements.

A summary of the considered intervention options is included in **Table 7.2**. Text indicated in grey is intervention options that are unlikely to be implemented or that have not been considered in the water balances of this phase of the Reconciliation Strategy.

Table 7.2 Summary of Mokolo catchment intervention options

Intervention option	Supply area	Volume (million m^3/a)	Implementation time
Planned/approved definite intervention options			
MCWAP-1	• Medupi Power Station • Steenbokpan coal mines • Domestic (Lephalale and Steenbokpan)	13	2016 Additional supply from Mokolo Dam, Mokolo Dam to be operated at high risk until MCWAP-2A
MCWAP-2A		75 - 100	2021 Transfer from Crocodile (West)
Other possible intervention options			
WCWDM	• Domestic	0.6	Phased in over 5-10 years
Eliminating unlawful use & compulsory licensing	• Irrigation	± 2	3-4 years
Groundwater development	• Domestic water requirements	To be further investigated when necessary.	
Raising Mokolo Dam	• Lephalale and environs	Raise 12 m: 17 Raise 15 m: 22	Technical and costs issues

Figure 7.2 shows the Mokolo catchment water balance if Mokolo Dam is operated at a high risk (according to the new water allocations) until MCWAP-2A is commissioned. Therefore, the water balance shows the additional yield available from Mokolo Dam, as part of MCWAP-1, to reduce after the commissioning of MCWAP-2A. This does not imply that the parallel pipeline will not be used but simply that the dam will return to be operated at a higher assurance of supply.

Alternatively, if the Mokolo Dam is continued to be operated at a higher risk after the commissioning of MCWAP-2A (**Figure 7.3**), approximately only 85 million m^3/a is required to meet the 2040 water requirement.

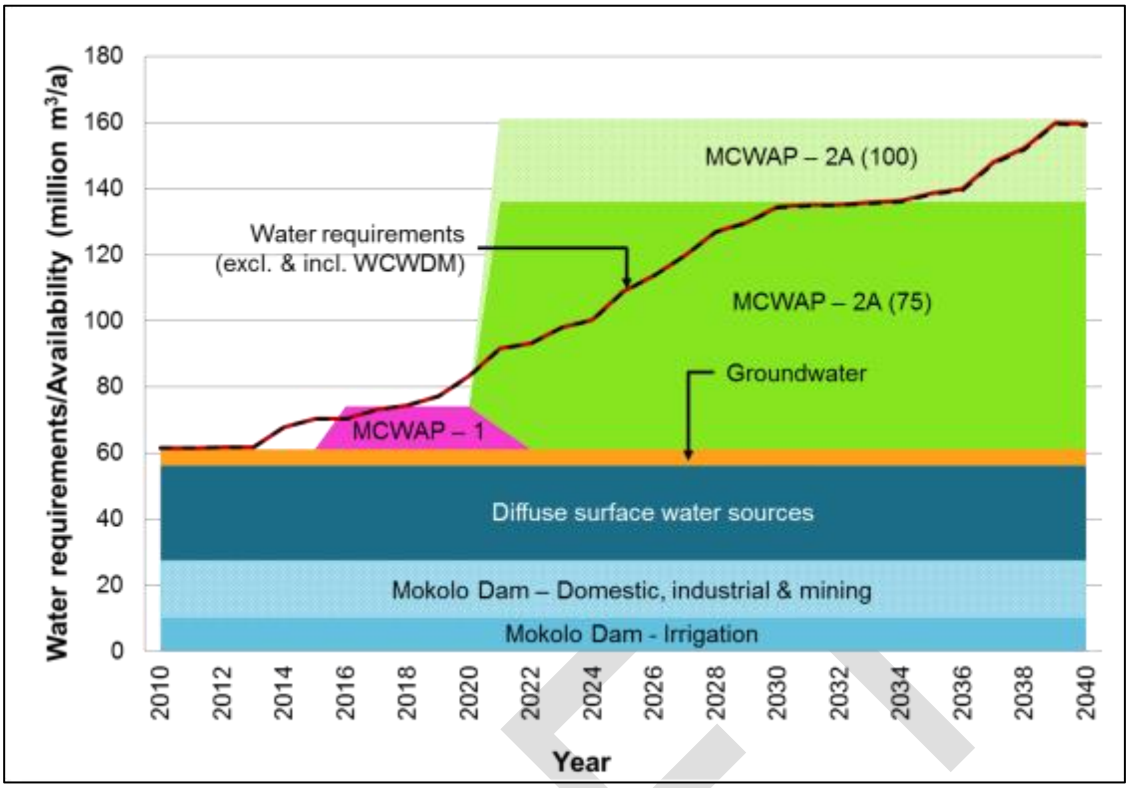

Figure 7.2 Water balance for the Mokolo catchment: Option 1

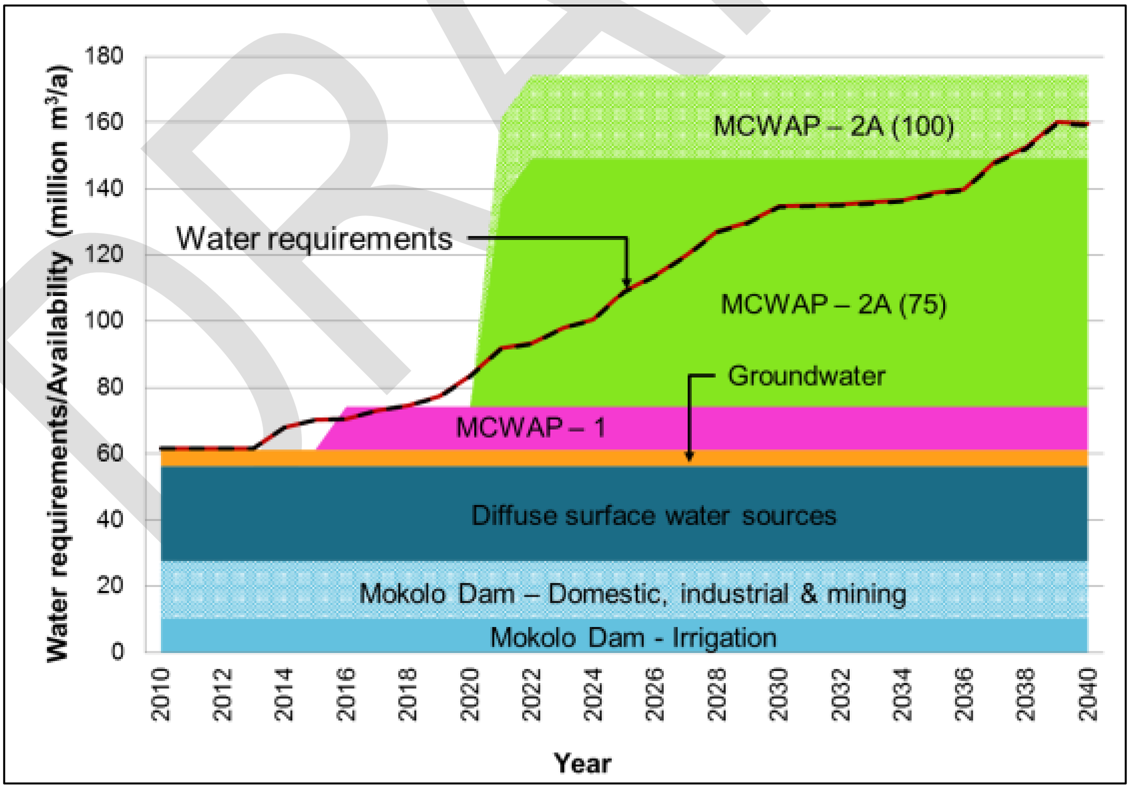

Figure 7.3 Water balance for the Mokolo catchment: Option 2

The proposed capacity of MCWAP-2A, ranging from 75 million m^3/a to 100 million m^3/a, is still under discussion and pending funding. However, for the purpose of this phase of the Reconciliation Strategy, a transfer of 100 million m^3/a for MCWAP-2A is recommended to meet the 2040 water requirements and to reduce the operating risk of Mokolo Dam.

The small domestic requirements of Mabatlane (Vaalwater) and Mabaleng (Alma), situated in the upper reaches of the catchment, are supplied from local groundwater resources. The water balances and possible required intervention options should be addressed in the ongoing local *All Towns Reconciliation Strategies*.

7.2.3 Lephalala catchment

There are no significant developments expected in the Lephalala catchment due to the limited water resources available and the high conservation importance of the Wilderness area in the middle reaches of the catchment.

The catchment is considered to be in balance. However, water shortages experienced in the area can be attributed to the significant development and utilisation of the groundwater exploitable potential (refer to **Figure 4.7** and **Figure 5.1**).

A summary of the considered intervention options is included in **Table 7.3**. Text indicated in grey is intervention options that are unlikely to be implemented or that have not been considered in this phase of the Reconciliation Strategy.

Table 7.3 Summary of Lephalala catchment intervention options

Intervention option	Supply Area	Volume (million m^3/a)	Implementation time/comment
Possible intervention options			
WCWDM	Domestic	0.3	Phased in over 5-10 years
Eliminating unlawful use & compulsory licensing	Irrigation	± 5.2	3-4 years
Groundwater development	Ga- Phahladira cluster area Ga-Seleka area	> 1.24	Groundwater seems to be almost fully utilised. To be further investigated in continuation and implementation phase.
Removal of invasive alien plants	Domestic/irrigation	< 1.2	IAPs reduce stream flow. If removed, increase in stream flow does not relate to available yield.
Increased river abstraction	Domestic	Only recommendation – To be further investigated in continuation and implementation phase.	

WCWDM in the domestic sector should be the first priority intervention option to be applied. If water losses can be reduced from 28% in 2010 to 20% by 2040, the current water availability may be sufficient to meet the 2040 domestic water requirements.

Figure 7.4 shows the effect of implementing WCWDM in the domestic sector on the domestic water requirements (irrigation and livestock water requirements, and the associated water resources are excluded).

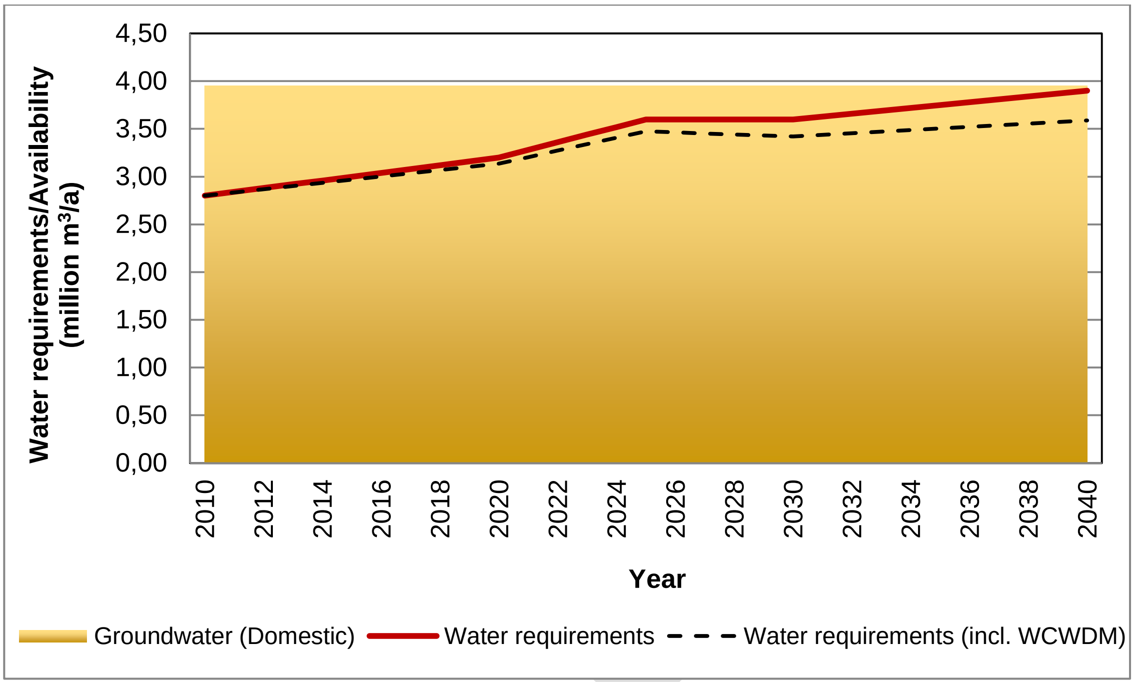

Figure 7.4 Water balance for the Lephalala catchment

Furthermore, unlawful irrigation water use is estimated at 5 million m^3/a, which will have a positive effect on the available water if eliminated. It should be noted that the water saved through eliminating unlawful use can not necessarily be supplied to the domestic sector without implementing additional infrastructure.

7.2.4 Mogalakwena catchment

The Mogalakwena catchment is the largest and most densely populated and industrialised catchment in the study area, and subsequently have significant water requirements. The overall water balance, including intervention options, for the catchment and for the Mogalakwena and Aganang LMs have been generated and investigated.

The growth in the water requirements for Modimolle and Mookgopong have been investigated extensively by Magalies Water. The growth in are planned to be met by the Magalies Water transfer from either the Klipvoor Dam or additional supply from the Roodeplaat Dam (both in the Crocodile (West) catchment).

As mentioned, major mining development is planned in the Mogalakwena and Aganang LM areas which will increase the domestic water requirements as well. The projected water requirements in these municipal areas have been extensively investigated as part of the ORWRDP. The majority of the growth in water requirements will be supplied by the ORWRDP Phase 2B and Phase 2G, which entails the transfer of water from Flag Boshielo Dam in the Olifants River catchment via a possible parallel pipeline (Phase 2B being the first pipeline and Phase 2G the second).

As with all other catchments, WCWDM is the primary intervention option and will have the largest impact on the urban domestic water requirements. If a canal or pipeline system is provided downstream of Glen Alpine Dam, approximately 0.6 million m^3/a can be saved and allocated elsewhere. Preliminary studies have shown that a lined canal is the preferred and more cost effective option.

The effluent transfer from the Polokwane WwTW to the Mogalakwena Platinum Mine has been discontinued due to the inadequate quality of the effluent. This can be attributed to the WwTW operating above its design capacity. The Polokwane LM, however, is in the process of developing the PRWwTW to treat the rapid growth in return flows. It is recommended that the effluent transfer be reinstated once the Polokwane WwTW is relieved by the PRWwTW, and can adequately treat the effluent. Provision has also been made to provide additional effluent from the PRWwTW to the Mokopane area.

The Lonim mining company has recently bought out some of the unused irrigation allocation from the Doorndraai Dam, but has not yet started to use this water.

A summary of the possible intervention options are given in **Table 7.4**. Text indicated in grey is intervention options that are unlikely to be implemented or that have not been considered in this phase of the Reconciliation Strategy.

As per **Section 5.2.4**, water balances for the entire Mogalakwena catchment and for the Mogalakwena and Aganang LMs have been generated. **Figure 7.5** shows the water balances for the entire Mogalakwena catchment with the following main interventions:

- WCWDM;
- Bought over irrigation allocation from Doorndraai Dam;
- The Magalies Water (Klipvoor Dam) transfer; and
- The ORWRDP - 2B and 2G as the main intervention options.

Only the water balance for the domestic, industrial and mining sector is shown as the water requirements and supply for irrigation and livestock watering is considered to remain constant over the study period.

From **Figure 7.5** it can be derived that the proposed intervention options will not be able to meet the 2040 water requirement. If additional effluent is transferred from Polokwane to the Mogalakwena catchment for industrial use, the 2040 water requirements can be met, refer to **Figure 7.6**. However, a significant deficit may occur from 2010 to 2021.

Table 7.4 Summary of Mogalakwena catchment intervention options

Intervention option	Supply area	Volume (million m^3/a)	Implementation time/comment
Planned/approved intervention options			
Magalies Water Transfer	• Modimolle & Mookgopong	6.6	2020 Water to be transferred from Klipvoor Dam
ORWRDP 2B and 2G	• Mokopane area (Mogalakwena LM and mines)	50	2022 Water to be transferred from Flag Boshielo Dam
Other possible intervention options			
WCWDM	• Domestic • Mining and industrial	2.7	Phased in over 5-10 years.
WCWDM	• Irrigation	0.6	Lined canal to be implemented downstream of Glen Alpine Dam
Reinstate existing Polokwane transfer	• Mining & industrial	7.7	2017 Transfer stopped due to inadequate quality
Additional Polokwane effluent transfer	• Mining & industrial	2.2 - 8.8	2020 Effluent to be transferred from upgraded WwTW
Water allocation transfer (Section 25)	• Mining & industrial	1.8	2017 Mining company bought out some unused Doorndraai Dam irrigation allocations
Eliminating unlawful use & compulsory licensing	• Irrigation	± 6	3-4 years
Additional groundwater development	• Rural domestic supply	To be further investigated in continuation and implementation phase.	
Raise Glen Alpine Dam	• Domestic	Only recommendation – To be further investigated in continuation and implementation phase.	
Crocodile West to Mokopane	• Mokopane	25	2018 - Alternative to ORWRDP – 2B and 2G.
Removal of IAP	• Domestic/irrigation	< 2.6	IAPs reduce stream flow. If removed, increase in stream flow does not relate to available yield.
Raise Donkerpoort Dam	• Domestic	Safety concerns and high costs.	
Proposed Groenvley Dam	Not viable due to unfavourable hydrological conditions.		

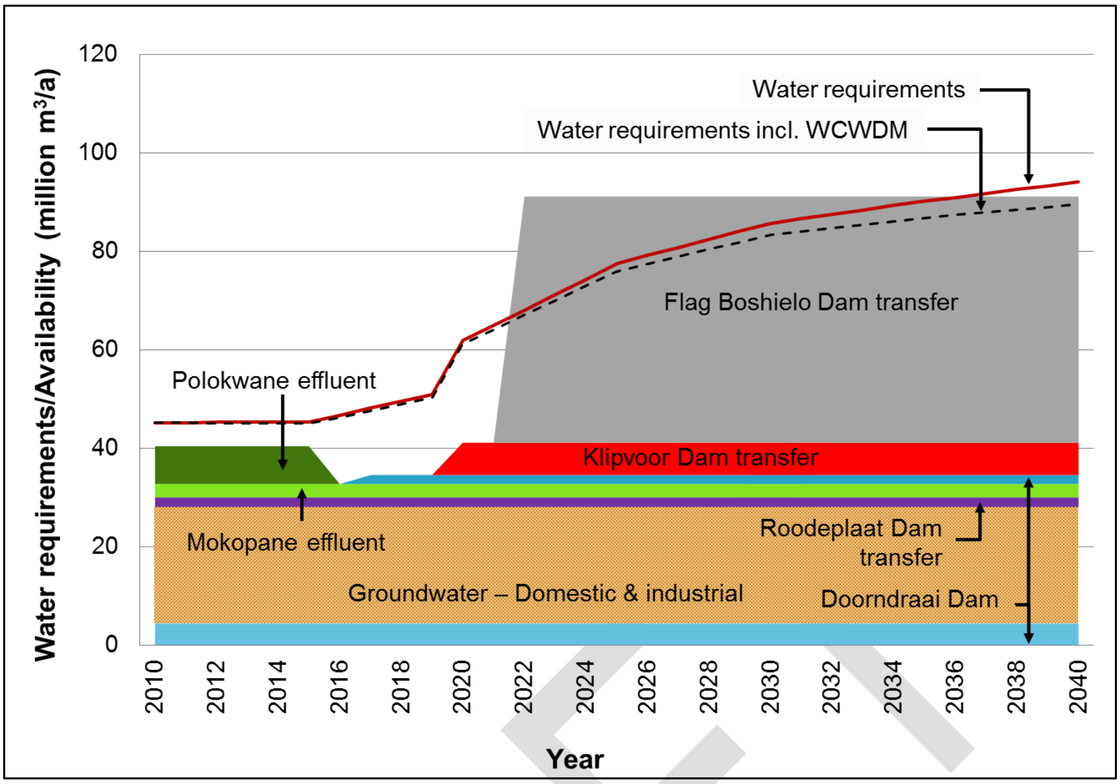

Figure 7.5 Water balance for the Mogalakwena catchment: Option 1

Note: Only domestic, mining and industrial sectors

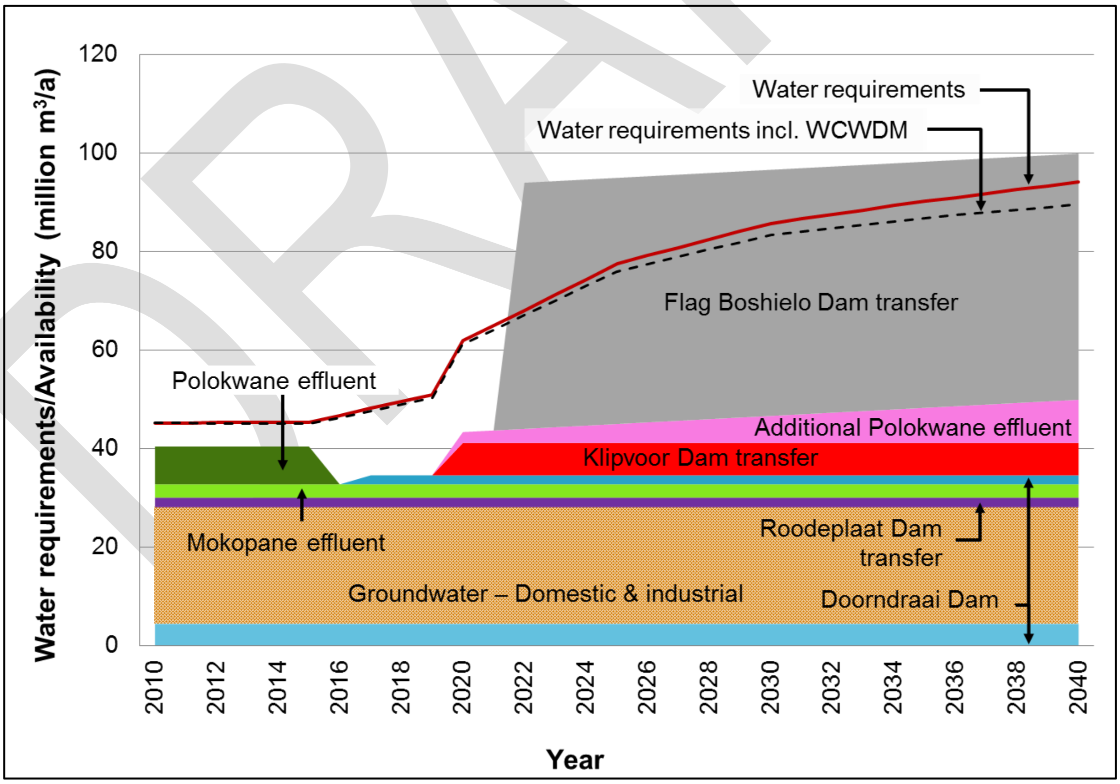

Figure 7.6 Water balance for the Mogalakwena catchment: Option 2

Note: Only domestic, mining and industrial sectors

To alleviate this deficit, new mining developments can either postpone their planned implementation time or alternatively, the current effluent transfer from Polokwane can be reinstated to supply the Mogalakwena Platinum Mine. This will free up water that can be used for domestic water requirements and subsequently reduce the deficit from 2010 to 2021. Furthermore, if the effluent transfer from Polokwane is reinstated, either the additional effluent transfer from Polokwane is not needed or the transfer from Flag Boshielo Dam can be reduced, refer to **Figure 7.7** and **Figure 7.8** respectively.

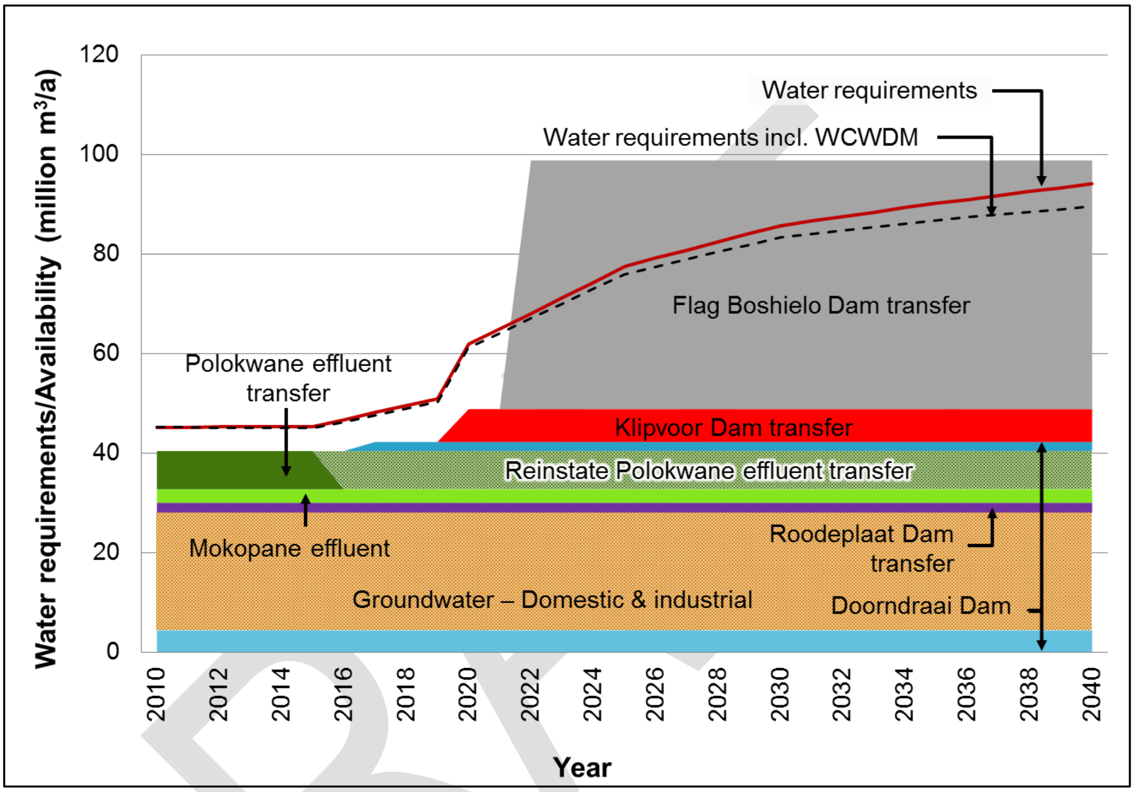

Figure 7.7 Water balance for the Mogalakwena catchment: Option 3

Note: Only domestic, mining and industrial sectors

The same proposed intervention scenarios as above apply for the Mogalakwena and Aganang LM focus area water balance, excluding the existing Roodeplaat Dam transfer and the planned Magalies Water or Klipvoor Dam transfer, refer to **Figure 7.9**, **Figure** 7.10 and **Figure** 7.11.

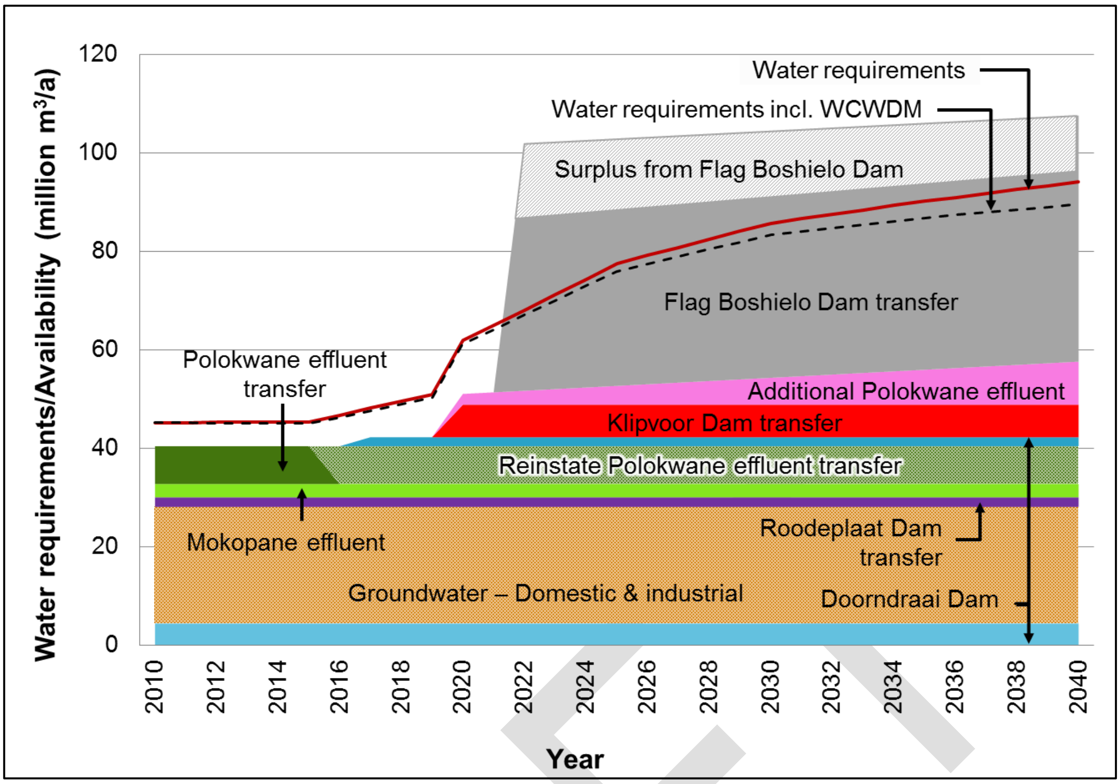

Figure 7.8 Water balance for the Mogalakwena catchment: Option 4

Note: Only domestic, mining and industrial sectors

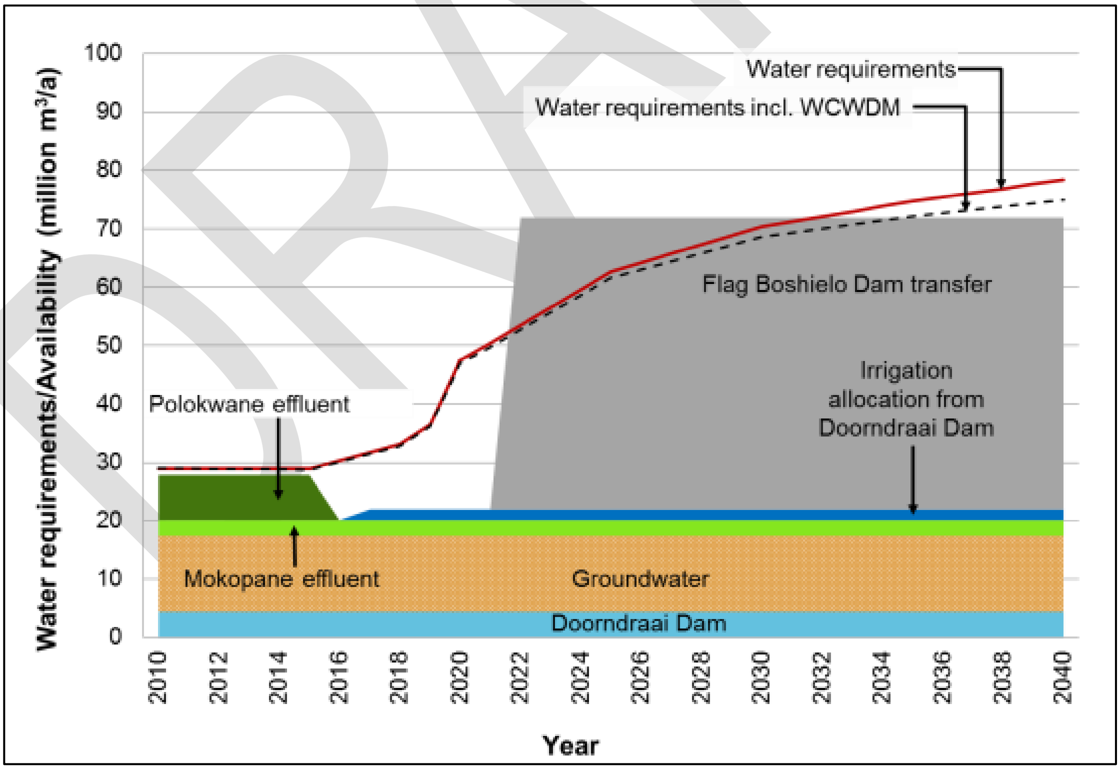

Figure 7.9 Water balance for the Mogalakwena and Aganang LM: Option 1

Note: Only domestic, mining and industrial sectors

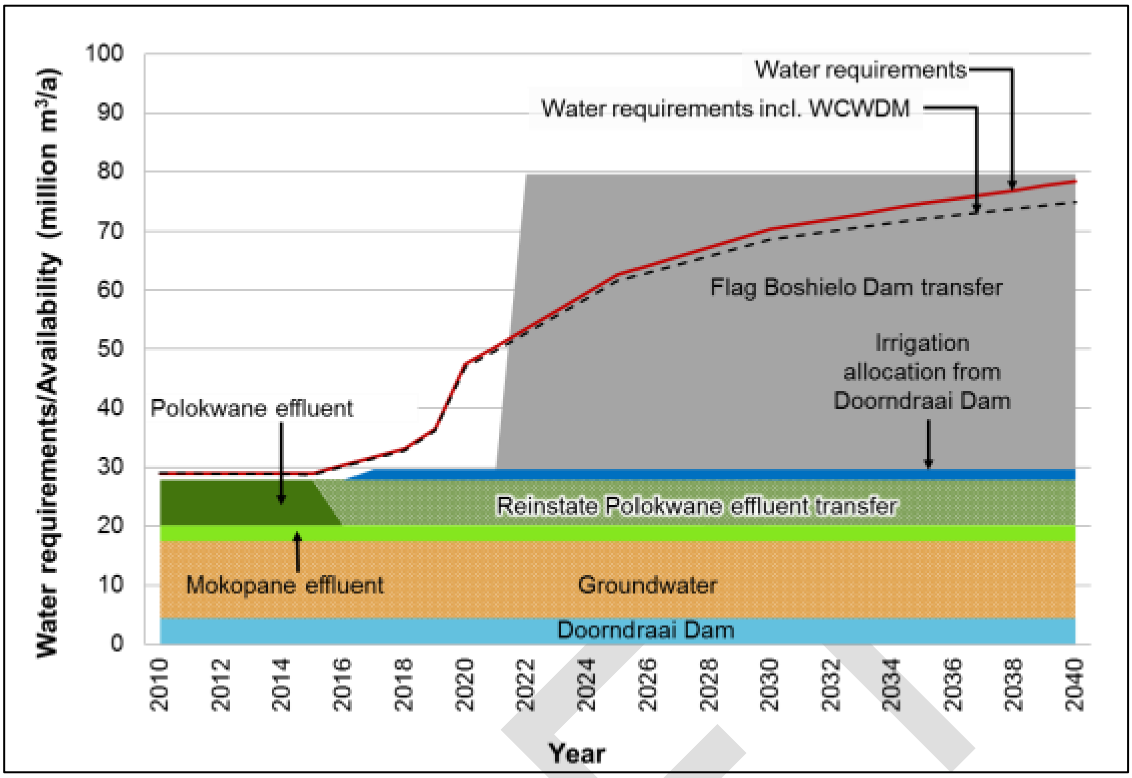

Figure 7.10 Water balance for the Mogalakwena and Aganang LM: Option 2

Note: Only domestic, mining and industrial sectors

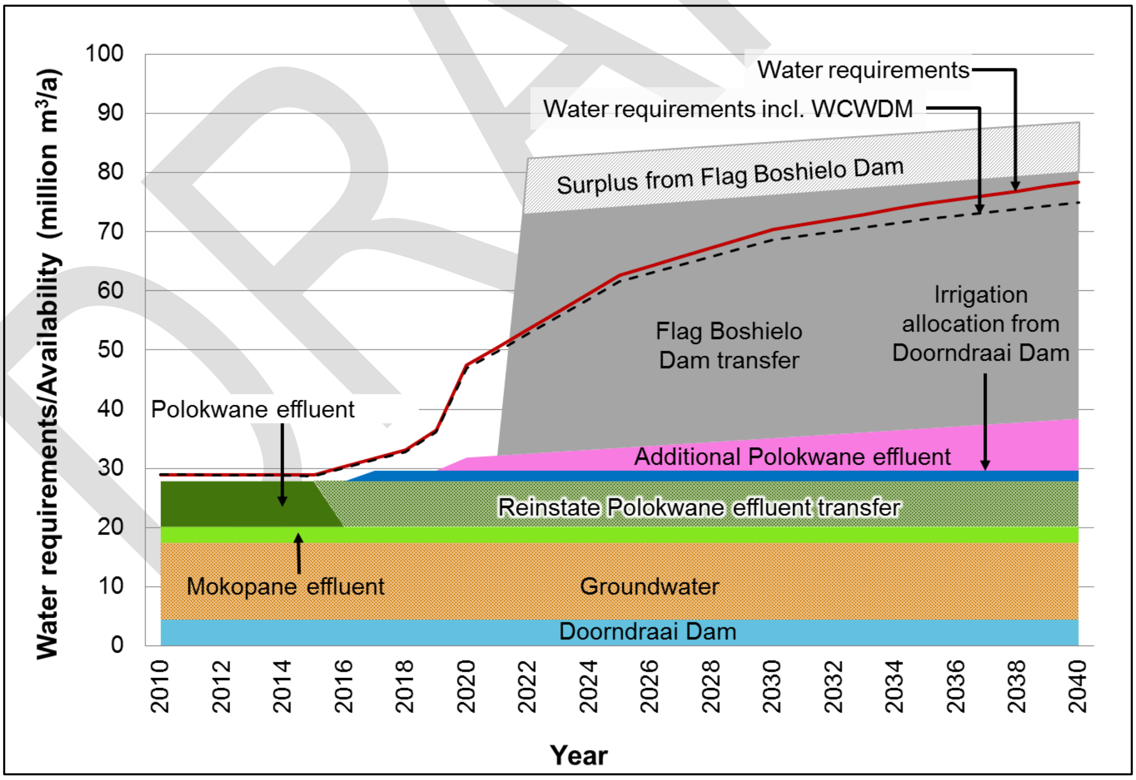

Figure 7.11 Water balance for the Mogalakwena and Aganang LM: Option 3

Note: Only domestic, mining and industrial sectors

In light of the above findings, it is recommended that the urgent action be taken to improve the effluent quality of the Polokwane WwTW to enable the reinstatement of the effluent transfer from this WwTW to the Mogalakwena Platinum Mine. If this approach is followed, the additional effluent transfer from Polokwane can be utilised in the town itself.

7.2.5 Sand catchment

a) Entire catchment

The Sand catchment has the largest current and projected future water requirements. The overall water balance for the catchment and for the following economic focus areas have been generated:

- Polokwane LM;
- Makhado LM;
- Musina LM; and
- Other areas such as Matoks and Molemole West Supply Area.

A summary of the possible intervention options are given in **Table 7.5**. Text indicated in grey is intervention options that are unlikely to be implemented or that have not been considered in this phase of the Reconciliation Strategy.

Table 7.5 Summary of Sand catchment intervention options

Intervention option	Supply area	Volume (million m^3/a)	Implementation time/comment
Planned/approved intervention options			
Nandoni Dam to Makhado LM transfer	• Louis Trichardt • Sinthimule/Kutama	5.5 to 8.5	2016/2017
Nandoni Dam to Matoks transfer	• Matoks	4.8 to 5.5	2019/2020
Glen Alpine Dam transfer	• Mogwadi (Molemole West supply area)	1.56	2020 1.6 sourced from unused irrigation allocation, 0.6 sourced from water savings.
PRWwTW effluent re-use	• Polokwane Industrial/domestic	± 13	2020 Treated effluent available from the new PRWwTW.
Rehabilitation and development of groundwater	• Polokwane	7.9	2018 Boreholes in the area can be refurbished
Other possible intervention options			
WCWDM	• Domestic	6.2	Phased in over 5-10 years Mining WCWDM considered to be insignificant (not applicable to new mines).
Eliminating unlawful use & compulsory licensing	• Irrigation	± 7	3-4 years
Louis Trichardt	• Louis Trichardt	1.7	2016

effluent re-use			
LEIP off-channel dam	• Musina LEIP	15-18	2019 Off-channel storage dam to be filled with water abstracted from the Limpopo River
LEIP re-use	• Musina LEIP	5	Includes re-use within industries and the Musina WwTW
Zhove Dam (Zimbabwe) transfer	• Musina SEZ & LEIP	< 30	2025 Significant international relations required & long lead time
Groundwater development	Groundwater resources over-exploited in most of catchment. Further development for irrigation not encouraged, but some WSS might have potential that should be further investigated on a local scale.		
Removal of IAP	• Domestic/irrigation	< 1.0	IAPs reduce stream flow. If removed, increase in stream flow does not relate to available yield.
Mutamba Dam	• CoAL	Long lead time, hydrological conditions not favourable.	

Figure 7.12 shows the proposed water balance for the entire Sand catchment and all water use sectors. Overall, it seems that the water requirements of the catchment can be met.

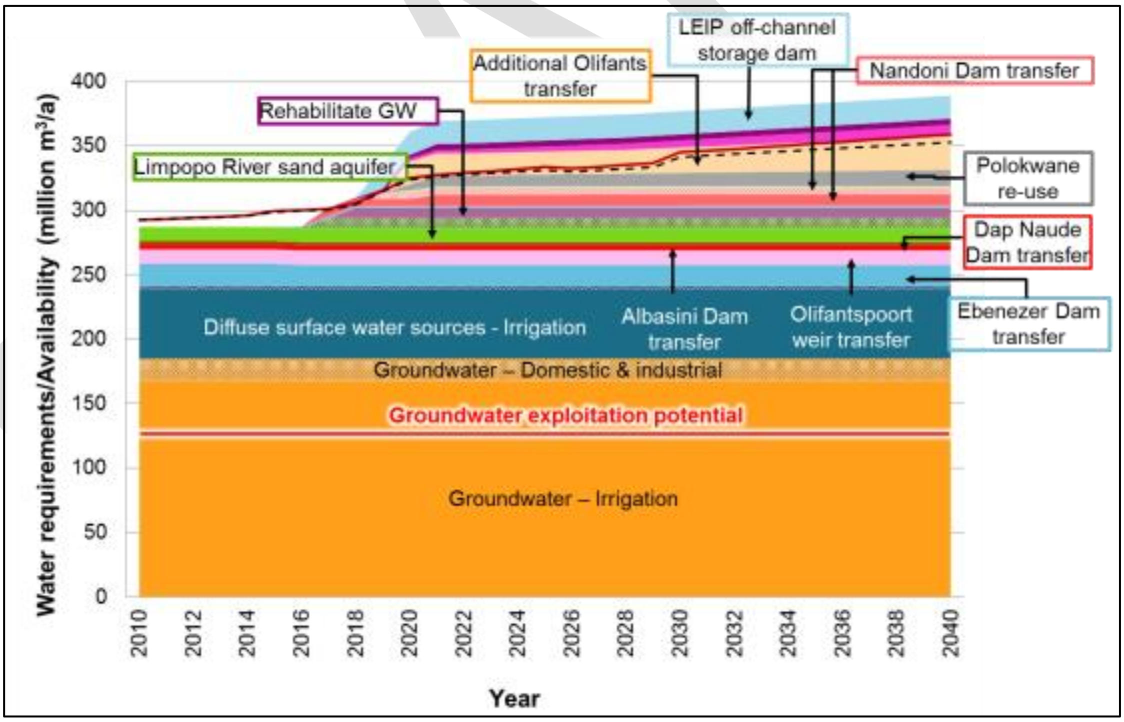

Figure 7.12 Water balance for the Sand catchment

Figure 7.13 and **Figure 7.14** show the water balances for only the domestic, industrial and mining sectors without and with the future Mokopane effluent transfer from Polokwane, respectively.

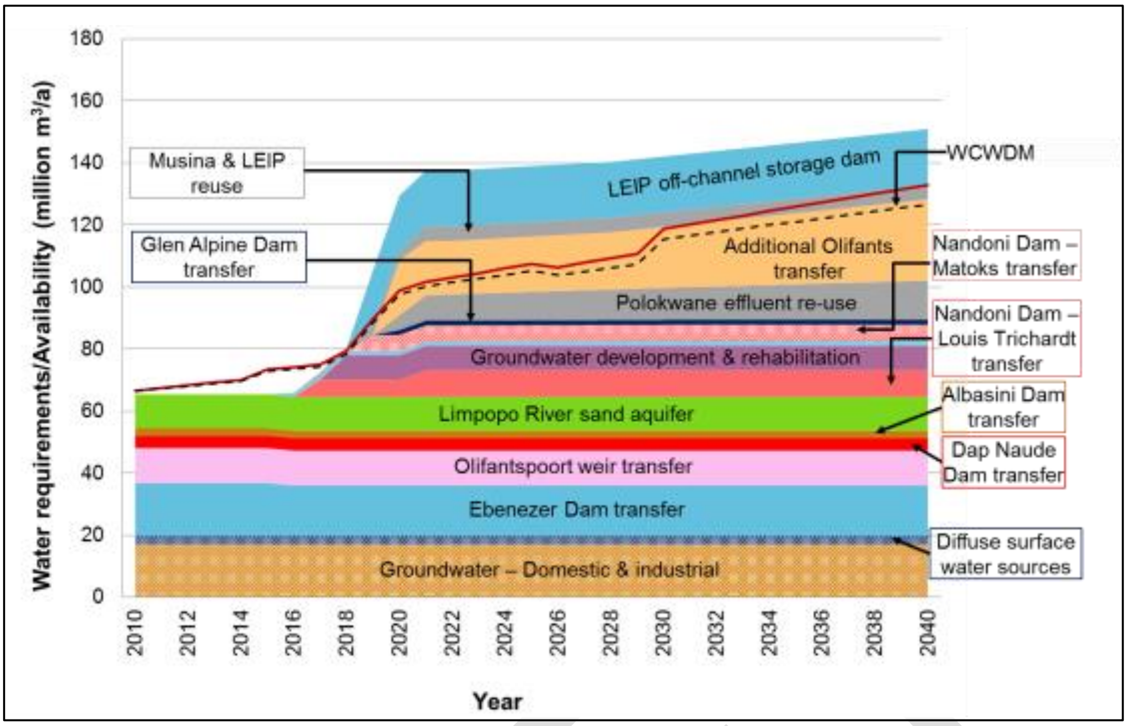

Figure 7.13 Water balance for the Sand catchment: Option 1

Note: Only domestic, mining and industrial sectors

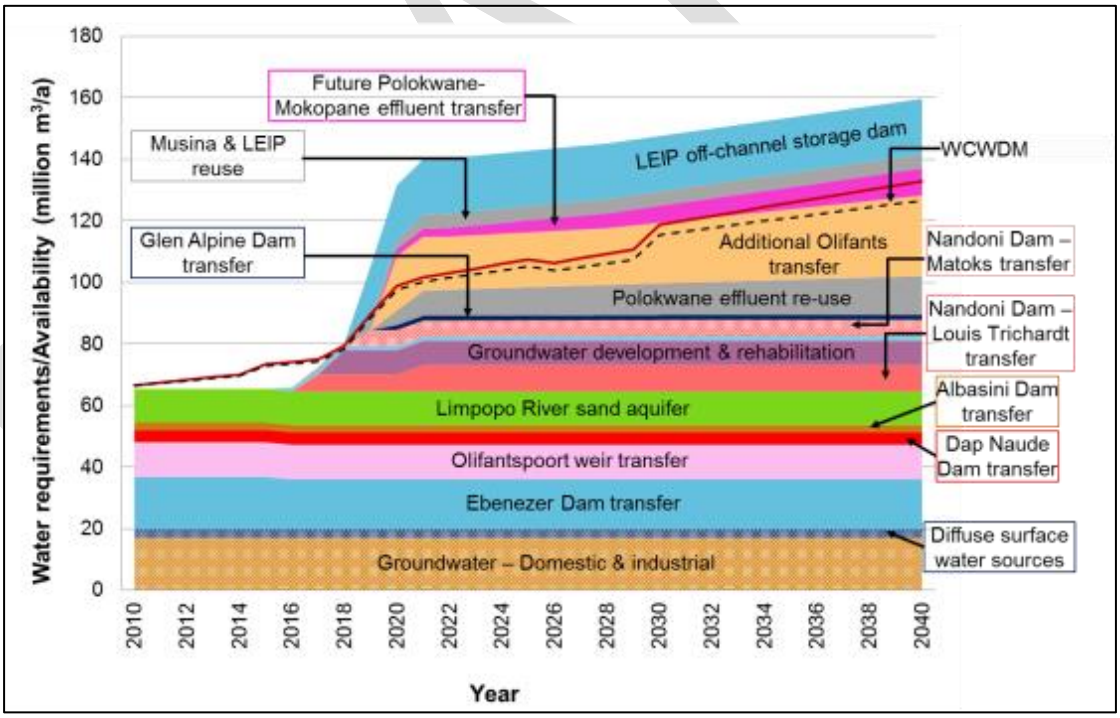

Figure 7.14 Water balance for the Sand catchment: Option 2

Note: Only domestic, mining and industrial sectors

Based on **Figure 7.12** to **Figure 7.14**, it can be derived that the 2040 water requirements can easily be met, with available surplus water. This however, is not necessarily the case for specific areas within the catchment. Economic focus areas in the catchment are spread and have independent water sources. The following sub-sections addresses the water balances in these focus areas.

b) Polokwane LM

The Polokwane LM has formed the basis of a number of water supply studies due to the significant expected increase in water requirements and severely limited local resources.

Augmenting supply to Polokwane LM from the Olifants WMA has been investigated as part of the ORWRDP. Other intervention options, such as the re-use of effluent to be generated by the new PRWwTW and the rehabilitation of groundwater resources, have also been identified. Specific WCWDM implementation plans and targets have been set for the municipality – reducing the water requirement by 3.3 million m^3/a from 2027 onwards. The water balance for Polokwane LM with these intervention options are shown in **Figure 7.15**. This water balance includes the change in supply volume from the Ebenezer and Dap Naude dams. The high and recommended water requirement projections, as recorded in the ORWRDP and the *All Towns Reconciliation Strategy for the Polokwane Cluster* (DWS, 2015a)respectively, are indicated.

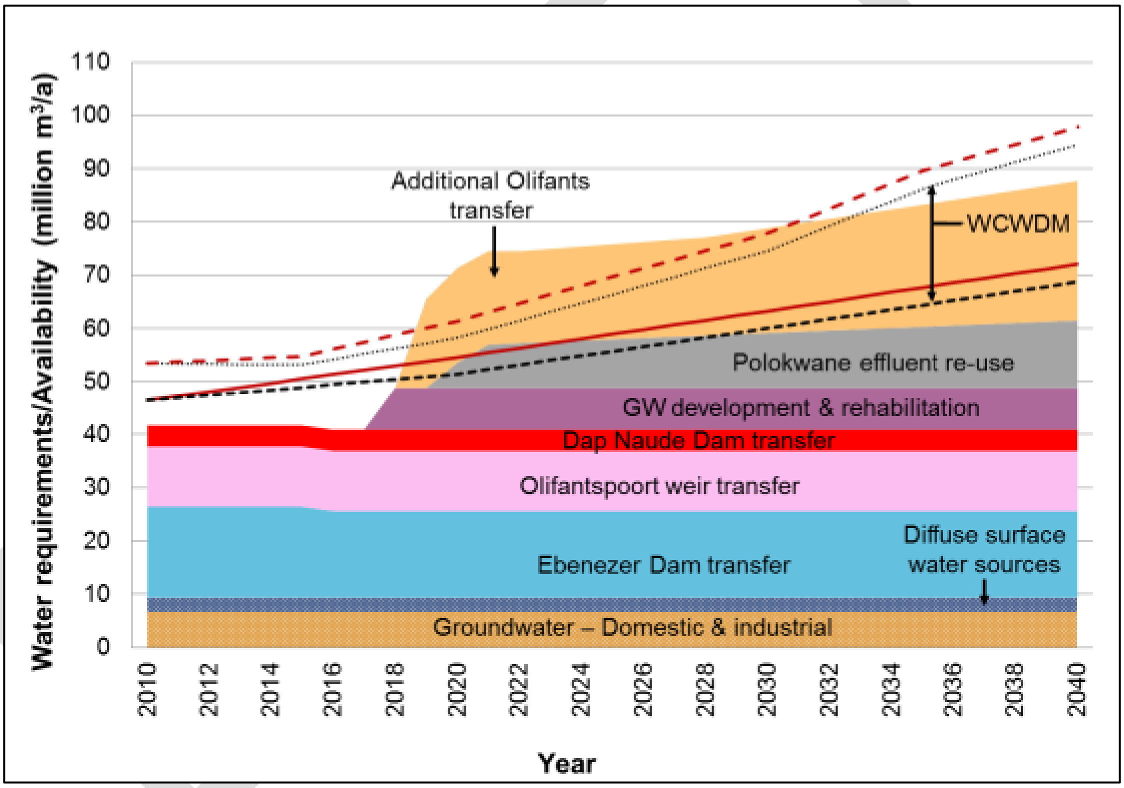

Figure 7.15 Water balance for the Polokwane LM: Option 1

Note: Only domestic, mining and industrial sectors

If the recommended water requirement projections prevail, the need for additional augmentation from the Olifants WMA is less. In terms of the high water requirement projection, additional intervention options are required by 2031. Of note is that a large deficit occurs between 2010 and 2018 for both water requirement scenarios.

Alternatively, if the current effluent transfer from Polokwane to the Mogalakwena Platinum Mine is reinstated (see **Section 7.2.4** and **Figure 7.7** and **Figure 7.11**), the future effluent transfer from Polokwane to Mokopane can rather be applied in the Polokwane LM itself, resulting in almost no need for additional augmentation from the Olifants WMA for the recommended water requirement scenario, refer to **Figure 7.16**. Implementing this combination of intervention options, will also meet the 2040 high scenario water requirements.

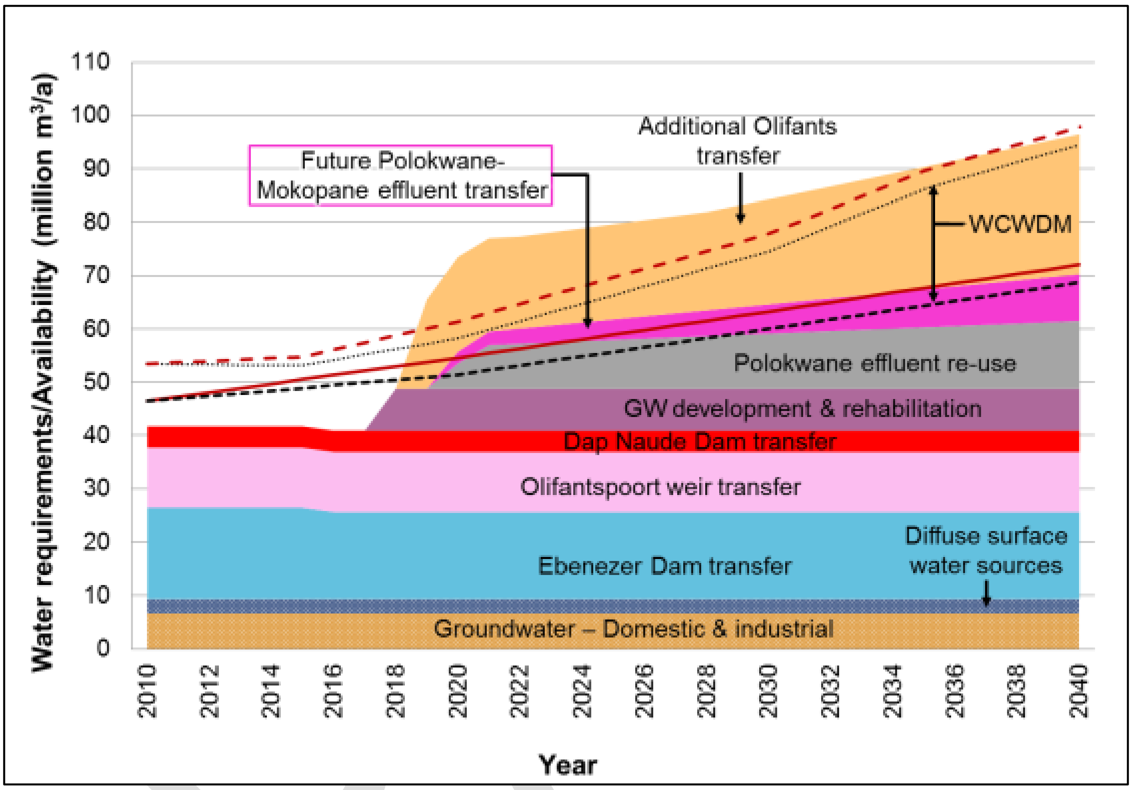

Figure 7.16 Water balance for the Polokwane LM: Option 2
Note: Only domestic, mining and industrial sectors

c) Makhado LM

The major increase in water requirement in the Makhado LM area is the expected growth in the domestic, industrial and especially the mining sector. A number of studies have been conducted to identify potential water sources for the urban areas, as well as for the CoAL developments. **Figure 7.17** shows the water balance for the considered Makhado LM area, including the following interventions:

- Re-use of effluent from Louis Trichardt;
- The Nandoni Dam transfer to Louis Trichardt;
- Bought over irrigation allocation from Nzhelele Dam;
- The Nzhelele Valley Bulk Water Supply Scheme, which includes:
  - Groundwater development;
  - Augmenting supply from Nzhelele Dam by raising the dam and providing the additional infrastructure;
  - Augmenting supply from Mutshedzi Dam by raising the dam, upgrading the WTW and providing the additional infrastructure; and

- Augmenting supply from the Vondo Dam scheme.

With reference to the *Luvuvhu and Letaba Reconciliation Strategy* (DWS, 2015b), water supplied to the Thohoyandou area from the Vondo Dam will be replaced by water from the Nandoni Dam in future. It was suggested that the available water from Vondo Dam be transferred to the Nzhelele Valley area. The time period, however, for which the surplus water from Vondo Dam is available is only five years before the water will be utilised by other users in the Luvuvhu and Letaba catchment.

Further investigation is required to determine if the Mutshedzi Dam can be raised and if so, what the additional available water will be. Considering the current storage capacity and yield available from the Mutshedzi Dam, it is highly unlikely that 10 million m^3/a will be additionally available if the dam is raised. Hence, this intervention is indicated in grey in **Figure 7.17**.

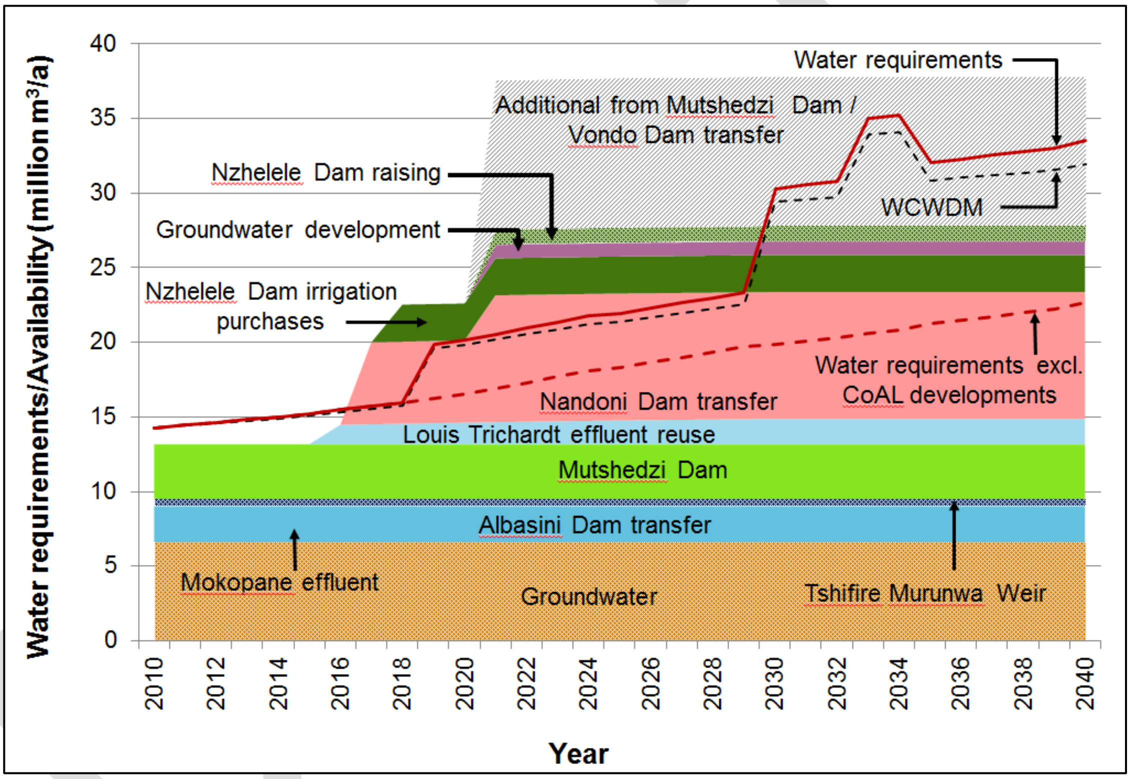

Figure 7.17 water balance for the Makhado LM: Option 1

Note: Only domestic, mining and industrial sectors

The irrigation water intended to be bought by CoAL, to supply their Makhado Coal Mine, is pending approval. Should the associated CoAL water use licence not be approved and the raising of Mutshedzi Dam not be viable, the effect on the water balance will be significant, refer to **Figure 7.18**. However, the available water will be sufficient to supply the domestic and industrial requirements of the area.

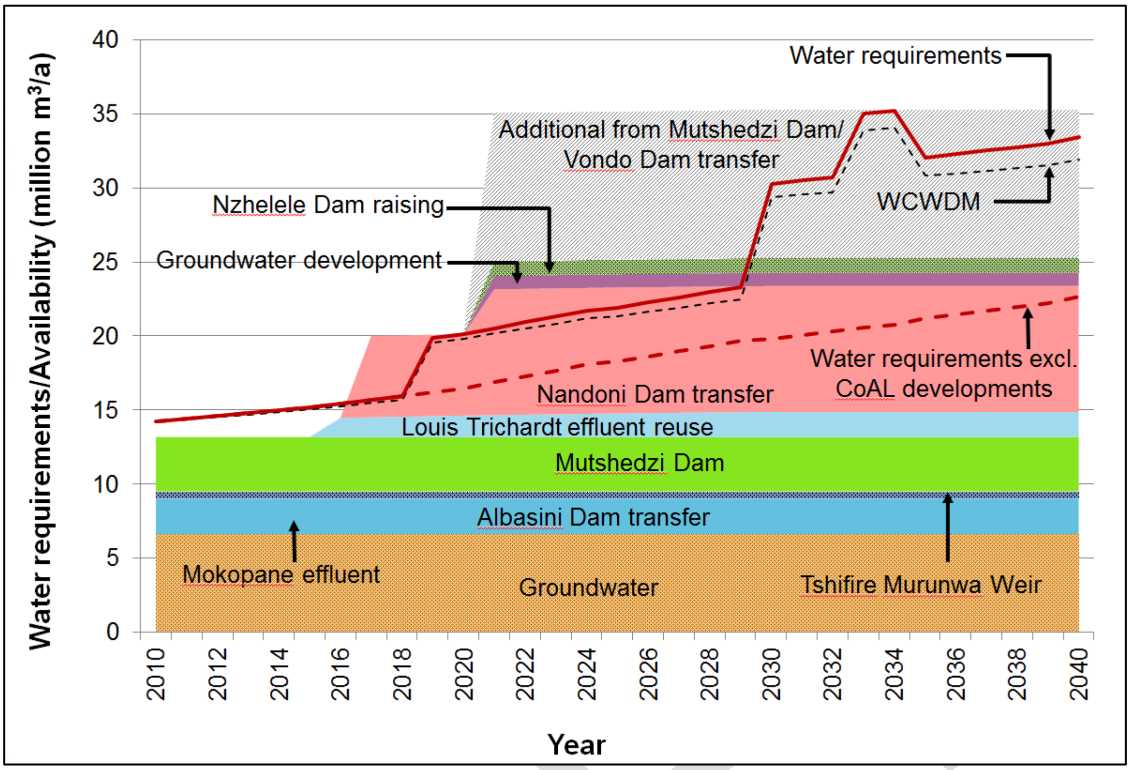

Figure 7.18 water balance for the Makhado LM: Option 2

Note: Only domestic, mining and industrial sectors

d) Musina and environs

The water requirements in the Musina area are expected to increase significantly due to the development of the LEIP and the SEZ. As mentioned earlier, updated water requirements have been received for the LEIP, but only a very high level estimate of the projected water requirements of the SEZ was available at the time of compiling this report. However, it is considered that the Musina SEZ refers more to the area that will be occupied by industrial operations, whereas the LEIP refers to the actual industries. In light of this, it is foreseen that some of the SEZ water requirements have been included in the projected LEIP water requirements.

In total the LEIP will require approximately 0.15 million m^3/a during construction which is planned to start at the end of 2016, pending the water use licence approval. Operations will start from 2017 and 23 million m^3/a will be required by 2022 when the LEIP is in full operation. The LEIP will be operated on a zero liquid discharge basis, with the water used and produced in the various plants being kept within the boundary limits of the particular plant. Used water will be fed to a dedicated effluent treatment facility and treated to be re-used within the park. The developers of LEIP are also negotiating the upgrade of the Musina WwTW to enable re-use million m^3/a is required to top up the system. Options identified to supply the top-up water include a 20 to 23 million m^3/a abstraction from the Limpopo River via an infiltration gallery system, over three months per year, which is then pumped to off-channel storage dams with a combined capacity of 17 million m^3.

Due to the close proximity of the LEIP, other SEZ developments and Musina town, it is proposed that a holistic approach is followed when identifying possible water resources. Considering the limited existing water resources, limited potential development options, and other financial and institutional processes and regulations to be followed, it is likely that the LEIP, other SEZ developments and Musina town will need to conjunctively develop, operate and maintain additional resources. It is thus recommended that the water requirements for the other SEZ developments, not included in the LEIP, also be supplied from the Limpopo River via the infiltration gallery and off-channel storage dam or any other alternative identified. It is essential that the correct projected water requirements from the other SEZ developments be included when identifying potential resources and determining the capacities of infrastructure.

The proposed water balance for the Musina focus area is shown in **Figure 7.19**. The balance shows the effect of implementing WCWDM measures in the area, mainly focussed on the domestic water requirements as new industries are expected to use water as efficient as possible. The estimated additional water requirements for the SEZ are shown as shaded areas.

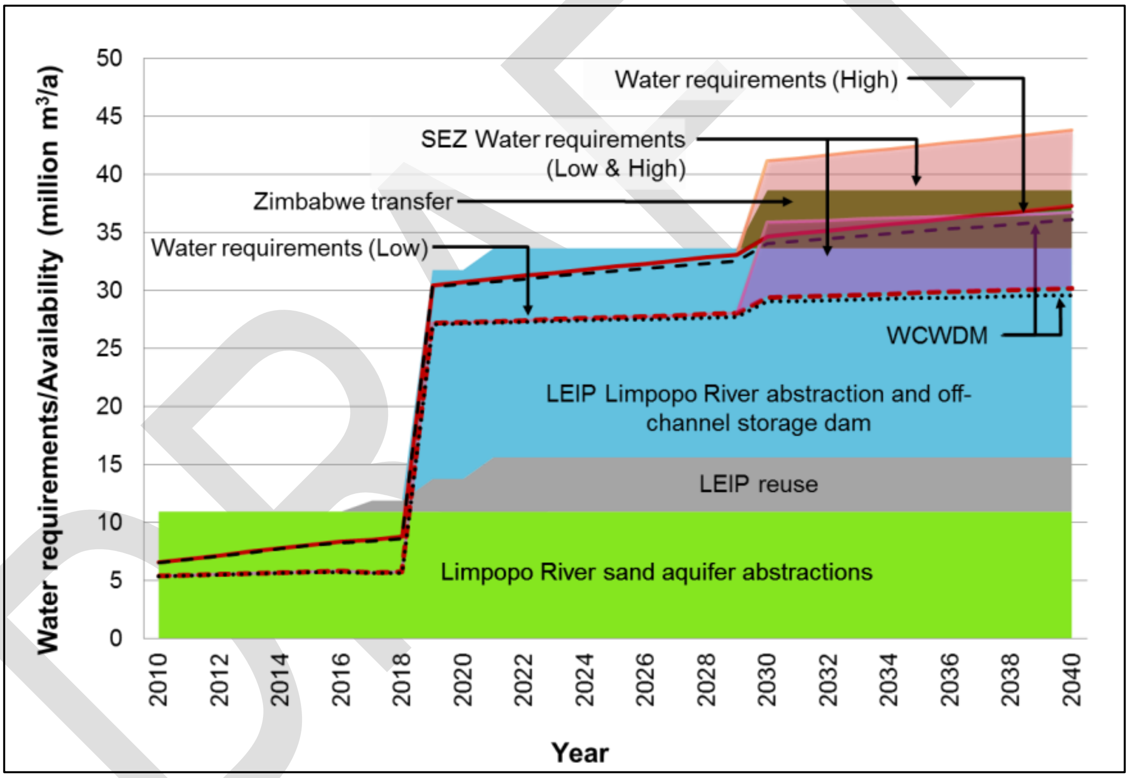

Figure 7.19 Water balance for the Musina LM

In the case of the low water requirement scenario, the water requirements for the municipality and the LEIP can be met by the current Limpopo River sand aquifer abstraction, LEIP re-use and the off-channel storage dams. The additional water requirements by the SEZ can potentially be met via the transfer of surplus water from Zimbabwe by 2028. To implement this transfer significant international negotiations and possible additional infrastructure will be required, resulting in a long lead time.

In case of the high water requirement scenario, the current Limpopo River sand aquifer abstraction, LEIP re-use and the off-channel storage dams will only be able to meet the water requirements up to 2028, after which additional interventions, such as the Zimbabwe transfer, need to be identified to meet the water requirements, especially if the additional SEZ water requirements apply.

e) Other areas of importance

The Matoks Supply Area, including the Botlokwa, Ramakgopa and Nthabiseng GWSs, were in balance at the 2010-development level. However, with reference to **Figure 4.7**, the developed groundwater resources are over-utilised. The water requirements for this area is expected to grow from 2.76 million m^3/a at 2010 to 8.3 million m^3/a by 2040. To meet the projected future requirements and to relieve the groundwater utilisation, 5.5 million m^3/a will be transferred from the Nandoni Dam in the Luvuvhu catchment.

The water requirements in the Molemole West Supply Area near Mogwadi, including the Gorkum, Silwermyn/Kirstenspruit and Ga-Hlako WSS, is expected to grow from 0.33 million m^3/a in 2010 to 2.5 million m^3/a in 2033 (WSM Leshika Consulting, 2014). Currently, the area is only supplied by groundwater (0.44 million m^3/a). The future water requirements are planned to be supplied by either a transfer from Glen Alpine Dam or a new regional groundwater scheme.

Estimates indicated that 2.18 million m^3/a is potentially available from the dam. This includes the historical allocation of 1.56 million m^3/a for irrigation to former Lebowa that has never been taken up, as well as the potential volume of 0.62 million m^3/a that can be saved by reducing downstream conveyance losses through installing pipelines or canals.

In conjunction with possible groundwater development of 1.1 million m^3/a, only 0.6 million m^3/a have to be transferred to meet the future requirements of the Molemole West Supply Area. The remainder can thus be applied elsewhere in the study area.

7.2.6 Nzhelele catchment

Although the water balance shown in **Figure 5.13** indicated that a surplus exists in the catchment, the available water sources allocated to domestic and industrial users are not sufficient to meet the current water requirement (**Figure 5.14**). Furthermore, groundwater available as part of WSS is also over-abstracted in some areas, leaving little scope for further groundwater development. As mentioned a significant number of opportunistic users have built weirs and canals from local streams, resulting in a reduction in the available water for downstream users. It is thus urgent that this matter be addressed.

The major increase in projected water requirements are the development of the Makhado and Generaal coal mines by CoAL. CoAL has submitted an application to buy out some of the irrigation allocations from the Nzhelele Dam to supply their Makhado mine from 2018 onwards.

They have also considered constructing a dam on the Mutamba River and to re-use treated effluent from Louis Trichardt, but both these options were omitted. The time required to construct the dam exceeds the mine implementation time and the available run-off is considered low. The DWS does not support the re-use of treated effluent from Louis Trichardt as it can be used in the town itself.

To supply the growth in domestic and industrial requirements, the Nzhelele Valley Bulk Water Supply Scheme has been identified as a possible intervention option – see **Section 7.2.5c)** and **Table 7.6**. However, as mentioned, the Vondo Dam and raised Mutshedzi Dam will not be able to supply the suggested 10 million m^3/a.

Table 7.6 Summary of Nzhelele catchment intervention options

Intervention option	Supply area	Volume (million m^3/a)	Implementation time/comment
Planned/approved intervention options			
Nzhelele Valley Bulk Water Supply		> 11.4	2020
Groundwater development	• Individual groundwater schemes	> 0.9	Equipping > 23 existing boreholes and siting, drilling and testing of nine new boreholes.
Augmenting supply from Nzhelele Dam	• Nzhelele supply area	> 0.5	New pipelines, pump stations and reservoirs, upgrading of existing pump stations, WTW and raising Nzhelele Dam.
Augmenting supply from Mutshedzi Dam	• Mutshedzi supply area	> 10	Upgrading existing WTW and pipelines, new pump stations and reservoirs and raising of Mutshedzi Dam.
Supply from Vondo Dam Scheme	• Nzhelele supply area • Mutshedzi supply area		Pipeline from Vondo Dam to Mutshedzi supply area to Nzhelele supply area.
Luphephe and Nwanedi Regional Bulk Water Supply	• Luphephe and Nwanedi supply area	1.1	Newly constructed WTW. Unused irrigation allocation from Luphephe and Nwanedi dams to be allocated to domestic users.
Water allocation transfer (Section 25) (CoAL)	• Makhado Coal Mine	2.5	2018 Water to be purchased from the irrigation sector.
Other possible intervention options			
WCWDM	• Domestic (rural) • Irrigation	1.0	Phased in over 5-10 years. Mining WCWDM considered to be insignificant (not applicable to new mines).
Eliminating unlawful use & compulsory licensing	• Irrigation	± 0.8	3-4 years
Re-use of effluent from Louis Trichardt and Musina (CoAL)	• Coal mines	1.7	Not supported by DWS as treated effluent from Louis Trichardt should rather be used by the town itself.
Groundwater development	• Domestic supply	To be further investigated in continuation and implementation phase.	
Refurbishment of the Nzhelele canal	• Domestic or irrigation supply	To be further investigated in continuation and implementation phase.	
Proposed dam on Mutamba River (CoAL)	• Coal mines	Long lead time, not a lot of runoff in the area.	
Removal of IAP	• Domestic/irrigation	< 2.1	IAPs reduce stream flow. If removed, increase in stream flow does not relate to available yield.
Proposed Wylliespoort Dam	Not further considered due to unfavourable topographical and hydrological conditions and limitations.		
Proposed Tshipise Dam	Not further considered due to unfavourable topographical and hydrological conditions and limitations.		

Additionally, the Luphephe and Nwanedi Regional Bulk Water Supply Scheme has been identified to supply the Luphephe/Nwanedzi scheme from the Nwanedi and Luphephe twin dams since they are under-allocated. The licence has been recently approved. However, of note is that the majority of this supply area falls outside of the study area.

A summary of the possible intervention options are given in **Table 7.6**. Text indicated in grey is intervention options that are unlikely to be implemented or that have not been considered in the water balances of this phase of the Reconciliation Strategy.

The catchment water balance with the proposed intervention options are shown in **Figure 7.20**. Only the water balance for the domestic, industrial and mining sector is shown as the water requirements and supply for irrigation and livestock watering is considered to remain constant over the Study period.

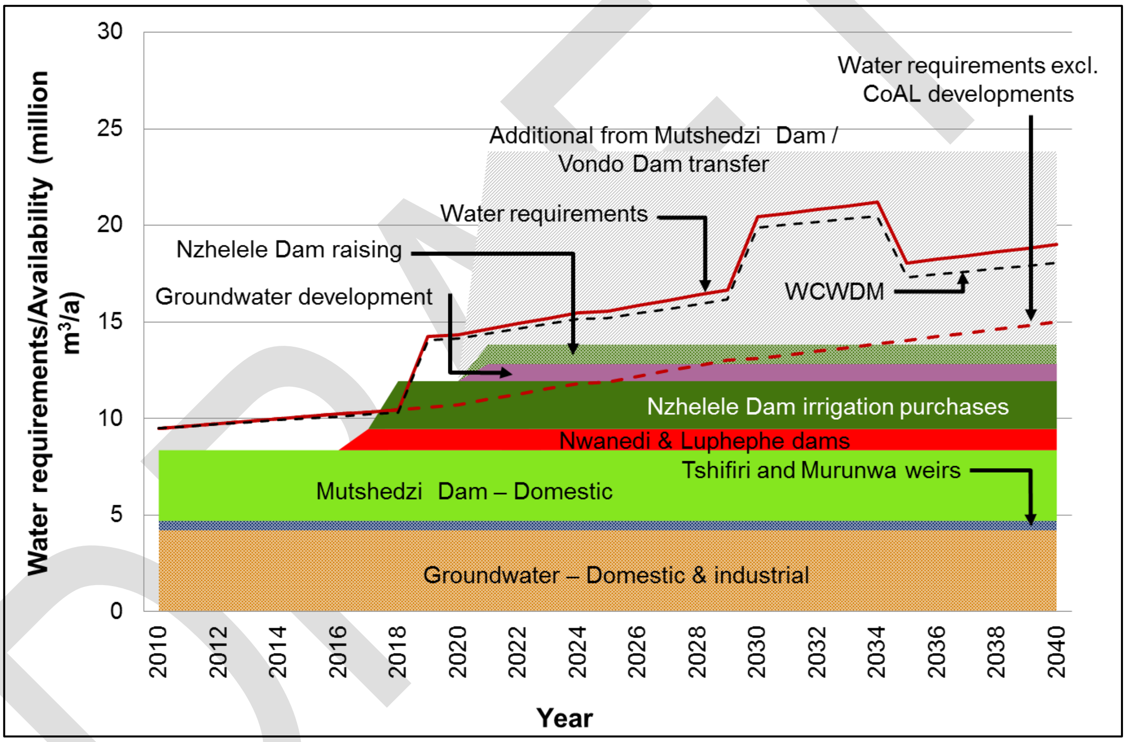

Figure 7.20 Water balance for the Nzhelele catchment: Option 1

Note: Only domestic, industrial and mining sectors

From **Figure 7.20** it can be interpreted that intervention options will be sufficient to meet the water requirements, pending the approval of the irrigation water allocation purchases and the availability of additional water from Mutshedzi Dam or Vondo Dam. However, it should be noted that the additional water from Mutshedzi Dam or Vondo Dam will supply domestic and industrial user and possiblily to a much lesser extent.

Figure 7.21 shows the effect if the water use licence to purchase some of the Nzhelele Dam irrigation allocations is not approved.

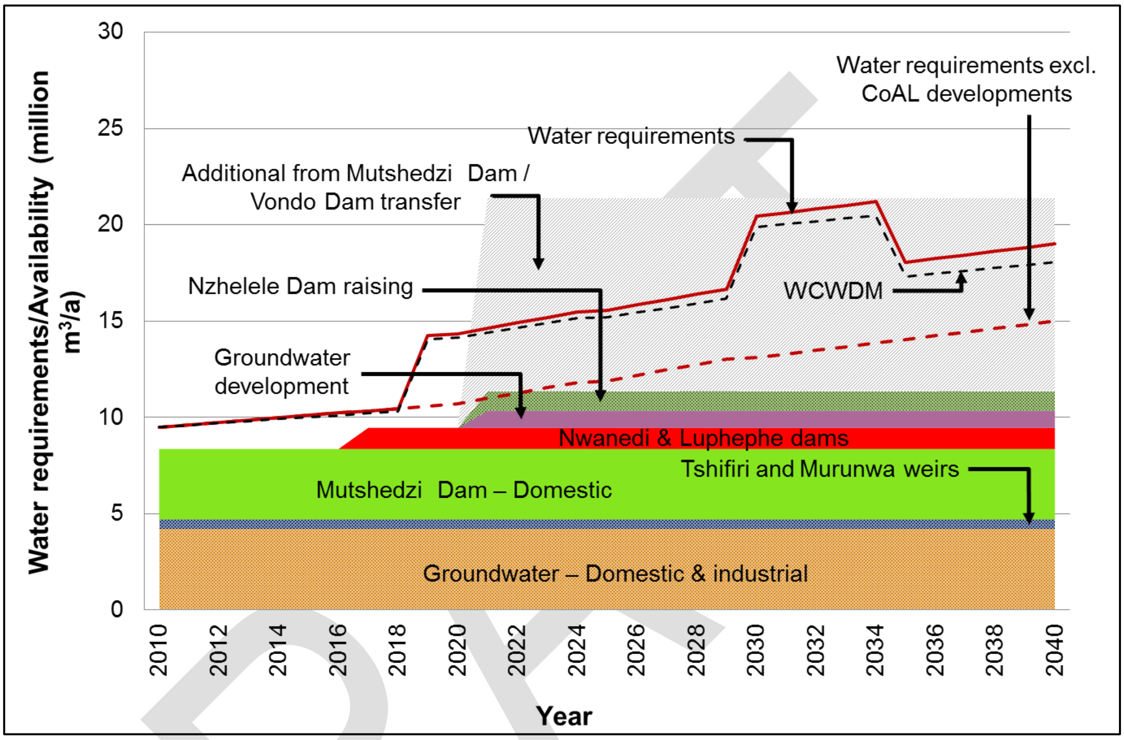

Figure 7.21 Water balance for the Nzhelele catchment: Option 2
Note: Only domestic, industrial and mining sectors

With reference to **Figure 7.17**, if the treated effluent is not used within Louis Trichardt, the transfer from Nandoni Dam will be able to meet the domestic and industrial requirements, excluding the coal mining activities up to 2037. This effluent can possibility used to augment domestic and industrial supply in the Makhado town area. The balance is shown in **Figure 7.22**.

Reducing afforestation in the vicinity of Makhado Town can increase the recharge and utilization of groundwater. Furthermore, no additional afforestation should be allowed in the catchment unless the impacts can be mitigated.

It is essential that the additional yield available from a raised Mutshedzi Dam be investigated in the continuation and implementation phase of this Reconciliation Strategy. Also strong consideration must be given to refurbish the Nzhelele canal and possibly reallocate the water available from Nzhelele Dam.

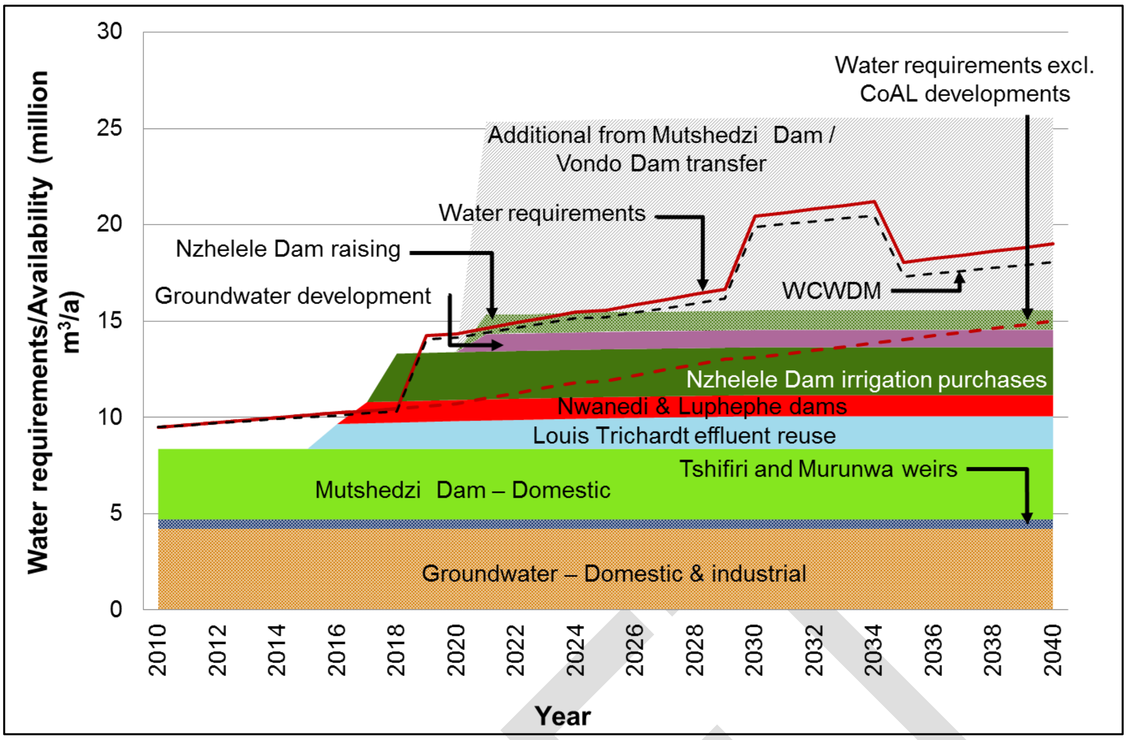

Figure 7.22 Water balance for the Nzhelele catchment: Option 3
Note: Only domestic, industrial and mining sectors

Another intervention option to consider for the Nzhelele catchment, along with the Musina area, is the transfer of water from Zimbabwe, possibly the Zhove Dam. As mentioned, it is proposed that the water released from Zhove Dam be abstracted as surface water from the Limpopo River on the Zimbabwe river banks and treated at the existing WTW located near Beitbridge before being transferred to South Africa.

This intervention option, however, entails significant negotiations and agreements between South Africa and Zimbabwe to ensure sustainable supply. Other than that, the option can be quite fast.

8 RISKS AND UNCERTAINTIES

The following risks and uncertainties have been identified with regard to the Reconciliation Strategy of the study area:

- The extent of unlawful water use, in all sectors, is unknown. The extent of unlawful water use, especially in the irrigation sector will only be known once the results of the *Validation and Verification Study* (DWS, 2015) are published. Until such time, the Reconciliation Strategy will have to rely on the available best estimates. Furthermore, during the continuation phase of the Reconciliation Strategy and once the extent of unlawful water use has been established, a reasonable attempt should be made to accommodate these users as lawful water users.
- The implementation of EWRs will have a major impact on the water availability. However, detailed Reserve Classification assessments of all catchments, excluding the Mokolo catchment, have to be conducted to determine the EWR and RWQO. Only when these studies have been completed the true effect on the available yield will be known.
- The estimated amount of water saved via WCWDM in urban areas (domestic and industrial sector) is highly governed by the cooperation of district and local municipalities, and as such cooperation is of utmost importance to achieve the WCWDM targets.
- Implementation of many of the management options is dependent on the cooperation of institutions such as local authorities, mining companies, etc.
- Only high level groundwater assessments were undertaken as part of this Reconciliation Strategy. More detailed local groundwater investigations are required to provide the correct development potential of the groundwater resources and to identify the best location for specific future regional developments. It is important to commission groundwater feasibility studies focussed on the areas identified for possible future development.

9 IMPLEMENTATION ARRANGEMENTS

The DWS needs to change the Study Steering Committee to a Strategy Steering Committee (SSC) with the continuation and implementation phase of the Reconciliation Strategy. The purpose of this SSC will be to oversee the implementation of the Strategy and recommend adaptive measures to accommodate any changes that may affect the reconciliation scenarios. This group will build on the current committee members, and will include other new relevant stakeholders. The SSC will comprise individuals from the following entities:

- DWS National and Regional Offices;
- Catchment Management Agencies (CMAs);
- Water Boards;
- Irrigation Boards (including the Limpopo Provincial Department of Agriculture);
- District and Local Municipalities;
- Water Use Associations (WUA);
- Industries, including Eskom and mines;
- Nature conservation institutions;

Strategy Steering Committee meetings need to be held twice a year to ensure progress and integration on intervention activities. Particular attention needs to be given to strategy recommendations requiring negotiations with Zimbabwean authorities. DWS International Liaisons will have to take the lead, most likely through the structures provided by LIMCOM.

10 ACTIONS AND RECOMMENDATIONS

10.1 ACTIONS THAT NEED TO BE STARTED AS A MATTER OF URGENCY

10.1.1 Verification of water entitlements

The verification component of the *Validation and Verification Study* (DWS, 2015) was still in process at the time of compiling this report.

Once the extent of unlawful irrigation water use has been determined, the DWS need to prepare a compliance monitoring and enforcement plan. This plan must clearly determine whether unlawful water use should be eliminated through prosecution or whether licences for the unlawful water users will be considered.

Areas where the removal of unlawful water use will impact significantly on the water resources need to be re-evaluated and water balances adjusted accordingly.

10.1.2 Monitor water use to confirm water requirement projections before implementing options

The monitoring of water use is essential for the operation and future planning of any water supply system. This is the only way how it will be possible to detect whether measures such as WCWDM etc. are successful and if the selected intervention options given in the Strategy will be sufficient to support the growing water requirements. Interactions with Municipalities and irrigation schemes are important to ensure that reliable water use data can be obtained at key points.

10.1.3 Water conservation and water demand management

Interactions with the Municipalities are necessary and essential for successful WCWDM. A comprehensive water balance in accordance with the modified IWA water balance guidelines must be developed along with a WCWDM plan for each of the LMs where saving through WCWDM can be obtained. These plans should address the related Water Services Schemes within the study area. Implementation of these plans needs to start as early as possible.

10.1.4 Monitor observed flows and storage levels at strategic points

With reference to the *Hydrological Analysis Report (P WMA 01/000/02914/3)* as part of this Study, the monitoring of observed flows and storage levels in dams and maintaining the related gauging stations to ensure accurate measurement, is essential. Quite a number of existing gauging points require attention to be able to provide reliable and very essential data required to be able to manage this system properly, and to be able to do sensible and realistic future planning of water resources and related assured water supply to users.

10.1.5 Water quality monitoring

The following is recommended with regard to surface water quality monitoring:

- The frequency of surface water quality monitoring should be increased for all problem determinants at the monitoring station as well as upstream and downstream points.
- The management and monitoring of WwTW should be improved to ensure that discharged effluent comply with standard and licence requirements.
- The monitoring frequency of diffuse sources of pollution, such as monitoring at large farms, should be increased to determine the impact of the agricultural activity on increased salinity; and
- In places were geology negatively affects water quality, monitoring must be increased and users must identify alternative water resources that can be used when levels are exceeded.

10.1.6 Groundwater monitoring

Groundwater monitoring and the availability of historic and current data is a key aspect of groundwater management. The following urgent actions are proposed:

- Enforcement of the compulsory groundwater monitoring as required by law for authorized water users. This data as well as all other available groundwater information must be added to the GRIP data base.
- The NGA and provincial data must be exported on a regular basis.
- The spatial distribution of the provincial groundwater monitoring network must be constantly improved.

10.1.7 Set clear targets for the construction of bulk water distribution systems

Significant delays in the construction of the bulk water supply systems from Nandoni Dam, MCWAP-1 and ORWRDP-2A are experienced. This results in ongoing deficits in water supply to several areas. Clear timeframes for construction and commissioning of new bulk water distribution systems need to be set up, confirmed and adhered to, so that deficits in water supply can be addressed in time and in many cases as soon as possible.

Interactions with the Municipalities and DWA Water Services are crucial to ensure effective and sufficient water supply within the study area.

10.1.8 Continuous integration between water balances and water supply planning to water services schemes

Continuous integration and interaction between the Reconciliation Strategy and related water balances with the water supply planning and construction of water supply related infrastructure need to take place. This is required to ensure that these developments are aligned with the Strategy and also to adjust or refine the strategy to address changing circumstances as and when required.

10.1.9 Cooperation between Musina LM, LEIP and the SEZ

Due to the close proximity of the LEIP, other SEZ developments and Musina town, it is proposed that a holistic approach is followed when identifying possible water resources. Considering the limited existing water resources, limited potential development options, and other financial and institutional processes and regulations to be followed, it is likely that the LEIP, other SEZ developments and Musina town will need to conjunctively develop, operate and maintain additional resources. It is thus recommended that the water requirements for the other SEZ developments, not included in the LEIP, also be supplied from the Limpopo River via the infiltration gallery and off-channel storage dam or any other alternative identified. It is essential that the correct projected water requirements from the other SEZ developments be included when identifying potential resources and determining the capacities of infrastructure.

10.2 MEDIUM AND LONG-TERM ACTIONS REQUIRED

10.2.1 Canal downstream of the Nzhelele Dam to be refurbushed

An investigation need to be initiated to determine the benefit and cost of refurbishing the canal downstream of the Nzhelele Dam or alternatively, to provide a pipeline with off-takes to major users, with the aim of reducing the significant losses. This needs to be followed by the design of this pipeline and the preparation of tenders, tender procedure, construction and commissioning of the construction.

10.2.2 Canal to be constructed downstream of the Glen Alpine Dam

Initial estimates have been made regarding the benefit and cost associated with providing a lined canal or pipeline downstream of the Glen Alpine Dam to reduce losses. This needs to be followed by the design of the canal and the preparation of tenders, tender procedure, construction and commissioning of the construction.

10.2.3 Commission a Classification study on the Luvuvhu and Mutale rivers.

A classification study was already completed for the Matlabas and Mokolo catchments. The agreed EWRs and related classes were included in the WRYM and WRPM analyses carried out in support of the Reconciliation Strategy study. However, only Desktop level EWRs were available for the other catchments and were used to predict the possible impact on the yield of a dam. Results showed that the impact is substantial in some cases. The need of properly determined high confidence EWRs are required in the continuation and implementation phase of the Strategy, as well as for the preparation of prefeasibility or feasibility studies. The commissioning of a Classification Study should thus be high on the priority list regarding the medium term related actions.

10.2.4 Commission feasibility studies on groundwater development in relevant areas

The availability of groundwater resources as an intervention option for the Reconciliation Strategy was determined by means of high level groundwater assessments (desktop catchment based water balances). Areas where the groundwater exploitation potential plays an important role as a future intervention option, require more detailed groundwater investigations well before the implementation of the option.

It is thus important to commission groundwater focussed feasibility studies on selected areas as indicated in the Strategy. This is required to provide or confirm the correct development potential of the identified groundwater resources, and to determine the best locations for the related groundwater abstractions, forming part of the envisaged groundwater scheme.

10.2.5 Commission studies to investigate potential supply from Zimbabwe

Initiate an investigation to determine feasibility and the most viable and cost effective option to transfer water from Zimbabwe, either via water releases from a tributary of the Limpopo River. The water requirements to be supplied by the transfer also need to be adequately determined.

10.3 OTHER RECOMMENDATIONS

The following other recommendations are made:

- Where possible newly installed sanitation should be either dry sanitation of use water to a high efficiency.
- Intervention options that can be applied per household or such, e.g. rainwater collection to water gardens, etc. should be encouraged.
- All new industrial and mining developments must incorporate water efficient systems and re-use of water where possible, i.e. operated on a zero liquid discharge basis, with the water used and produced in the development being kept within the boundary limits of the particular development. The impact of existing industrial and mining activities on water quality should be monitored and mitigation measures be implemented as applicable.

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