WSMLESHIKA CONSULTING (PTY) LTD

PROJECT NUMBER: WK21047

INVESTIGATION OF GROUNDWATER AND SURFACE WATER INTERACTION FOR THE PROTECTION OF WATER RESOURCES IN THE LOWER VAAL CATCHMENT (WP11380)

DATE: January2022

REPORT VERSION: V1.1

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WP11380

DWS REPORT NUMBER: RDM/WMA05/00/GWSW/0122

Published by

Department of Water and Sanitation

Private Bag X313

PRETORIA, 0001

Republic of South Africa

Tel: +27 (12) 336 7500

Fax: +27 (12) 323 0321

This report should be cited as:

Department of Water and Sanitation (DWS), South Africa. 2022. Investigation of Groundwater and Surface Water Interaction for the Protection of Water Resources in the Lower Vaal Catchment: Inception Report. Prepared by WSM Leshika Consulting (Pty) Ltd. Report no. RDM/WMA05/00/GWSW/0122

Compiled by:

WSM Leshika Consulting

Postnet Suite No.8

Private Bag X9676

Polokwane 0700

DOCUMENT INDEX

Report name	Report number
Inception Report	**RDM/WMA05/00/GWSW/0122**
Gap Analysis Report	RDM/WMA05/00/GWSW/0222
Quantified Recharge and Baseflow Report	RDM/WMA05/00/GWSW/0123
Protection Zones Report	RDM/WMA05/00/GWSW/0223
External Reviewer Report	RDM/WMA05/00/GWSW/0323
Capacity Building Trainings Report	RDM/WMA05/00/GWSW/0423
Main Report	RDM/WMA05/00/GWSW/0523
Close-our Report	RDM/WMA05/00/GWSW/0623

Bold indicates this report

APPROVAL

TITLE:	Inception Report
DATE:	January 2022
AUTHORS:	Project Team
EDITOR:	Fourie I.
REVIEWERS:	Sami. K; Project Management Team
LEAD CONSULTANT:	WSM Leshika Consulting
REPORT NO:	RDM/WMA05/00/GWSW/0122
FORMAT:	MSWord and PDF
WEB ADDRESS:	http://www.dws.gov.za

Approved for WSM Leshika Consulting by:

____

Mr. K. Sami

Study Leader

Approved for the Department of Water and Sanitation by:

____

Ms L. Molokomme

Project Manager

Mr K. Majola

Scientific Manager: Groundwater Reserve Determination

____

Mr Y. Atwaru

Director: Reserve Determination

ACKNOWLEDGEMENTS

The following persons contributed to this project.

Project Management Team

Molokomme, L.	DWS: Water Ecosystems Management
Xxxxxxx	xxxxxxxxxxx
Xxxxxxx	xxxxxxxxxxx
Xxxxxxx	xxxxxxxxxxx
Sami, K.	WSM Leshika (Pty) Ltd

AUTHORS

The following persons contributed to this report:

Author	Company
Sami, K	WSM Leshika (Pty) Ltd
Leshika, D.	WSM Leshika (Pty) Ltd
Seago, C.	WSM Leshika (Pty) Ltd

REPORT SCHEDULE

Version	Date
First draft	December 2021
Final	January 2022

TABLE OF CONTENTS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

BHNR	Basic Human Needs Reserve
CD:WEM	Chief Directorate: Water Ecosystems Management
CV	Coefficient of Variability
Dir: NWRP	Directorate National Water Resource Planning
DM	District Municipality
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
GRAII	Groundwater Resource Assessment Phase II
GRIP	Groundwater Resource Information Project
GRUs	Groundwater Resource Units
IUA	Integrated Unit of Analysis
ISP	Internal Strategic Perspective
MAP	Mean annual precipitation
MAR	Mean Annual Runoff
MCA	Multi-Criteria Analysis
MRU	Management Resource Units
NGA	National Groundwater Archive
NGI	National Geo-spatial Information
NWA	National Water Act
OCSD	Off-Channel Storage Dam
PES	Present Ecological State
PES/EI/ES	Present Ecological State/Ecological Importance/Ecological Sensitivity
PM	Project Manager
PMC	Project Management Committee
PSC	Project Steering Committee
PSP	Professional Service Provider
RDRM	Revised Desktop Reserve Model
REC	Recommended Ecological Category
RO	Regional Office
RPO	Red Meat Producers Organisation
RQO(s)	Resource Quality Objective(s)
RU(s)	Resource Unit(s)
SALGA	South African Local Government Association

SAM	Social Accounting Matrix
ToR	Terms of Reference
TPC(s)	Threshold(s) of Probable Concern
WARMS	Water Authorisation and Management System
WIM	Water Impact Model
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012
WRC	Water Resource Classes
WRCS	Water Resource Classification System
WRSM2000/Pitman	Water Resources Simulation Model 2000 – Pitman Model
WRUI	Water Resource Use Importance
WRYM	Water Resources Yield Model
ZQM	National Groundwater Quality Monitoring Network

INTRODUCTION

1.1 STUDY CONTEXT AND MOTIVATION

The purpose of the NWA (1998) is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors: promoting equitable access to water; redressing the results of past racial and gender discrimination; promoting the efficient, sustainable and beneficial use of water in the public interest; facilitating social and economic development; protecting aquatic and associated ecosystems and their biological diversity and ; meeting international obligations (NWA, 1998). Chapter 3 introduces a series of measures which together are intended to protect all water resources.

The Chief Directorate: Water Ecosystems Management (CD: WEM) is tasked with the responsibility to coordinate all Reserve determination studies which have priority over other uses in terms of the NWA.

This study intends to determine and quantify groundwater and surface water interactions and identify protection zoning to prevent the disturbance of the ecological integrity of ecosystems where such interactions occur. A feasibility study undertaken by the Department of Water and Sanitation (DWS) in 2007 and the National Water Resource Strategy II identified the need for surface-subsurface interaction studies in the lower Vaal. The purpose of such studies would be understanding subsurface processes when determining the Reserve.

The Lower Vaal catchment (former WMA 10) lies in the north-eastern part of the Northern Cape Province, the western part of Northwest Province, and a part of the northern Free State Province. It contains the Molopo, Harts and Vaal (below Bloemhof dam) catchments. Included in these basins are the Dry Harts, and Kuruman catchments. The Molopo river forms an international boundary and contains transboundary aquifers. These catchments include Tertiary catchments C31-C33, C91-92, D41, and Quaternary catchments D73A, D42C-D, D73B-E. These catchments include dolomites, where interaction can be significant.

The main rivers are perennial and most of their tributaries are ephemeral. The main source of surface water is the Vaal River, which flows into the study area below Bloemhof Dam, before its confluence with the Orange River. The main dams are Wentzel, Taung, Spitskop, Vaalharts Weir, Douglas weir and Bloemhof. The only pan is Barbaspan, located in the Harts sub-catchment.

Major towns include Kimberley, Lichtenburg, Kuruman, Vryburg and Postmasburg.

1.2 PURPOSE AND LAYOUT OF THE REPORT

This Inception Report describes the proposed work to be undertaken by the appointed Professional Service Provider (PSP). The study was commissioned by the Chief Directorate: Water Systems Management of the Department of Water and Sanitation (DWS). The PSP team consists of WSM Leshika Consulting (Pty) Ltd.

The work description in the report is based on the data available for the Lower Vaal catchment and covers the data needs for the application of the proposed methods. During the execution of the activities and tasks of the study, the data and information will be evaluated for consistency and any irresolvable anomalies and deficiencies will be brought under the attention of the Client for clarification by the data and information originators.

The purpose of the Inception Report is to define the extend of work and associated costs based on the proposed methodology and availability of information, existing data as well as initial evaluations carried out after the submission of the Proposal.

The Terms of Reference (TOR) and Technical Proposal defined the objective of Inception as being to ensure clarity on the objectives, methodology and deliverables are obtained. The inception report will form the basis of finalising the methodology and schedule (Gantt Chart) of tasks, resource requirements and project deliverables in a modular manner with clear milestones for events and deliverables. This will be carried out in consultation with the Client and through liaison with key stakeholders to ensure the Study Plan will achieve the objectives and expectations for the study. This Study Plan (Inception Report) will form the baseline for monitoring and evaluation of progress during the Study Implementation Phase.

A specific requirement of the TOR is the training and capacity building. The need and the envisaged topics for formal capacity building or training activities (if required) will be discussed and confirmed with the Client during the inception phase in order to set up a schedule and a tracking system for the identified capacity building or training activities which will be included in the Inception Report.

The inception report (Study Plan) includes the following components:

- Final description of sub-tasks and any additional work that may be requested by the Client.
- Updated task and activity logical flow diagram - indicating the dependencies of the tasks.
- Finalising the responsibilities and compile a study reporting structure that clearly defines the communication channels and procedures.
- Modular budget for all tasks and disbursements.
- Detailed schedule of personnel hours and costs.
- Detail schedule of events, milestones, and deliverables - detail work breakdown structure.
- Listing of the constraints and risks that may have an influence in the execution of the Study Plan.
- Evaluation and agreement of information sources to apply in the study especially where the data differs significantly.
- Define, describe, and agree with the Client the methods of how information and data generated from the study will be stored and disseminated.
- Develop a capacity building programme together with DWS

Section 2 of the Inception Report presents the study area and a summary of existing information. **Section 3** provides the existing information and data requirements followed by **Section 4,** which describes the tasks. **Section 5** describes the project procedure and methods, and **Section 6** describes the management structure and capacity building. Liaison, reporting and communication are in

Section 7. The project structure and study team are outlined in **Section 8,** and finally, the financial summary is presented in **Section 9.**

1.3 AIMS AND OBJECTIVES

The need to undertake significant groundwater-surface water interaction work became apparent to the DWS due to the need to understand groundwater flow, water levels, and water quantity and quality when determining the Reserve.

It is the Consultant's understanding that the main objectives of the study are:

- Review existing water resource information
- Conduct a hydrocensus on an institutional level
- Conduct a groundwater resource assessment of recharge, baseflow, abstraction, groundwater balance, present status category
- Quantify aquifer parameters and describe aquifer types
- Determine groundwater-surface water interactions both in terms of quality and quantity to determine protection zones
- Capacity building and skills transfer to DWS staff

The project timeframe is 24 months, starting from November 2021-November 2023.

OVERVIEW OF STUDY AREA

1.4 Drainage

The Lower Vaal catchment spans across three Provinces. A portion is in the North-West Province, a portion is in the Northern Cape Province, and a small fraction of the area lies within the Free State province. The drainage regions included in the study area are: D41 (excl. D41A), parts of D42C and D42D, parts of D73A and D73C, C31, C32, C33, C91 and C92 (figure 2-1).

The main rivers in drainage regions D41 and D42 are the Molopo River, the Nossob River, and the Kuruman River. The main rivers in these drainage regions that are of interest to this study are the Molopo and Kuruman Rivers in the Far Northern Cape. The Nossob River does not form part of this study. The Molopo River forms the border between South Africa and Botswana and together with its tributaries it drains much of the northern part of the Lower Vaal catchment. The Molopo River flows from approximately 35 km north-east of Mafikeng along the border with Botswana to the west where it joins the Nossob River approximately 70 km from the Namibian border.

The Kuruman River together with its tributaries mainly drains the southern part of the Lower Vaal catchment. The Kuruman River originates approximately 35 km southeast of Kuruman and joins its tributaries approximately 120 km north-west of Kuruman.

The Kuruman and Molopo Rivers, which drain the Kalahari and northern Lower Orange regions, do not make a meaningful contribution to the surface water resources not interactions with groundwater. However, dolomitic springs form distinct groundwater ecosystems and are a form of surface-groundwater interaction.

Drainage regions C31, C32, C33, C91 and C92 are divided into the Harts River catchment and the Vaal River catchment. The Harts River drains a catchment area of approximately 31 000 km^2 and has one major tributary, the Dry Harts River which joins the Harts River just downstream of Taung.

The stretch of Vaal River considered here is the reach between Bloemhof Dam and the Orange and Vaal River confluence. The total catchment area is almost 22 500 km^2

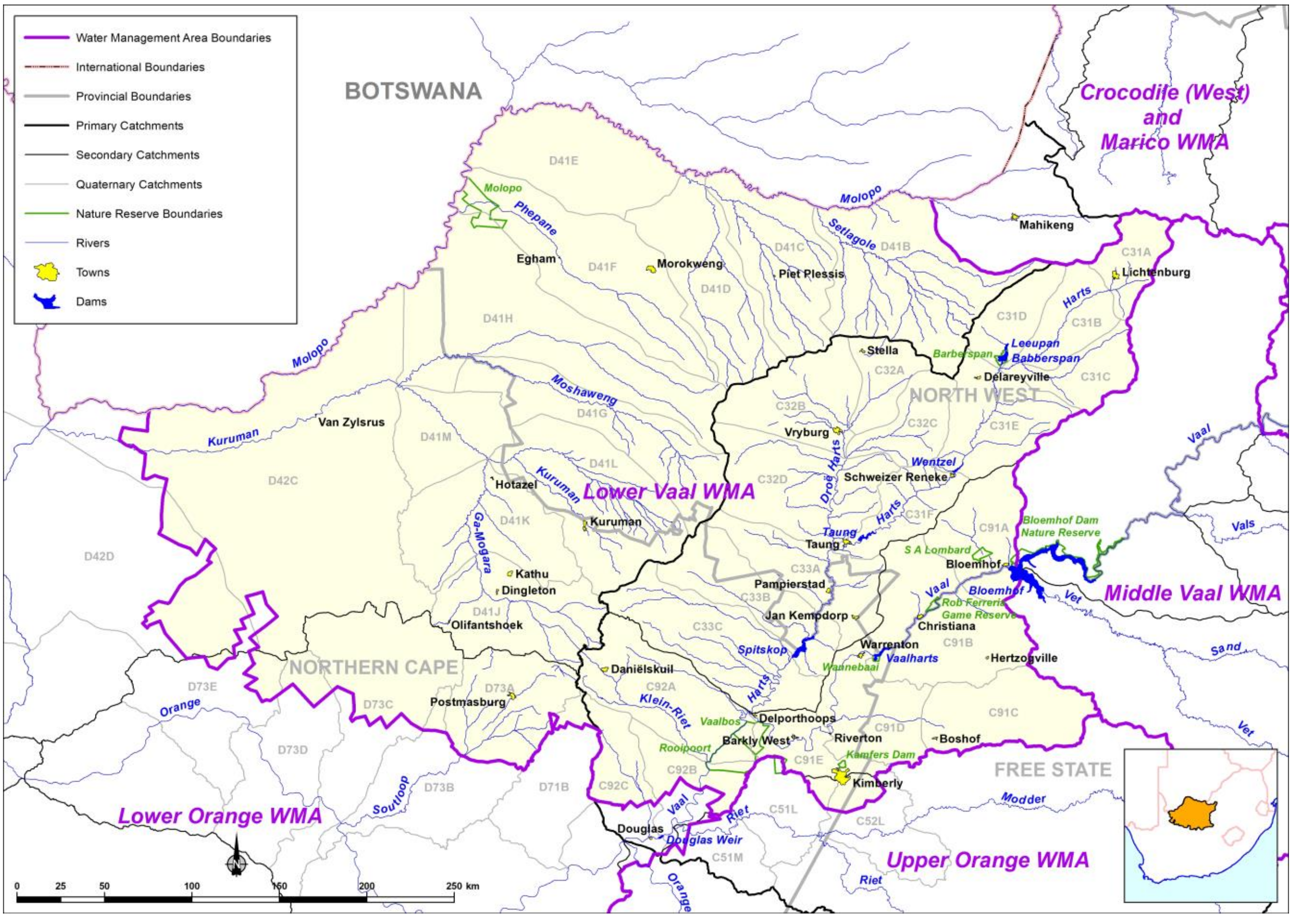

Figure 0-1 The Lower Vaal catchment

1.5 Climate

Climatic conditions are fairly uniform from east to west across the study area. The **mean annual temperature** ranges between 18.3ºC in the east to 17.4ºC in the west. Maximum temperatures are experienced in January and minimum temperatures usually occur in July (DWA, 2011).

Rainfall is strongly seasonal with most rain occurring in the summer period (October to April). The peak rainfall months are December and January. Rainfall occurs generally as convective thunderstorms and is sometimes accompanied by hail. The overall feature of **mean annual rainfall** over the study area is that it decreases fairly uniformly westwards from the western parts of the North-West Province to the eastern parts of the Northern Cape Province. The mean annual precipitation (MAP) for the North-West Province as a whole is 481 mm and for the Northern Cape Province as a whole 202 mm. The **average coefficient of variation** (CV) ranges from 31 % to 38 % for the North-West Province and the Northern Cape Province respectively. The overall range of the MAP for the entire study area is 100 mm to 600 mm while the overall range of the CV over the entire study area is 25 % to 40 %.

For the **driest year in five** (80 % exceedance probability) the annual rainfall ranges between 600 mm in the eastern part of the study area and less than 100 mm in the western part of the study area.

For the **wettest year in five** (20 % exceedance probability) the annual rainfall ranges between 800 mm and 100 mm in the eastern and western parts of the study area respectively (DWA, 2011).

1.6 GEOLOGY

Due to the extremely arid nature of the Lower Vaal catchment, groundwater plays a very important role in the water resources of this catchment. In many areas the only source of water is groundwater since there are no sustainable surface water resources. A large portion of the central and north-east corner of Lower Vaal CATCHMENT is underlain by the Transvaal Supergroup consisting of the dolomite, chert, and subordinate limestone (DWAF, 2004). This area is characterised by a high potential for groundwater with a 50 to 75% probability and accessibility throughout the dolomitic area. The groundwater level is between 8 to 20 metres deep on average. Water is found mainly in fractures; dissolution features are not prominent. Interactions occur where these compartments drain via dolomitic eyes.

The Olifantshoek Supergroup lies to the west of this area in the vicinity of Vanzylsrus, Hotazel, Sishen and Postmasburg. Here the Geology presents very low-to-low grade metamorphic rocks of schist, quartzite, lava, subgreywacke and conglomerates. Tillite with sandstone, mudstone and shale is also found in the area (DWAF,2004).

Unlike the central dolomitic area, the geology of the western part of the catchment does not lend itself to groundwater resources. Boreholes tend to be less successful and much deeper, up to 125 metres. Water is also often saline. It is this very limited and unreliable groundwater resource that necessitated the implementation of the Kalahari East and West rural water supply schemes. There is no connection between surface and groundwater.

The Ventersdorp Supergroup lies to the east and north of the Transvaal Supergroup are areas composed mainly of volcanic rocks, andesite, quartz porphyry, sedimentary rocks, conglomerate, and sandstone. This area also represents a low-grade metamorphism and water is found in weathered fractures. Probability of a successful borehole yielding >2l/s is 10-20% with and average groundwater level of between 8 to 20 metres deep.

The main minerals in this area are iron, manganese (associated with the Kalahari Manganese field) and asbestos mines in the southwest. This has a major impact on the water situation of the region since there are a number of Manganese mines in the area which are situated in the region where ground ware is extremely limited.

This has necessitated schemes such as the Vaal Gamagara to supply water to these mines. The iron ore mine at Kathu is better situated with regard to ground water and although the Vaal Gamagara scheme was developed to supply this mine, it still receives most of its water from groundwater. Alluvial diamonds are associated with the central and east area and Kimberlite diamonds in the west near Kimberley.

There are also a few copper, zinc and gold mines throughout the catchment area.

1.7 Water Related Infrastructure

1.7.1 The Hartz River catchment

By far the largest water user in the Lower Vaal catchment is the irrigation sector. Development of the water infrastructure within this area has therefore been driven largely by this sector. The Vaalharts irrigation scheme was developed in the mid 1930's and diverts water from the Vaal to irrigators along the Vaal River but mostly in the Harts River catchment. Later, in 1971, the Bloemhof Dam was completed to regulate the flow in the Lower Vaal and increase the assurance of supply to the Vaalharts scheme. The Vaalharts canals were upgraded in the early nineties to increase their peak rate of supply from 28.3 m_3/s to 48 m_3/s (DWA, 2011).

The Wentzel Dam was constructed in 1935 to supply water to Schweizer Reinecke and for limited irrigation. In 1975 the Spitzkop Dam was constructed in order to supply irrigators along the lower Harts.

The Taung Dam was constructed on the Harts River in 1993 to augment irrigation supplies to the Taung irrigation area and support new irrigation development in the Pudimoe area. The development of additional irrigation did not materialise.

This scheme is of relevance as irrigation return flows supply a salt load to the Harts River

1.7.2 The Kuruman/Molopo catchment

The Vaal Gamagara scheme was constructed in the mid 1960's. This scheme sources its water from the Vaal River and also supplies water to small towns in the area and to farmers for stock-watering and domestic purposes (DWA, 2011).

The Kalahari West Rural Water Supply Scheme was implemented as an emergency scheme in 1984 to supply water to farmers in a limited area north of Upington for domestic and stock watering purposes.

The Kalahari East Rural Water Supply Scheme was implemented in the early 1990's to supply water to a much larger area of the Kalahari.

1.7.3 Institutions Responsible for Community Water Supplies

Water Supply

The District Municipalities within the Lower Vaal catchment are as follows:

- Lejweleputswa
- Frances Baard
- Ruth Segomotsi Mompati
- John Taolo Gaetsewe
- Kimberley Municipality

The Riverton-Kimberley Scheme abstracts from the Vaal River at Riverton, and it is pumped to Kimberley. Abstractions are over 40 million m_3/a.

Wentzel Dam is the most upstream dam on the Harts River and relies totally on the natural flow from the Harts. It supplies Schweizer Reneke town demand with 1 million m^3/a. Taung Dam is located downstream of Wentzel Dam not far upstream of the town of Taung. The Taung Dam was built in the

Harts River in 1993 to augment irrigation supplies to the Taung irrigation area and possibly support new irrigation areas in the Pudimoe area. Currently the dam is not utilised at all.

Irrigation Boards

- Vaalharts irrigation scheme
- Harts' river Government water scheme

The Vaalharts Government Water Scheme is the most significant water supply scheme in the Lower Vaal. Water is released from Bloemhof Dam to the Vaalharts Weir, situated on the Vaal River between Christiana and Warrenton, from where it is diverted into a canal. The incremental yield of Bloemhof Dam is less than the water requirements of the Vaalharts Scheme and other irrigators along the Lower Vaal. Bloemhof Dam is consequently supplemented by releases from Vaal Dam in times of shortages. The Vaalharts therefore forms part of the greater Vaal System. Naledi and Greater Taung Municipalities source their water from the Vaalharts scheme, and water is purified at Pudimoe treatment works. Pokwane Municipality also obtain water directly from the Vaalharts canal system to supply Jan Kempdorp, Hartswater, and Pampierstad, with water purified at the Jan Kempdorp, Hartswater and Pampierstad treatment works. Average transfers to the Vaalharts Irrigation Scheme (including distribution losses) are estimated at 450 million m_3/a. The Vaalharts canal system is reasonably old and in need of refurbishment. Distribution losses are therefore high and estimated to be in the order of 127 million m_3/a.

Spitskop Dam was constructed in 1975 in order to supply irrigators along the lower Harts upstream of the Vaal confluence. The dam is positioned downstream of the Vaalharts Irrigation Scheme and therefore substantial volumes of return flows seep into the dam. The dam is currently only utilised to supply irrigation along the Harts River downstream of the dam.

The Douglas Weir (Orange-Vaal Transfer Scheme) is the most downstream storage structure in the Vaal River situated just upstream of the confluence with the Orange River. The Douglas Irrigation Scheme, as well as Douglas Town, is supplied from the Douglas Weir and, in addition to the runoff entering Douglas Weir from the upstream incremental catchments, water is transferred (pumped) from the Orange River into Douglas Weir. Since these two user groups do not have allocations from the Vaal River Sub-system, they only have access to the outflow from the Vaal. During periods of insufficient flow from the Vaal, the supply to these users is augmented with transfers from the Orange River System by means of the Orange-Vaal Transfer Scheme

Water Boards and Water User Associations

There are only two water boards in the Lower Vaal catchment,

- the Kalahari East Water User Association
- Sedibeng Water

The Kalahari East Water User Association receives water from Upington's municipal supply and distributes this to farmers in the Kalahari for stock-watering and domestic use.

Mines

There are a number of Manganese mines in the Lower Vaal catchment which have significant water requirements. These are all situated in the dry north-west section of the catchment and those listed in the table below have an allocation from the Vaal Gamagara scheme. The other significant mines are the Finch diamond mine and Sishen iron ore mine near Kathu. They make use of dolomitic ground water to meet their water requirements.

The Vaal-Gamagara Government Water Scheme was initiated in 1964 to supply water mainly to the mines in the Gamagara Valley in the vicinity of Postmasburg and further north of this town. An abstraction works and low-lift pumping station are located on the Vaal River near Delportshoop, just below the confluence with the Harts River. The scheme has an allocation of 13.7 million m_3/a from the Vaal River.

1.8 The Reserve and Resource Quality Objectives

The intermediate Reserve for the Lower Vaal was undertaken in 2009 (AGES. 2009). The groundwater reserve determination was undertaken with the GYMR mode. It was compared with the results obtained using GRDM methodology to demonstrate the differences in terms of groundwater flow balances and management of groundwater resources. The report states that the existing GRDM methodology based on stress index should not be used. The existing GRDM system classifies the groundwater units based on “stress indexes”. It was found that this classification cannot and should not be used as it is not based actual, but estimated groundwater volumes. It could lead to incorrect perceptions that the groundwater systems are actually stressed.

It calculated recharge at 983 Mm_3/a at a 95% and borehole abstraction of 49.6 Mm_3/a, (represents 5 % of recharge) from 6293 active boreholes. Livestock water use was estimated at of 5.3 Mm_3/a. The BHN community water allocation was calculated at of 13.4 Mm_3/a (represents 1.4 % of recharge) for a total of 1012833 people in the catchment. The water was allocated at 25 L/person/day where there was no WARMS data available. Farm irrigation volumes from groundwater resources amount to 172 Mm_3/a (17.5 % of recharge), according to the WARMS data (registered volumes from boreholes). Spring flow is one of the lowest users of groundwater at 1.3 Mm_3/a from 224 springs.

Based on the GRDM methodology, the report suggests recharge would be estimated at 1871 Mm_3/a, which is 47% higher than the recharge determined at a 95% assurance level by the GYMR model. The groundwater component of base flow would be 1254 Mm_3/a. This figure is 2.3 times the base flow values obtained from the GYMR method. It is concluded from this study that this method will consistently produce groundwater base flows groundwater allocations that are unrealistically high.

The PSP is accordance with this conclusion as the GRDM methodology cannot account for how groundwater abstraction can impact on baseflow, nor is the suggested recharge estimated methodology linked to baseflow to derive a water balance.

Groundwater RQOs and numerical limits were set in (DWS, 2014). These are based on maximum water level fluctuations, but do not consider borehole location.

The investigation focussed on surface water and ephemeral catchments were excluded. Six IUAs were identified and utilised for developing RQOs for the Lower Vaal. The D catchments of the western portion feeding the Kuruman and Molopo rivers were excluded (table 2-1 and figure 2-2).

Table 0-1 Catchments with a Reserve established

IUA	Quaternary
LV-A1	C31A-C31D
LV-A2	C31E
LV-A3	C32-A-D
LV-A4	C31F, C33A-C
LV-B	C91A-E, C92A-C
LV-C	Dolomitic aquifers

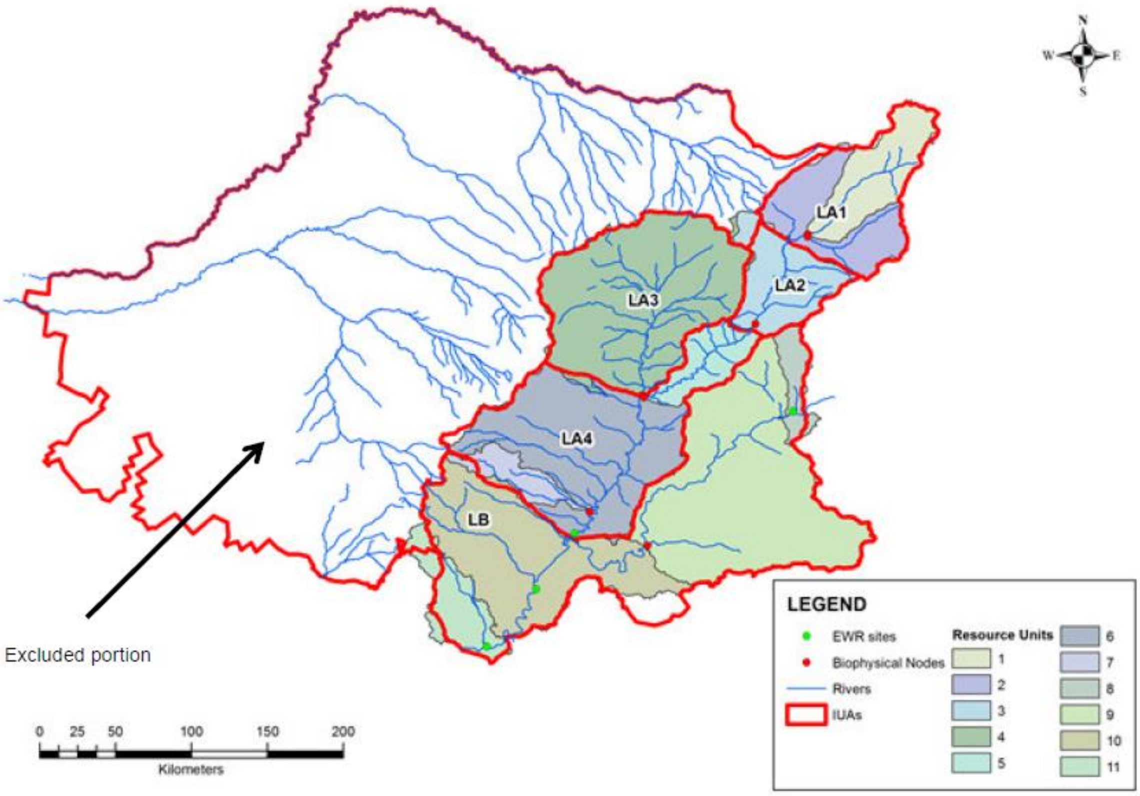

Figure 0-2 Portion of the Lower Vaal with a Reserve established

Reserve Determinations for the catchments of the Lower Vaal were gazetted in 2018 and 2020 and priority wetlands identified. However, these were not linked to integrated to existing surface water-groundwater models. The prescribed GRDM algorithm was used and an "allocable groundwater" volume (MCM/annum) was calculated, accounting for Basic Human Needs, baseflow requirements and the current water use.

INFORMATION REVIEW AND DATA REQUIREMENTS

1.9 Existing Reports

Table 3.1 lists the reports that have been obtained.

Table 0-1 Existing Reports

Report	Prepared by
Department of Water Affairs, South Africa, March 2011. Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8, 9, 10 Water Resource Analysis Report	WRP Consulting Engineers (Pty) Ltd
Lower Vaal Water Management Area: Water Resources Situation Assessment Report Main Report P 10000/00/0301	BKS
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE LOWER VAAL WATER MANAGEMENT AREA (WMA10) WP10535 RESOURCE UNIT DELINEATION REPORT REPORT NUMBER: RDM/WMA10/00/CON/RQO/0113	the Institute of Natural Resources (INR) NPC.
DEVELOPMENT OF INTERNAL STRATEGIC PERSPECTIVES GROUNDWATER OVERVIEW FOR LOWER VAAL CATCHMENT MANAGEMENT AREA	Darcy Groundwater Scientists and Consultants
Department of Water and Sanitation (DWS). 2014. Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS REPORT. Report No.: RDM/WMA10/00/CON/RQO/0214.	Institute of Natural Resources (INR) NPC. INR
Department of Water Affairs and Forestry, South Africa. 2004. *Internal Strategic Perspective: Vaal River System Overarching*. Report No P RSA C000/00/0103	PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3
PREPARATION OF CLIMATE RESILIENT WATER RESOURCES INVESTMENT STRATEGY & PLAN	WRP Consulting Engineers (Pty) Ltd

AND LESOTHO-BOTSWANA WATER TRANSFER MULTIPURPOSE TRANSBOUNDARY PROJECT Components i and ii. Groundwater report ORASECOM 006/2019	
Department of Water and Environmental Affairs (DWEA), 2009. Resource Directed Measures: Intermediate Reserve Determination Study for the Integrated Vaal River System: Lower Vaal Water Management Area. Groundwater Component: Groundwater Report.	Compiled by Raath, CJD (AGES),

1.10 HYDROLOGICAL DATA AND INFORMATION

Table 3.2 lists the information and data required for the execution of the work. During the execution of the activities and tasks an evaluation of the consistency of the data will be carried out as a matter of course and any irresolvable anomalies and deficiencies will be brought under the attention of the Client for clarification by the originators.

Table 0-2 Data sources

Type of Data	Data	Source
Catchment delineation	Quaternary catchment boundaries	WR2012
Population	Population	Stats SA
Climatic data	Rainfall and evaporation	ORASECOM/SAWS
Geology	Lithology and structures	CGS geological maps
Hydrology	WRSM2000 /Pitman Network	project team
Geohydrology	Harvest Potential Exploitation Potential Recharge Hydrochemistry Water levels Borehole yields	ORASECOM ORASECOM ORASECOM ZQM database and hydrocensus data NGA HYDSTRA NGA
Groundwater use	Licenced groundwater use Municipal water use Schedule 1 water use Livestock water use	WARMS Hydrocensus ORASECOM GRA II (DWAF, 2006a)

Surface Water Use		All Towns Strategies Annual Operating Rules Northern Region Reconciliation
Wetlands	location	NFEPA
Dolomitic eyes	Location and flow	DWS hydrological services and dolomite maps

It was also identified that the same data elements listed in **Table 3.2** would be required from other studies, like the WRSM2000/Pitman setup utilised for the ORASECOM hydrology of the Vaal system. This can be sourced by the study team since they were involved in the development of the hydrology.

Data sources to be used for the assessment of the significant groundwater resources will be from the NGA ZQM, GRAII, and updates to GRAII undertaken for ORASECOM 2019, which the study team were involved in.

WARMS or any current Validation and Verification studies will require the assistance of the DWS to obtain. The WARMS data was previously obtained in 2018 for the ORASECOM investigation, as was the ZQM data, However, data to present day will be required. The study team have also been responsible for the Classification of Surface and Groundwater Resources of the entire Vaal River System (DWA, 2012). All the relevant information and data from these studies is therefore available and assessable.

1.11 Assessment of Information

Reserve studies have been undertaken. These studies, however, did not incorporate integrated surface and subsurface modelling hence may not be in line with the groundwater balance. It is uncertain how the groundwater reserve was calculated and if it incorporates Schedule 1 water use and the BHNR.

Identifying the spatial distribution and extent of wetlands will rely on the NFEPA spatial and metadata.

Quantitative assessment of surface-groundwater interactions will require running WRSM2000/Pitman with the groundwater module and calibration against groundwater data. This has not been done in past studies and the data required to generate or update the groundwater component of the Reserve and quantify interactions. The groundwater use data will be updated based on latest WARMS (Water Authorisation and Management System) data and data in existing reports. Since existing WRSM2000 /Pitman simulations were not calibrated against groundwater variables like baseflow and recharge, it is not likely that the existing simulations can be used to obtain time series information from which to derive the groundwater contribution to surface water, or the reverse.

Previous studies were based on groundwater resources as listed in GRAII. These were not compared to a water balance of recharge, use and baseflow as monitored at gauging stations. Large errors were found during ORASECOM (2019).

The Reserve study did not contain a separate groundwater report hence the role of groundwater in maintaining the EWR is not reported on. This dearth of information suggests that the surface-groundwater interactions and Groundwater reserve will need to be evaluated, as this was not done in the pre-existing studies.

1.12 ASSUMPTIONS AND PROVISOS

It is assumed that all data from previous modelling studies will be available to the study team. The study team already has the hydrology and water resource model setups.

It is also assumed that reviewer comments will be provided to the PSP as an integrated set of comments by the DWS Project Manager (PM), immediately after the closure of the review period. This will need to be three (3) weeks for the Project Management Committee (PMC) and two (2) weeks for the Project Steering Committee meetings (PSC).

It is assumed DWS will assist in obtaining WARMS data.

The existing hydrology rainfall period will need to be extended. The extension of the hydrology will also be required as part of the current Central Region Reconciliation study, which the study team is involved with however, the timing of this study is still uncertain as work has not commenced. The Hydrology of the Lower Vaal will be undertaken as part of this study. It is critical that the DWS obtain rainfall up to and including hydrological year 2019 from SAWS free of charge for the project, otherwise the extension of the hydrology is not possible. The year 2019 is required so the hydrology is aligned with the reconciliation strategies. A similar requirement has been made by the Reconciliation Strategy project teams.

It should be noted that the data from the mining management plans will be essential to apply in the analysis of the study. It is therefore proposed that the study team engage with the mining sector (through DWS) to solicit cooperation and sharing of primary climatological and hydrological data to be applied (after critical review) in this assignment. Information from the recent Vaal-Gamagara pipeline feasibility studies will be sources, specifically in terms of options of groundwater use linked to the scheme.

1.13 RISKS AND UNCERTAINTIES

The review period poses a significant risk to the project timing if the review and report finalisation periods are not met. A two (2) week window has been allocated after the receipt of integrated comments from the DWS PM for the attention of the project team to make corrections and produce finalised documents. Should review periods not be met by DWS, or report finalisation by the project team, there will be a direct impact on the financial management of the project as invoices and payment are linked to final deliverables.

A risk in obtaining information from Local Government, water boards and irrigation boards timeously during the hydrocensus period also exists. This information will be required to assess current abstractions and identify stressed areas and protection zones. The assistance of the DWS may be required if this data is not forthcoming

SCOPE OF WORK

The major rivers are perennial, hence surface-subsurface interaction is expected. The significant surface water use and impoundments negate approaches such as hydrograph interactions for quantifying interactions with groundwater. The observed flow is consequently highly modified.

Significant groundwater use for irrigation and mining also impacts on observed low flows, again negating the use of observed flows for quantifying interactions.

These facts are key factors in the adopted methodology.

1.14 Study tasks

The proposed study has been structured and broken down into various tasks and sub-tasks as listed in table 4-1

Table 0-1: Proposed Study tasks and deliverables

Section	Task description	Deliverables
2,2	Study Inception	
	Identification of existing reports	• Inception report • Work programme • Capacity building plan • Expenditure projections
	Refine scope of work	
	Identify role players	
	Identify Capacity building objectives	
2.3	Review of Water Resource Information	
2.3.1	Literature Review and data gathering	Hydrogeological Report covering: • Groundwater resources including Harvest Potential, Recharge, Baseflow and groundwater use • Conceptual model of aquifers and aquifer types • Water balance and stress index • Identification of interaction zones • Identification of other potential studies to improve results
2.3.2	Hydrocensus	
2.3.3	Resource Assessment	
2.4	Surface-Groundwater Interactions	
2.4.1	Quantity groundwater recharge and baseflow	Reports covering:
2.4.2	Categorise groundwater quality	

Section	Task description	Deliverables
2.4.3	Groundwater levels and their fluctuations	• Surface-subsurface interactions using WRSM2000/Pitman and GRDM Methodology • Map of protection zones • Map of groundwater levels
2.4.4	Determination relevance of groundwater contribution to surface water and identify protection zones	
2.4.5	Groundwater conceptual model and maps	
2.4.6	Present status of groundwater	
2.4.7	Compilation of a monitoring programme	
3	Communication and Liaison	
3.1	Coordination of meetings	• Meeting documentation • Secretarial services • Project file of correspondence • Study Management Committee meetings (6) • Project steering Committee Meetings (3) • Progress reports (24) • Technical reports (7)
3.2	Study Management	• Invoices with financial monitoring reports (5). • Technical task team Meetings (4) • Close out report • Technical Reports (5) on sections 2.2-2.4
4	Capacity Building	• Trained officials • Summary document of training process and defining any further training that may still be required • Training workshop • Training manuals

The Review of information or Gap analysis report will summarise existing groundwater resources including Harvest Potential, Recharge, Baseflow and groundwater use from existing datasets. A Conceptual model of aquifers and aquifer types will be developed to identify areas where interaction modelling is of significance.

The Quantify Recharge and Baseflow Modelling Report will include the results the hydrological modelling to derive the surface and groundwater balance. Calibrated recharge and baseflow volumes will be obtained, as well as volumes of channel loss

The Protection zone Report will identify stressed areas, areas of particular significance where groundwater baseflow contributes to surface flow.

The Surface subsurface interaction report will quantify interactions and draw comparisons between natural baseflow, present day baseflow, and the existing Reserve determinations

The Main report will summarise the findings of the above reports

Capacity Building Report will describe the training provided

1.15 Cross Reference with the Technical Proposal

The scope and methods described in the proposal remained similar in this Inception Report with the following minor comments:

- Stakeholders are identified engagement events are now defined and budgeted.
- The WRSM2000/Pitman network utilised my not be WR2012 but will be the latest version compatible with existing WRYM and WRPM setups to facilitate updates to annual operating rules.

STUDY PROCEDURE AND METHODS

1.16 Study Inception

Objective

Ensure clarity on the objectives, methodology and deliverables is obtained. The inception report will form the basis of finalising the methodology and schedule (Gantt Chart) of tasks, resource requirements and project deliverables in a modular manner with clear milestones for events and deliverables. This will be carried out in consultation with the Client and through liaison with key stakeholders to ensure the Study Plan will achieve the objectives and expectations for the study. This Study Plan (Inception Report) will form the baseline for monitoring and evaluation of progress during the Study Implementation Phase.

The Inception Report will be presented to the Client for their comments and inputs before the document is finalised. In addition, the formatting of meeting agendas and minutes, progress reports, records of decisions and administrative tracking will be agreed with the Client during the Inception Phase.

A specific requirement of the TOR is the training and capacity building. The need and the envisaged topics for formal capacity building or training activities (if required) will be discussed and confirmed with the Client during the inception phase in order to set up a schedule and a tracking system for the identified capacity building or training activities which will be included in the Inception Report.

The inception report (Study Plan) will include the following components:

- Final description of sub-tasks and any additional work that may be requested by the Client.
- Updated task and activity logical flow diagram - indicating the dependencies of the tasks.

- Finalising the responsibilities and compile a study reporting structure that clearly defines the communication channels and procedures.
- Modular budget for all tasks and disbursements.
- Detailed schedule of personnel hours and costs.
- Detail schedule of events, milestones, and deliverables - detail work breakdown structure.
- Listing of the constraints and risks that may have an influence in the execution of the Study Plan.
- Evaluation and agreement of information sources to apply in the study especially where the data differs significantly.
- Define, describe, and agree with the Client the methods of how information and data generated from the study will be stored and disseminated.
- Develop a capacity building programme together with DWS

Deliverables:

- Inception Report including work programme and expenditure projections
- Presentation material (Power Point slides) of the Inception Report
- A summary the training process, and defining any further training that may still be required, and the roles of interns identified as needing training

According to the PSP contract the final Inception Report must be presented at the first PMC meeting and delivered in February 2022.

Information required from the DWS

-
- PMC and PSC members
- Report numbers
- Input on mentorship and capacity building

1.17 Review of Water Resource Information and Data Gathering

During this phase the relevant reports, data and information will be sourced and reviewed to improve the teams existing knowledge of surface subsurface interactions

Deliverables

Gap analysis Report covering:

- groundwater use and stress index
- source areas of interactions
- groundwater resource assessment
- Parameters of aquifer

- Water resource infrastructure
- data shortcomings
- maps of aquifer types and water levels

1.17.1 Conduct a Literature Search

Objective: The review of existing information will form the basis for clarification of objectives, methods, resource requirements and additional tasks

The objectives will be to:

- Conduct a literature review
- Obtain data from the NGA, GRAII, National water quality database, WR2012, WRYM and WRPM network studies etc
- Obtain census data and sources of water
- Evaluate land use maps
- Identify infrastructure
- Gather flow data from the DWS Hydrological network, including springs, as well as use data from Local Municipalities, especially Mmabatho's water use record.

1.17.2 Conduct a hydrocensus

The actions include:

- Obtain WARMS data
- Hydrocensus of relevant institutions
- Identify wetlands and protected areas
- Identify contaminant sources
- Analysis of water quality status

The identified institutions to be conducted include:

- Stakeholder identification and compilation of an interested and affected parties (IAP) database
- Stakeholder engagement and communication strategy and plan for the project
- Briefing of the IAPs, i.e. Irrigation Board, Water Board, Large Users, etc - to advise of project
- Maintenance of the IAP (interested and affected parties) database
- One on one sessions with affected stakeholders – i.e. thorough and meaningful stakeholder engagement that talks to project activities.
- Project team meetings and site progress meetings
- Monthly reports on the stakeholder engagement process, issues, and resolutions

- Close Out Report on complete stakeholder engagement process in word and PowerPoint format.
- Monitoring and evaluation process to allow for lessons learnt from the engagement process
- Collection of data held by stakeholders regarding surface and groundwater use, monitoring, water quality
- Understanding of water resource issues and problems identified by stakeholder institutions

1.17.3 Groundwater Resource Assessment

Objective: To quantify groundwater resources in the study area and a water balance.

The tasks include:

- Derive a groundwater conceptual model
- Summarise existing recharge, baseflow, stress index and Present Status category
- Determine aquifer types
- Quantify hydraulic characteristics

1.18 Determination of GW-SW Interaction

The objectives of this task are a quantitative assessment of the groundwater- surface water interactions to determine protection zones.

Deliverables:

Recharge and Baseflow Report, Protection Zone Report and Surface water groundwater interaction report covering:

- Quantity and quality of groundwater baseflow and recharge per existing databases per Quaternary catchment based on modelling and calibration
- Modelling of surface-groundwater interactions using WRSM2000/Pitman based on the existing surface water hydrology network and regional groundwater data to quantify baseflow volumes, recharge and existing baseflow reduction
- Ground water levels and their fluctuations
- Proposed groundwater protection zones
- Impacts of groundwater abstraction on baseflow
- The present status category of each catchment
- Classification of aquifers
- Recommendations for monitoring

1.18.1 Investigate the Quantity of Baseflow and Recharge

Objectives

The objectives of this task are to derive a calibrated water balance of surface and groundwater, calibrating recharge to match observed discharges and therefore derive an understanding of the resource available and to determine the impacts of abstraction on discharges.

Approach

Rainfall is the most important driver in the rainfall-runoff-recharge process. Variability in rainfall not only affects recharge, but also affects baseflow, hence it is a driver in maintaining low flows in rivers to meet the demands of downstream users. Any analysis of how the variability of rainfall can affect aquifer yields and the constraints on abstraction to maintain baseflow requires that resource evaluation be based on a time series of rainfall rather than on mean annual recharge.

The approach utilised will consist of:

- Utilising network setups of rainfall, water use, and dam releases in the ORASECOM hydrology and extending the record to calibrate the WRSM2000/Pitman model. Without modelling the Upper and Middle Vaal systems, observed flow records into Bloemhof dam will have to be used to extend upstream inflows. This data will have to be evaluated to assess if there were no long-term trends in the data that would influence the calibration and the natural timeseries generation. All networks will have to be checked against Google Earth to ensure that it is physically representative. Dolomitic compartments will have to be configured into the WRSM2000/Pitman runoff units and hydro-climatic conditions for each sub-division will have to be determined. The extension of the record for D41A feeding into D41 in the Lower Vaal is available from the Northern Region Reconciliation strategy.
- Detailed crop and irrigation system information will be obtained from the Vaal-Harts Scheme to correctly calibrate return flow factors for the scheme. All flow data will have to be patched before calibration can be done on the system. Assumptions on long-term groundwater use will have to be added to the models and timeseries of irrigation groundwater use will have to be generated.
- The existing Hydrology does not include Groundwater. Flow and dam balance data will be obtained for all gauges that have reasonable length and quality data in the catchment for the required hydrological period (1920 to 2019 hydrological years) for the catchments. These data will be used for model calibration, especially of low flows resulting from groundwater baseflow.
- Configuration of extendedWRSM2000/Pitman model baseflow and recharge against observed flow data will allow a calibrated time series of recharge and baseflow to be obtained. These will also be compared to the GRAII recharge and baseflow data, The Sami module of WRSM2000/Pitman will be calibrated to ensure that the effects of groundwater abstraction are correctly reflected in the base flow generated by the model.
- Evaluation of EWRs upstream and downstream of the dolomites, and RQOs set for the river, which may form one of the largest and most important components of existing groundwater demands
- After successful calibration of the WRSM2000/Pitman model, naturalised streamflows will be generated for at least each quaternary catchment as this data will be required to update the DWS Water Resources Yield Model (WRYM) and Water Resource Planning Model (WRPM) in future

(during the Central region Reconciliation Strategy). Different scenarios of natural flows can then be generated for example: Natural conditions (without any land and water uses, natural condition including present day development groundwater abstractions, natural condition including present day development groundwater abstractions and AIP. This will allow a derivation of a time series and groundwater balance, including recharge, baseflow, evapotranspiration and abstraction under natural and present conditions, hence a quantification of the resource with the ability to examine drought conditions and minimum baseflows.

- Based on the WRSM2000/Pitman simulations an assessment of the impact of groundwater abstraction and SFR activities on baseflow will be undertaken. Based on the findings recommendations will be made regarding the updating of the WRYM and WRPM systems, which the DWS utilise for planning and operational impact. A qualitative statement on the expected impact of the findings on the water resources availability will be made.
- Quantification of available groundwater resources per groundwater unit
- Based on the WRSM2000/Pitman simulations an assessment of the impact of groundwater abstraction and SFR activities on baseflow will be undertaken

Deliverable:

- Interaction Modelling report
- Recommendations on future revision to the WRYM and WRPM systems for the Vaal River

1.18.2 Evaluate Groundwater Quality

Objective: To characterise groundwater quality in each Quaternary catchment

Approach:

The approach will consist of:

- Categorise groundwater quality from the National Monitoring network (ZQM) into water quality classes for each catchment in terms of TDS, Nitrates, Fluorides, sulphates, and metals and other constituents found to be a problem.

1.18.3 Provide Groundwater Levels

Objective: Derive maps of groundwater level and depth to groundwater

Approach

- Collate groundwater level data in the NGA
- Derive depth to groundwater and piezometric maps
- Determine water level trends and fluctuations from monitoring boreholes

1.18.4 Determine relationships between groundwater and surface water

Objective: To identify priority areas where groundwater surface interaction is important and zones which need to be protected

Approach:

- Based on 2.4.1, derive baseflow indices
- Based on the relevance of baseflow (baseflow indices) the depth to groundwater, and groundwater quality, derive groundwater protection zones

Deliverable: Protection zone report

1.18.5 Describe the conceptual model of aquifer systems

Objective: Qualitatively describe the variations in aquifer systems

Approach:

- Map aquifer systems into types based on borehole yield and groundwater occurrence
- Map aquifer systems by groundwater quality'
- Map aquifers by interactions
- Map aquifers by baseflow index

1.18.6 Describe the Status of aquifer systems

Objective: To describe the present-day aquifer systems relative to natural conditions

Approach:

- Derive a stress index for each catchment relative to aquifer recharge from 2.4.1
- To determine the Present Status Category based on Stress Index and Water Quality Class
- Determine the impacts of groundwater abstraction on surface water flows using WRSM2000/Pitman, calibrated against present day flows. This will be achieved by calibrating the flow time series, then deriving a natural baseflow sequence, and a flow sequence under present day abstraction applied from 1920-2010.

1.18.7 Monitoring Programme

Objective: To identify data required for monitoring and propose a monitoring programme

Approach:

- Based on the existing hydrological network and identified protection zones, propose priority monitoring areas

Deliverable

Surface-Groundwater interaction report

This section of the report involves production of the output of the study, i.e., production of the main and close out reports and electronic data, as well as input to the gazette and management of the review period.

1.19 SUMMARY REPORTS AND ELECTRONIC DATA

All results of the study are summarised in a Main Report. The purpose of this document is to provide a succinct summary of the technical outputs of the study. The Close Out Report will summarise tasks such as management and communication strategies. All raw data, maps, GIS information, models, minutes of meeting and reports will be provided electronically on flash drives, together with a detailed inventory of what is provided.

Deliverable dates:

- According to the programme the three deliverables linked to this task are due September and October 2023.

1.20 Task and Deliverable Schedule

The due dates for deliverables from each task are shown in table 5-1.

Table 0-1 Deliverable due dates

NUMBER	DELIVERABLE	DUE DATE
4.3.1	Inception Report	February 2022
4.3.2	Gap Analysis Report	July 2022
4.3.3	Quantified Recharge and Baseflow Report	February 2023
4.3.4	Protection Zones Report	June 2023
4.3.5	Surface-Groundwater Interactions Report	September 2023
4.3.6	Project Steering Committee Meetings, updated stakeholder Issues and Responses	3 times throughout the project lifecycle
4.3.7	Project Management Committee Meetings and Ad-hoc Meetings	6 times throughout the project lifecycle
4.3.8	External Reviewer Report	October 2023
4.3.9	Management, Coordination and Liaison	Throughout the project lifecycle
4.3.10	Capacity Building Trainings Report	October 2023
4.3.11	Capacity Building Workshop	November 2022
4.3.12	Main Report	September 2023
4.3.13	Close-out Report	September 2023
4.3.14	Electronic Data Transfer	October 2023

MANAGEMENT, CAPACITY BUILDING AND TEAM STRUCTURE

1.21 Study Management

Project management caters for six Project Management Committee (PMC) meetings in an unspecified location. This is also advantageous when members are located in various locations. Covid 19 protocols have resulted in such meetings being virtual as common practice. Part of the Project Management function will be providing secretariat and communication coordination services. PMC meetings and all arrangements (invitation, agenda, presentations, and minutes) in this regard will be provided by the DWS.

Financial management will consist of invoices- per deliverable, progress reports (summarised), cash flow projections and general budget administration.

The budget also caters for an independent reviewer that will be appointed in liaison with the client.

The **Study Leader** will be responsible for overall coordination of the Consultant Study Team and activities will include:

- Serving as link between DWS Study Manager and Consultant Team
- Ensuring that the sub-consultants and/or co-consultants and specialists are properly briefed by the Task Leaders prior to commencing with work.
- Convene regular meetings with the Task Leaders as dictated by programme and progress.
- Rendering guidance and assistance to the Task Leaders.
- Monitoring and control of performance, programming, and cost of study, including revision of the Study Plan if and when necessary.

1.21.1 Financial control

A budget monitoring system comprising of an interactive spreadsheet model will be used to monitor and control costs. Budgets will be assigned to the key activities (sub tasks) under each main Task. Actual costs incurred will be correlated with completion targets to ensure compliance with progress.

Should deviations from the allocated costs for the key activities become evident, the Study Leader shall assess the reason/s and impact of such deviations and institute corrective action as required.

Where additional work may be required, the Study Leader shall obtain a detailed motivation and budget (both time and costs) from the relevant Task Leader for such additional activities for assessment and submission to the Study Manager for consideration and approval. *No additional expenses outside the approved budget will be allowed without the prior written approval of the Client.*

The Study Leader will submit progress report to the Client outlining costs against progress for each Task in a format as prescribed by the Study Manager.

1.21.2 Study administration

Study administration duties to be performed will include:

- Compiling, certifying, and submitting deliverables-based invoices to the Client from input received from the Task Leaders. The Client will be presented with only one invoice per deliverable from the Consultant Study Team. The Study Leader will arrange payment to the other members of the Study Team after receiving same from the Client.

- Keeping minutes of meetings with the Client and other stakeholder bodies and distribution thereof to the interested parties.
- Ensuring that all project files and data are kept up to date and accessible to the Client if and when required.

The **Study Leader** will provide a secretariat to perform the required duties for the Study Management Committee.

1.22 Project Management Committee

The Project management committee will undertake general management and sanction all deliverables. These will occur 6 times over the project duration and be chaired by the Client. The secretariat will be provided by the PSP. Each meeting will be preceded by a progress report.

1.23 Project steering committee

The project steering committee will provide technical input and guidance. It will meet 3 times and will include stakeholders. It is proposed that PSC 1 takes place in February 2022, after the Inception Report; PSC 2 in February 2023 after PMC 3; and the final PSC3 in September or October 2023.

Due to Covid 19 restrictions and budget constraints (no venues have been budgeted for in the Technical Proposal), it is suggested that at least 2 of these meetings be virtual, and 1 be held within the Lower Vaal catchment.

1.24 Technical task Meetings

Technical team leaders are to be available for up to 4 other meetings on an ad hoc basis.

1.25 Information required from the DWS

Guidance from the DWS Project Management Team regarding the following points, in particular:

- Report numbers
- Report formats
- Numbers of final reports to be printed and flash drives to be delivered at the end of the study
- Invoicing process, including format of invoices and deliverable dates
- DWS letters and input, as required
- List of Stakeholders and contact details
- Review of all documents, letters etc. as required
- Selection of the Project Management and Project Steering committees
- Compilation of PSC and PMC review comments within the agreed three (3) and two (2) week review periods respectively

- Other information or assistance as required

1.26 Capacity Building

The Capacity Building task of this study programme will focus on the further capacitation of DWS staff. The process to be followed to ensure capacitation through building on earlier exposure of staff members to surface-subsurface interaction quantification processes. This will require liaison with DWS during the inception phase of the study. A 5-day training session in the use and application of the DWS water resource models is envisaged, with specific attention to the groundwater-surface water interaction simulation methods.

Objective: The objective is to transfer skills to the DWS.

Approach:

- Training course in data extraction to assess groundwater resources
- Training course on WRSM2000/Pitman with emphasis on modelling surface-groundwater interactions with hands on application of the model, together with raining material
- Participation of DWS by parallel assessment of data used throughout the study
- Secondment of staff for certain tasks

The training will also include the following:

- Presenting the theory and simulation algorithms with interactive discussions.
- Demonstrating the application of the surface-groundwater model using example catchments.
- Practical's for trainees to evaluate key concepts:
  - Base flow separation.
  - Recharge derived from Soil Moisture – output of rainfall-runoff model.
  - Evaluate model parameter sensitivities on the simulation results.

Products:

- Power point presentations.
- Excel spreadsheets.

LIASION AND COMMUNICATION AND REPORTING

1.27 Committees

A **Project Steering Committee** (PSC) will be vital for the study as the members of the committee will be responsible to guide the process. The PSC will be a representative body of various sectors in the study area. Its purpose would be to provide guidance in the progressive development of procedures to operationalise Resource Directed Measures in the study area.

The identification of stakeholders will be an on-going process, refined throughout the process as the on-the ground understanding of affected stakeholders improves through interaction with various stakeholders in the catchment. The identification of key stakeholders and community representatives for this project is important and will be done in collaboration with the Department, and stakeholders in the study area.

Stakeholders' details will be captured on an electronic database. Comments and contributions received from stakeholders are recorded linking each comment to the name of the person who made it. Typically, stakeholders representing the following sectors of society: national, provincial, and local government (relevant local and district municipalities), relevant agricultural organisations and water boards.

The **PSP** will be responsible for the distribution of invitations and documents to the PSC members two weeks in advance of meetings. Recording, compilation, and distribution of the minutes of each PSC meeting will also be undertaken. A dry-run meeting will be held before each PSC meeting – this may be planned to coincide with PMC meetings.

Ad-hoc meetings: Meetings to discuss specific technical details will be held. The number of meetings will be determined as the need arises; however, this proposal includes for 4 ad-hoc meetings to be held in Pretoria.

Recording of comments: An Issues and Response Report will be updated as the process unfolds. This report will list all the comments and questions from stakeholders during the project and responses to those from the project team. This report will provide a record of stakeholder comments throughout the process and responses from the team.

DWS web site: All public information will be made available to the DWS to upload on the Department's website and this address will be sent to all stakeholders.

1.28 Client liaison (meetings)

Liaison with the DWS Study Manager will include the following activities:

- Coordination and attendance of six (6) Project Management Committee (PMC) Meetings every four months with the DWS Study Manager. The PMC meetings will either co-inside or be integrated with the Project Steering Committee Meetings (3). Technical, administrative, and financial progress reports will be presented at each of these meetings.
- Coordination and attendance of three (3) PSC meetings
- Establishing interim communication (between meetings) to advise the Study Manager of, inter alia, notable events or problem situations, possible changes to the scope of work, appointment of sub-consultants, etc.
- Coordination and attendance of 4 other ad hoc meetings of the Technical Task team
- Compiling and updating the "Record of Decisions" and "Record of Requests" and ensuring that all recorded actions are attended to within the specified budget and time limits.
- Maintain a project file of all correspondence

- Motivating the appointment of proposed new members of the consultant team to the Study Manager as and when required.
- Implementing the appointment of the sub-consultants and/or co-consultants and specialists after approval by the Client.
- Provision of secretarial services at all the meetings
- Submission of monthly progress reports and quarterly technical reports

Deliverable/s: The following deliverables will be produced:

- Inputs for the Inception Report, including review of existing information
- Invitation to three meetings (3 x PSC)
- Agenda, attendance register, minutes of three PSC meetings
- Compilation of the Issues and Response Report (Ongoing with final report at the end of the study)
- Inputs to the DWS website
- Inputs for the Closure Report

1.29 Proposed PMC Meeting dates

PMC meeting dates as proposed below. Dates have been selected so as to report on main project deliverables. In most instances the PMC meeting will also serve as a dry run for the following PSC meeting.

- PMC1: February 2022.
- PMC 2: July 2022
- PMC 3: February 2023
- PMC 4: June 2023
- PMC 5: September 2023
- PMC 6: October 2023

STUDY STRUCTURE, PROGRAMME AND STUDY TEAM

1.30 Study Team

The study team (table 8-1) consists of individuals with extensive experience in the field of groundwater resource planning, implementation, development of integrated surface groundwater resource models and the compilation of groundwater strategies. The proposed team members have been involved in a variety of studies for DWS, Municipalities, Mining Houses, the World Bank, and the European Union over the past 30 years.

This pool of experience and knowledge will ensure the successful execution of the work and production of deliverables.

No changes are proposed from the technical proposal

Table 0-1: The following Key Personnel form the core of the study team.

Name	Company	Position	Profession & skills
Sami K, MSc Pr.Sci.Nat	WSM Leshika Consulting	Study Leader / Principal Hydrogeologist	Hydrogeologist, groundwater resources evaluation, modelling, SW-GW interaction
Masvopo T, BSc(Hons) Pr. Sci. Nat)	WSM Leshika Consulting	Hydrogeologist	Hydrogeologist, GIS, mapping, drilling, and pumping tests
Haasbroek, B BSc(Hons) Pr. Sci. Nat)	Specialist Sub-consultant	Hydrologist	Hydrologist, Water Resources Planner, Hydro-informatics
Seago, C (M. Eng., Pr. Eng.)	Specialist Sub-consultant	Water Resources	Agricultural Engineer, Water Resources Engineering
Leshika D, BAdmin MBA	WSM Leshika Consulting	Institutional and Social Development	ISD Practitioner, Institutional and public participation
Fourie, I	WSM Leshika Consulting	Project Secretary	Meetings and minutes

1.31 Study Structure

The study structure is shown in figure 8-1.

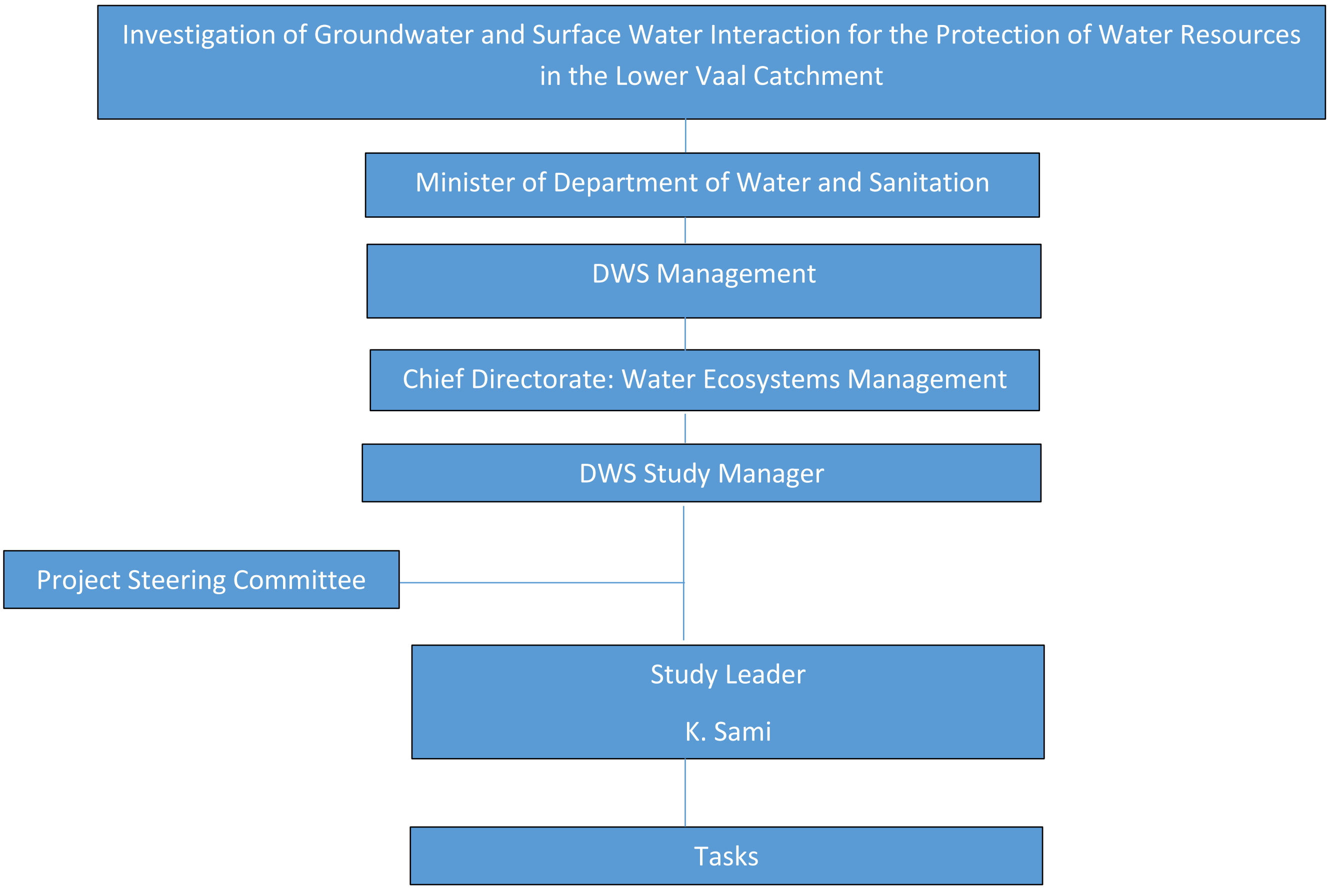

Figure 0-1 Project Organogram

1.32 Task Responsibility

Study leader: K. Sami

Task leaders: K. Sami, D. Leshika (Hydrocensus)

Financial manager: C. Haupt

Administration: I. Fourie

Compilation of reports: I. Fourie

Editor: C. Haupt

Communications regarding meetings: K. Sami, I. Fourie

Notes:

- The PSP is not responsible for ensuring reports are signed by the other delegated authorities as shown on the signatory pages of the reports.
- The PSP is not responsible for ensuring PMC and PSC comments on technical reports are received timeously.

1.33 Project Flow Chart

A flow chart of project tasks and subtasks and the responsible person is shown in figure 8-2. A Gannt chart of project progress is shown in table 8-2.

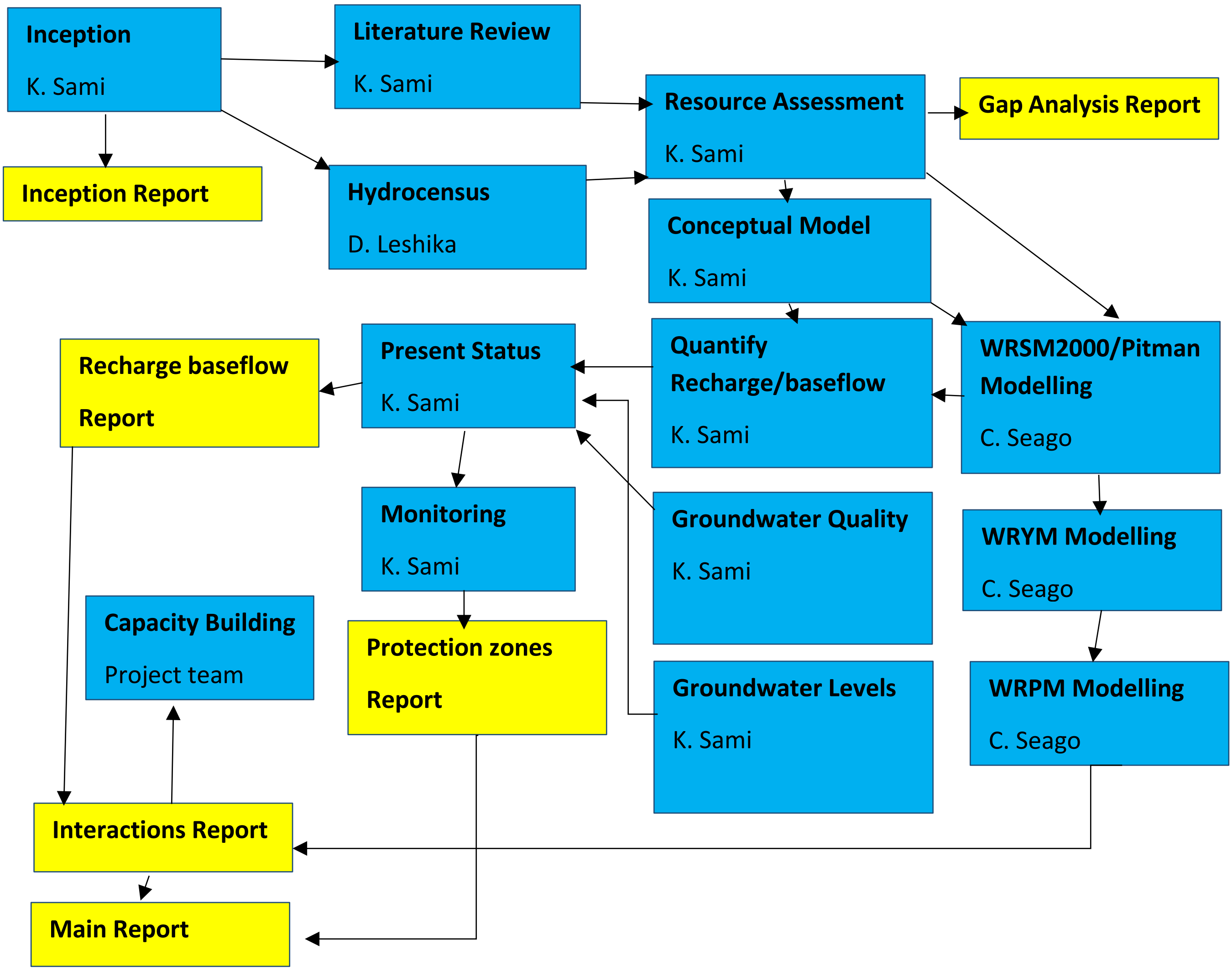

Figure 0-2 Flow chart of tasks and sub-tasks

Table 0-2GANTT chart for the Lower Vaal study

TASKS	2021			2022												2023										
	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov
Inception		Draft			FR																					
Review of Information										FR																
Literature review																										
Hydrocensus																										
Resource assessment																										
Surface-groundwater interactions																	R							R		
Quantify recharge and baseflow																										
Categorise water quality																										
Groundwater levels																										
Protection zones																					R					
Groundwater cocneptual model																										
Present status																										
Montoring programme																										
Communication and liasion																										
PSC Meetings																										
PMC mettings																										
Technical coordination																										
Mobilsation of team																										
Financial management																										
Issues and response report																								R		
Reviewer																										
Capacity Builidng																									R	
training																										
Workshop																										
ADDITIONAL REPORTING																										
Main report																								R		
Close-out report																								R		

FINANCIAL SUMMARY

The costs presented in this section are based on the work program and estimated person-hour schedule provided in the previous sections. The costs are applicable to the study period, which has been programmed for 24 months.

1.34 Summary of Costs

A summary of the proposed Study Costs is provided in table 9-1.

Table 0-1 Summary of the proposed Study Costs.

Item	Cost (Rand)			% of Total
	Excl VAT	VAT	Incl VAT	
Professional Fees	2 156 100	323 415	2 479 515	94.69
Disbursements	121 000	18 150	139 150	5.31
Total	2 277 100	341 565	2 618 665	

1.35 Professional Fees

Estimates of the total professional fees for each team member and costs per task are provided in Table 9-2.

1.36 Cash Flow

A cash flow projection graph (excl. VAT) is provided in **Figure 9-1.** The figures are shown for month incurred and linked to the GANTT chart (figure 8-2). Because invoice is by deliverables only, it is expected that the PSP will incur a negative cash flow and it is hoped that reports are reviewed, and invoices are processed timeously.

Table 0-2 Costs by task

Task	Task description and personnel	Rate	Amount	Unit	Cost
1	**Study Inception**				**R85 200**
	K. Sami	1 400	40	hours	R56 000
	B. Haasbroek	1 100	16	hours	R17 600
	T Masvopo	850	8	hours	R6 800
	C. Seago	1 200	4	hours	R4 800
2	**Review of Information**				**R431 800**
2.A	**Literature Review**				
	K. Sami	1 400	24	hours	R33 600

	B. Haasbroek	1 100	30	hours	R33 000
	T Masvopo	850	32	hours	R27 200
	C. Seago	1 200	22	hours	R26 400
2.B	**Hydrocensus**				
	K. Sami	1 400	8	hours	R11 200
	T Masvopo	850	40	hours	R34 000
	D. Leshika	1 200	40	hours	R48 000
	I. Fourie	350	24	hours	R8 400
	Travel			sum	R5 000
2.C	**Resource Assessment**				
	K. Sami	1 400	24	hours	R33 600
	T Masvopo	850	32	hours	R27 200
2.D	**Report Compilation**				
	K. Sami	1 400	40	hours	R56 000
	B. Haasbroek	1 100	22	hours	R24 200
	T Masvopo	850	40	hours	R34 000
	C. Seago	1 200	18	hours	R21 600
	I. Fourie	350	24	hours	R8 400
3	**Surface - groundwater Interactions**				**R822 800**
3.A	**Quantify recharge and baseflow**				
	K. Sami	1 400	20	hours	R28 000
	B. Haasbroek	1 100	90	hours	R99 000
	T Masvopo	850	40	hours	R34 000
	C. Seago	1 200	73	hours	R87 600
3b	**Categorise water quality**			hours	
	K. Sami	1 400	24	hours	R33 600
	T Masvopo	850	24	hours	R20 400
3c	**Groundwater levels**				
	T Masvopo	850	80	hours	R68 000
3d	**Protection zones**				
	K. Sami	1 400	40	hours	R56 000
	T Masvopo	850	60	hours	R51 000
3e	**Groundwater conceptual model**	0			
	K. Sami	1 400	24	hours	R33 600
	T Masvopo	850	60	hours	R51 000
3f	**Present status**				
	K. Sami	1 400	32	hours	R44 800
	T Masvopo	850	16	hours	R13 600
3g	**Monitoring Programme**				
	K. Sami	1 400	24	hours	R33 600
	B. Haasbroek	1 100	16	hours	R17 600

	T Masvopo	850	8	hours	R6 800
3h	**Report Compilations**				
	K. Sami	1 400	40	hours	R56 000
	B. Haasbroek	1 100	22	hours	R24 200
	T Masvopo	850	40	hours	R34 000
	C. Seago	1 200	18	hours	R21 600
	I. Fourie	350	24	hours	R8 400
4	**Study Management Communication and Liaison**				**R663 700**
4a	**Study Steering Committee Meetings**				
	K. Sami	1 400	80	hours	R112 000
	T Masvopo	850	24	hours	R20 400
	I. Fourie	350	120	hours	R42 000
	Travel			sum	R6 000
	Office costs			sum	R2 000
	subsistence			sum	R2 000
4b	**Study Management Committee Meetings and adhoc meetings**				
	K. Sami	1 400	120	hours	R168 000
	C. Seago	1 200	24	hours	R28 800
	I. Fourie	350	120	hours	R42 000
	Travel			sum	R6 000
	Office costs			sum	R2 000
	subsistence			sum	R2 000
4c	**Study Administration, Co-ordination, Liaison and Monitoring**				
	K. Sami	1 400	24	hours	R33 600
	B. Haasbroek	1 100	16	hours	R17 600
	I. Fourie	350	40	hours	R14 000
4d	**Mobilisation of study team**				
	I. Fourie	350	16	hours	R5 600
4e	**Financial Management**				
	K. Sami	1 400	8	hours	R11 200
	I. Fourie	350	150	hours	R52 500
4f	**Reviewer**	1 600	60	hours	R96 000
5	**Capacity Building**				**R148 000**
	K. Sami	1 400	40	hours	R56 000
	B. Haasbroek	1 100	40	hours	R44 000
	D. Leshika	1 200	40	hours	R48 000
6	**Additional reporting**				**R125 600**
6.1	**Main Report**				
	K. Sami	1 400	24	hours	R33 600

	B. Haasbroek	1 100	24	hours	R26 400
	T Masvopo	850	24	hours	R20 400
	I. Fourie	350	32	hours	R11 200
6.2	**Close Out Report**				
	K. Sami	1 400	8	hours	R11 200
	B. Haasbroek	1 100	8	hours	R8 800
	I. Fourie	350	24	hours	R8 400
6.3	**Electronic Data Transfer**				
	I. Fourie	350	16	hours	R5 600
	TOTAL				**R2 277 100**
	15% VAT				**R341 565**
	GRAND TOTAL				**R2 618 665**

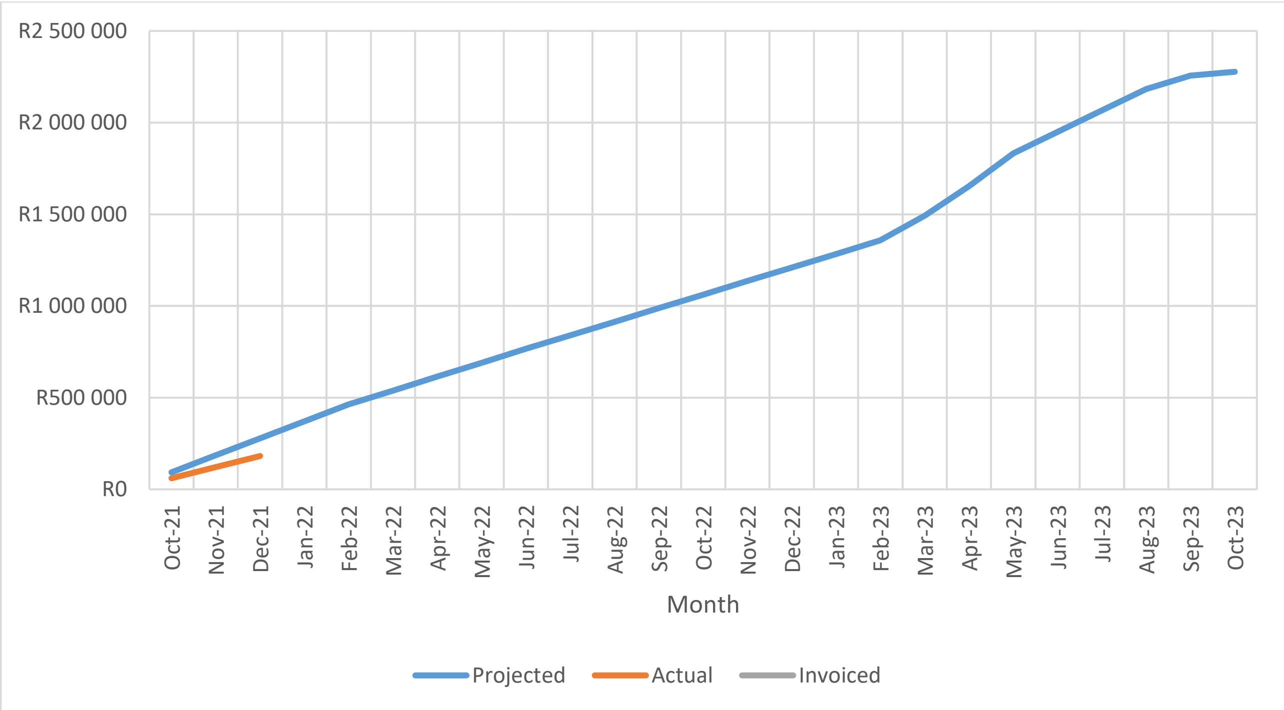

Figure 0-1 Cash flow

REFERENCES

Department of Water Affairs, South Africa, March 2011. Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8, 9, 10 Water Resource Analysis Report. Prepared by: WRP Consulting Engineers (Pty) Ltd.

Department of Water Affairs and Forestry 2002. Lower Vaal Water Management Area: Water Resources Situation Assessment Report Main Report P 10000/00/0301. Prepared by: BKS.

Department of Water and Sanitation (DWS) 2014. Determination Of Resource Quality Objectives in The Lower Vaal Water Management Area (WMA10) WP10535 Resource Unit Delineation Report. Report Number: RDM/WMA10/00/Con/RQO/0113. Prepared by: the Institute of Natural Resources (INR) NPC.

Department of Water Affairs and Forestry, South Africa, March 2004. Development Of Internal Strategic Perspectives Groundwater Overview for Lower Vaal Catchment Management Area. Prepared by: Darcy Groundwater Scientists and Consultants.

Department of Water and Sanitation (DWS). 2014. Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): Resource Quality Objectives and Numerical Limits Report. Report No: RDM/WMA10/00/CON/RQO/0214. Prepared by: Institute of Natural Resources (INR) NPC. INR.

Department of Water Affairs and Forestry, South Africa. 2004. Internal Strategic Perspective: Vaal River System Overarching. Report No P RSA C000/00/0103. Prepared by: PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3.

Preparation Of Climate Resilient Water Resources Investment Strategy & Plan and Lesotho-Botswana Water Transfer Multipurpose Transboundary Project Components I And II. Groundwater report ORASECOM 006/2019. Prepared by: WRP Consulting Engineers (Pty) Ltd.

Department of Water and Environmental Affairs (DWEA), 2009. Resource Directed Measures: Intermediate Reserve Determination Study for the Integrated Vaal River System: Lower Vaal Water Management Area. Groundwater Component: Groundwater Report. Prepared by: Raath, CJD (AGES).

APPENDIX A - COMMENTS

Section	Comment	Addressed (Y/N)	Modification
Stanley Nzama			
1.1	This part of the sentence gives an impression that the Act only focuses on water resources protection which is not correct, only Chapter of the Act focuses on water resources protection.	Y	As per the suggested sentence provided by SN
	Various editorial	Y	
Fig 2-1	This figure does not adequately reflect the description provided in the text paragraphs.	Y	Map changed
2.5	I feel that this section was not appropriately portrayed. What is this section telling us about? Or what is message being given in this section? Further discussion during the Inception meeting would be useful	Y	The section has been expanded to explain why this conclusion was reached
2.5	This paragraph exclusively talks about the Reserve whereas the section is supposedly reflecting on RQOs ***[2.5 Resource Quality Objectives]***, is it misplaced maybe?	Y	Terminology and heading changed
5.2.1	Wil Literature review include research work conducted especially in the country or it will be limited to government reports?	N	All relevant reports. This includes WRC and ORASECOM
5.3.1	Will it be feasibly to investigate quantity of ***groundwater contribution*** to baseflow?	n	Yes using WRSM2000/Pitman, calibrated against gauging stations during dry periods

5.3.2	There are several water quality parameters that can also be included, especially the ones considered when a groundwater quality component of Reserve is determined. Is the study team flexible in terms of consideration of such variables? Or are there any specific reasons for choosing only TDS, Nitrates, Fluorides, sulphates, and metals only?	Y	Other constituents found to be a problem
Lawrence Mulangaphuma			
1.1	Chapter 3 of the National Water Act (NWA) 1998 (Act 36 of 1998) deals with the protection of water resources. The NWA deals with wide range of aspects not protection of water resource only.	Y	See above
Adaora Okonkwo			
2.1	Page4: It is no longer Lower Vaal WMA(Check throughout the document). Paragraph 4. The first sentence needs rephrasing	Y	Rephrased
3.3	Page14: The first paragraph: the reserve report should be sourced from the Department so that the process is not repeated.	N	This has already been sourced, both intermediate Reserve report and the Gazetted RQOs
4.2	Page17: Second bullet: Why is there the deviation from the technical proposal?	N	Since the proposal was submitted, the Reconciliation Strategies have been initiated. These are agreed to run to 2019-2020, and will revise the WRYM/PM models. This study should be compatible with the Central Region Recon to avoid duplication an d sol that the results can be incorporated
	All editorial corrections	Y	Noted and corrected

5.3.2	How were the groundwater quality parameters determined? Is the study only looking at those parameters?	Y	See above
5.3.4	Protection in terms of quantity was discussed. What happens to the quality aspect?	Y	Groundwater quality added
6.2	The PMC meetings are lumped together with *ad hoc* meetings and it will take place 6 times throughout the study. This is different from what is written on page 27. Please check the two pages	Y	Amended to read 6 times
6.2	What is the difference between Project Management meeting and study Management meeting?	Y	Headings corrected
7.1	The responsibility of the project steering Committee is not captured correctly.	Y	Responsibility changed to PSP
Kwazikwakhe Majola			
cover	There's a new version for the approval page which includes Project Manager, Scientific Manager and Director. The Chief Director is no longer included.	Y	New version replaces old one
2.1	Please check others in the report for consistency	Y	WMA replaced by catchment throughout document
6.1	For meetings, what is the plan if Covid-19 restrictions do not allow for maximum physical participation?	Y	Virtual PMCs suggested

6.1.2	Invoices not monthly but Deliverable-based	Y	corrected
6.3	Can the times of these meetings be included as well, for instance the 1st PSC meeting will be after which Deliverable, and then the others. Also, will these be in one area or spread through the study area?	Y	Dates proposed
6.5	I was under the impression that this is developed by the PSP in collaboration with the DWS	Y	Modified so that only list of stakeholders and contact details be provided by the DWS