Department of Water & Sanitation

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REPORT

Integrated Water Quality Management Plan for the Olifants River System

Scenario Analysis Report

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DEPARTMENT OF WATER AND SANITATION

Water Resource Planning Systems Series

Development of an Integrated Water Quality Management Plan for the Olifants River System

Scenarios Analysis Report

Study Report No. 4

P WMA 04/B50/00/8916/5

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15.0	P WMA 04/B50/00/8916/16	Study Close-out Report

APPROVAL

Title: Development of an Integrated Water Quality Management Plan for the Olifants River System: **Scenarios Analysis Report**

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The project team would also like to acknowledge the Project Steering Committee members as well as broader stakeholders who have taken time to review the reports and who have contributed positively to the project. A full list of names is included in Appendix B and C to this report.

EXECUTIVE SUMMARY

The Department of Water and Sanitation (DWS) from a planning perspective has identified the need to develop an overarching Integrated Water Quality Management Plan (IWQMP) for the Olifants WMA in order to manage the water resources and needs to take cognisance of, and align to a number of studies and initiatives that have been completed to date, and needs to establish clear goals relating to the quality of the relevant water resource in order to facilitate a balance between protection and use of water resources.

The main objective of the study is to develop management measures to maintain and improve the water quality in the Olifants WMA in a holistic and sustainable manner so as to ensure sustainable provision of water to local and international users. The management measures will be of an overarching nature and will deal with the broader Olifants WMA while taking the strategies and plans developed at the sub-catchment level into account.

The following aspects of the study have already been undertaken:

- Inception Report (Report No: P WMA 04/B50/00/8916/1);
- Water Quality Status Assessment and International Obligations With Respect To Water Quality Report: (Report No: P WMA 04/B50/00/8916/3); and
- Water Quality Planning Limits Report: (Report No: P WMA 04/B50/00/8916/4).

The following components are now underway:

- Scenario Analysis Report;
- Reconciliation and Foresight Report;
- Management Options Report;
- Integrated Water Quality Management Plans for each Sub-catchment:
  - IWQMP for the Upper Olifants sub-catchment;
  - IWQMP for the Middle Olifants sub-catchment;
  - IWQMP for the Lower Olifants sub-catchment;
  - IWQMP for the Steelpoort sub-catchment; and
  - IWQMP for the Letaba and Shingwedzi sub-catchments,
- Monitoring Programmes Report;
- Overarching IWQMP for the Olifants River System; and
- Implementation Plan Report.

The key to the successful management of the water quality in the Olifants River System is the formulation of management measures that will integrate all the relevant aspects that have a bearing on the water resources. In this respect an assessment of the physical, economic, social, institutional, statutory and ecological aspects in the system was undertaken to understand the current situation and therefore be in a position to assess existing management options and proposed new options that will be able to handle the existing as well as anticipated future challenges (DWS Report number: P WMA 04/B50/00/8916/3).

Furthermore it is expected that the growing economy, in the Olifants System, will intensify the pressures on the water quality of the resource and it is therefore necessary to find innovative measures that offer economical and sustainable management solutions.

The following scenarios will be taken forward into the Management Options component.

In respect of water quality the strategy for salinity will need to consider: defunct mines, operating mines, industries and power stations and the irrigation return flows in the case of the Lower Moses and Elands rivers. The main sources of pollution contributing to salinity that need to be addressed, and for which scenarios interventions will be considered are:

- Reduced load due to seepages from the mine, industrial and power station waste storage facilities and mining operations in the Upper Olifants sub-catchment, some load from the Steelpoort sub-catchments and the Ga-Selati in the lower Olifants sub-catchments.;
- Reduced load from excess mine water on the mining operations threatening to decant or starting to flood the coal reserves in the Upper Olifants sub-catchment; and
- Reduced load from irrigation return flows in the Upper and Middle Olifants.

In terms of nutrients the largest impacts are from poorly managed wastewater treatment works and contaminated run-off from urban and agricultural areas. The main sources of pollution contributing to nutrients in the system that need to be addressed, and for which interventions will be considered are: The following scenarios to be considered are likely to have the biggest impact on controlling nutrients (and microbiological contamination):

- Reduction of nutrient load from domestic WWTW that discharge to the water resources, by considering a reduction of the orthophosphate concentration to 1 mg/L;
- Reduction of nutrient and sediment load from agricultural areas and areas where changing land uses may be occurring;
- Reduction of nutrient and sediment load from run-off from urban/ densely populated areas; and
- Improved reuse of effluent from domestic wastewater treatment works not designed to meet the general discharge limits.

Groundwater is addressed separately and will include the scenario around the protection of groundwater and the treatment of groundwater for potable supply.

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LIST OF ACRONYMS

COGTA	Co-operative Governance and Traditional Affairs
CSIR	Council for Scientific and Industrial Research
DMR	Department of Mineral Resources
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
IWQMP	Integrated Water Quality Management Plan
KNP	Kruger National Park
MU	Management Unit
MWCB	Mine Water Co-ordinating Body
PAC	Project Administrative Committee
PGM	Platinum Group Metals
PMC	Project Management Committee
PSC	Project Steering Committee
PSP	Professional Service Provider
RQOs	Resource Quality Objectives
RWQOs	Resource Water Quality Objectives
SALGA	South African Local Government Association
TDS	Total Dissolved Salts
WC/ WDM	Water Conservation/ Water Demand Management
WMA	Water Management Area
WMS	Water Management System
WQP	Water Quality Planning
WQPL	Water Quality Planning Limits
WRC	Water Research Commission
WWTW	Wastewater Treatment Works

1. INTRODUCTION

1.1 Background

The Olifants River System, the spatial extent of which includes tertiary drainage regions B11, B12, B20, B31, B32, B41, B42, B52, B52, B60, B71, B72 and B73 in the Olifants River catchment, B81, B82 and B83 in the Letaba catchment and B90 in the Shingwedzi catchment, is a highly utilised and regulated catchment and like many other Water Management Areas (WMA) in South Africa, its water resources are becoming more stressed from both a water quantity and water quality point of view. This is due to an accelerated rate of development and the scarcity of water resources. There is therefore an urgency to ensure that water resources in the Olifants River System are able to sustain their level of uses and be maintained at their desired states.

The Olifants River originates at Trichardt, east of Johannesburg. The Olifants River flows northwards through Witbank Dam down to Loskop Dam. The confluences of the Klein Olifants, Spookspruit, Klipspruit and Wilge Rivers with the Olifants River are between the Witbank and Loskop dams. From Loskop Dam the Olifants River flows some 80 km to Flag Boshielo Dam. The Moses and Elands Rivers join the Olifants River downstream of Loskop Dam from the west while the Bloed River joins from the east. The Steelpoort River confluences with the Olifants about 50 kilometres before the confluence of the Olifants and Blyde rivers after which it confluences with the Ga-Selati on the border of the Kruger National Park (KNP). The Letaba River joins the Olifants River upstream of the border into Mozambique in the KNP, after which it flows into the Massingir Dam about six (6) kilomteres from the border, before it joins the Limpopo River which eventually discharges into the Indian Ocean. The Shingwidzi River flows south east through the KNP becoming the Rio Shingwidzi in Mozambique where it confluences with the Rio Elefantes downstream of the Massingir Dam.

This study focusses on the South African sector of the Olifants River system and does not deal with the Mozambique sector, however the improvement in the South Africa portion of the Olifants River system, will ultimately have a positive impact on the Massingir Dam and the lowest reaches of the Rio Elephantes which is controlled by inflows from upstream (South Africa).

Formal economic activity in the system is highly diverse and is characterised by commercial and subsistence agriculture (both irrigated and rain fed), diverse mining activities', manufacturing, commerce and tourism. Large coal deposits are found in the eMalahleni and Middelburg areas (Upper Olifants) and large platinum group metal (PGM) deposits are found in the Steelpoort, and copper in the Phalaborwa areas. The catchment is home to several large thermal power stations, which provide energy to large portions of the country. Extensive agriculture can be found in the Loskop Dam area, the lower catchment near the confluence of the Blyde and

Olifants Rivers as well as in the Steelpoort Valley and the upper Selati catchment. A large informal economy exists in the Middle Olifants, with many resource-poor farmers dependent upon ecosystem services. The area has many important tourist destinations, including the Blyde River Canyon and the Kruger National Park. Land use in the Olifants River System is diverse and consists of irrigated and dryland cultivation, improved and unimproved grazing, mining, industry, forestry and urban and rural settlements.

The Department of Water and Sanitation (DWS) from a planning perspective has identified the need to develop an overarching Integrated Water Quality Management Plan (IWQMP) for the Olifants WMA in order to manage the water resources and needs to take cognisance of, and align to a number of studies and initiatives that have been completed to date, and needs to establish clear goals relating to the quality of the relevant water resource in order to facilitate a balance between protection and use of water resources.

The main objective of the study is to develop management measures to maintain and improve the water quality in the Olifants WMA in a holistic and sustainable manner so as to ensure sustainable provision of water to local and international users. The management measures will be of an overarching nature and will deal with the broader Olifants WMA while taking the strategies and plans developed at the sub-catchment level into account.

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    - IWQMP for the Letaba and Shingwedzi sub-catchments,
- Monitoring Programmes Report;

- Overarching IWQMP for the Olifants River System; and
- Implementation Plan Report.

1.2 Development and analysis of scenarios

The Status Assessment and Water Quality Planning Limits reports (P WMA 04/B50/00/8916/3 and P WMA 04/B50/00/8916/4 respectively) have indicated specific areas of concern in the six delineated sub-catchments of the Olifants WMA, with the major issues identified as the impacts from mining; wastewater discharge; urban run-off; industrial; and agricultural activities that have a bearing on its future management and operation.

Non-compliant wastewater treatment works contributing to organic, microbiological and nutrient loads are a serious threat to the water resources of the WMA. This situation appears to be continuing unabated, and until such time as this matter is addressed by all the role players at the appropriate levels, water quality management goals will not be achieved. This must be prioritised by the larger municipalities as well as local authorities of the smaller towns and will form part of the implementation plan for this project.

Mining activities are impacting significantly on the water quality of the water resource system which is changing the characteristics of some of the water resources to such an extent that its ecological infrastructure value has been lost. Complete or partial loss of wetlands, and impacts on water quality due to mining activities has, and continues, to impact on the water resource system of the WMA. Decisions around future mining need to be informed by a better understanding of the cumulative long-term effects on the water resource system. In addition a strategy needs to be developed and implemented to deal with the water discharging from the defunct mines as well as existing mines post-closure and will form part of the implementation plan for this project.

Runoff from commercial agricultural areas contains agro-chemicals, which are causing eutrophication or contamination of water with pesticides downstream of the irrigated areas. While the impacts from the use of pesticides (including herbicides) are still relatively unknown a strategy must be developed to get a better understanding of these impacts.

Erosion, turbidity and sediment deposition are diminishing the potential of the hydrological system and loss of natural filters such as wetlands are also resulting in an increase in sediments in the water, increased erosion and terrestrial alien invasion.

Models have been run to determine the extent of the salinity and nutrient concerns and scenarios for the main areas impact have been put forward. The approach used is described in Chapter 2 of this report.

1.3 Objective of the evaluation of water quality management scenarios

The evaluation of water quality management scenarios for the major areas of concern noted forms the core activity for the development of the IWQMP and has the objective of assessing the feasibility of possible management scenarios that could be implemented in the short, medium and long term:

- Options, most likely operational in nature, to be implemented over the first five years (quick wins);
- Medium term strategies that would require further investigations and have the objective of covering a ten to fifteen year planning period; and
- Long term management measures to ensure that the water quality in the system is maintained where it is in an acceptable condition or even improved and considers the planning period up to the year 2040.

The key to successful control of water quality parameters at levels acceptable for water users in the Olifants River System is the formulation of management measures that will integrate all the relevant aspects that have a bearing on all aspects of the water resources. This requires assessments of the physical, economic, social, institutional, statutory and ecological aspects in the system in order to understand the current situation and be in a position to find management options that will be able to handle the existing as well as anticipated future challenges. Furthermore it has been identified that the growing economy, particularly in the Upper and Middle Olifants sub-catchments and to a lesser extent the upper parts of the Letaba sub-catchment, have and will continue to intensify the pressures on the water quality of the resource. It is therefore necessary to find innovative measures that offer economical and sustainable management solutions.

The Reconciliation Strategy (DWS, 2015) has put forward the following intervention scenarios:

- WC/ WDM (Irrigation, Urban and Mining Sectors);
- Eliminate Unlawful Use;
- Development of Groundwater Resources;
- Removal of Invasive Alien Plants;
- Treatment of mine water; and
- Municipal effluent re-use.

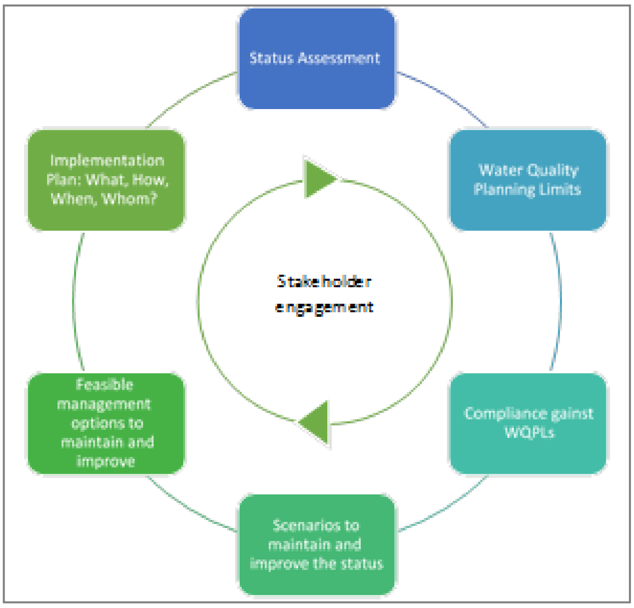
All of these are relevant to or will have an impact on the IWQMP for the Olifants WMA and are described more fully in the Reconciliation and Foresight Report (P WMA 04/B50/00/8916/6).

The approach followed in proposing the various scenarios to be assessed for the IWQMP is described in the sections to follow.

2. APPROACH TO EVALUATION OF MANAGEMENT SCENARIOS

2.1 Introduction

The approach followed for the development of the IWQMP involved:



- The assessment of the Olifants WMA to obtain a perspective of water quality (variables of concern), pollution sources and key water users. This included the assessment of existing Water Quality Planning Limits (WQPLs) previously known as Resource Water Quality Objectives (RWQOs) and establishment of WQPLs where not available as described in *The Status Assessment and Water Quality Planning Limits reports* (P WMA 04/B50/00/8916/3 and P WMA 04/B50/00/8916/4 respectively).
- An understanding of the salinity and nutrient balance using modelling of the system to determine the origin of the major contributions was undertaken. Following on this further modelling was undertaken to assess how the system complies with the WQPLs to determine possible future scenarios.
- Identifying and developing proposed management measures to improve the non-compliance cases, address water quality stresses and priorities and allow utilisation of available allocatable water quality to the benefit of the water users in the system. The management measures were evaluated on the basis of their technical, environmental (range of aspects), social and economic feasibility. The scenarios identified were then formulated into a proposed strategy for implementation.

2.2 Modelling approach used for the surface water component

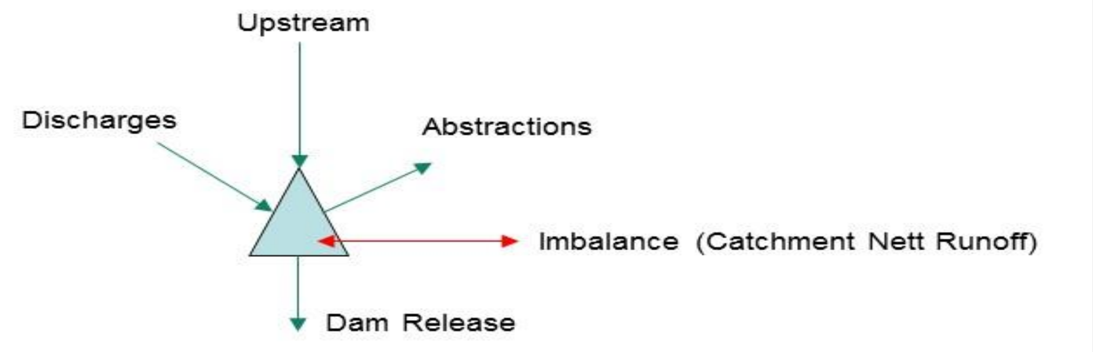
The data and information used in determining load and compliance included:

- Data sources:
    - DWS:
        - Hydrological Services Website (https://www.dwa.gov.za/Hydrology/)
            - Flow records

            - Rainfall
        - Resource Quality Information Services (https://www.dwa.gov.za/iwqs/wms/data/000key.asp)
            - Google Earth files
            - WQ data
- WR2012:
    - Books: WR1990, WR2005
    - Website (http://waterresourceswr2012.co.za/) (1920-2009)
- South African Weather Services - data purchased on request as required;
- MOVE Software aimed at making the most of the available relatively infrequent grab sample data to arrive at reasonable estimates of the observed river or dam water quality time series: used where gaps existed in data. The system is a user-friendly interactive modelling system that allows users to patch daily water quality data and aggregate it into flow-weighted monthly values compatible with the monthly time step used in the system water resources planning models (WRC Report number K5/2327/1).
- Determination of catchment load balances using the following basic calculation to identify the major load contributors in each MU:

Load (kg/day) = Volumetric Flow Rate (m^3/s) x Concentration (mg/l)

x unit conversion factor (86.4)



In undertaking the load calculations the following principles were used:

- Present day flows takes into consideration the abstractions and returns;
- Naturalized flows should only be used in those management units where there is limited activity taking place;
- In those management units where there is no flow gauge, present day flows should be used;
- If the upstream MU only has data to 2010, only model downstream MUs until 2010;

- Depending on the properties of the load source:
  - High flows can carry high loads/ concentrations;
  - High flows can dilute loads and subsequently the concentrations;
- To do a mass balance you require a continuous data set;
- Artificial data sets can be created using regression analysis.

Some general challenges experienced included:

- Negative flow catchments in some of the management units (MU25, MU24, MU9); and there are certain Mus that have no water data and/ or flow data; and
- Present day flows seems to be over estimating the flows.

3. COMPLIANCE AGAINST WQPL

The data sourced during the water quality status assessment (Report number: P WMA 04/B50/00/8916/3) was used to assess the compliance against the WQPLs that have been derived. Table 1 illustrates the 95% data vs the WQPLs. While using the 95% data gives the worst case and may not be an accurate picture at a specific point on a specific day, it does give an indication of the major problems seen throughout the WMA.

Colour coding for the MUs column refers to the sub-catchment areas indicated in Figure 1.

Figure 2, Figure 3, Figure 4Figure 5Figure 6 and Figure 7 illustrate the compliance assessment per sub-catchment.

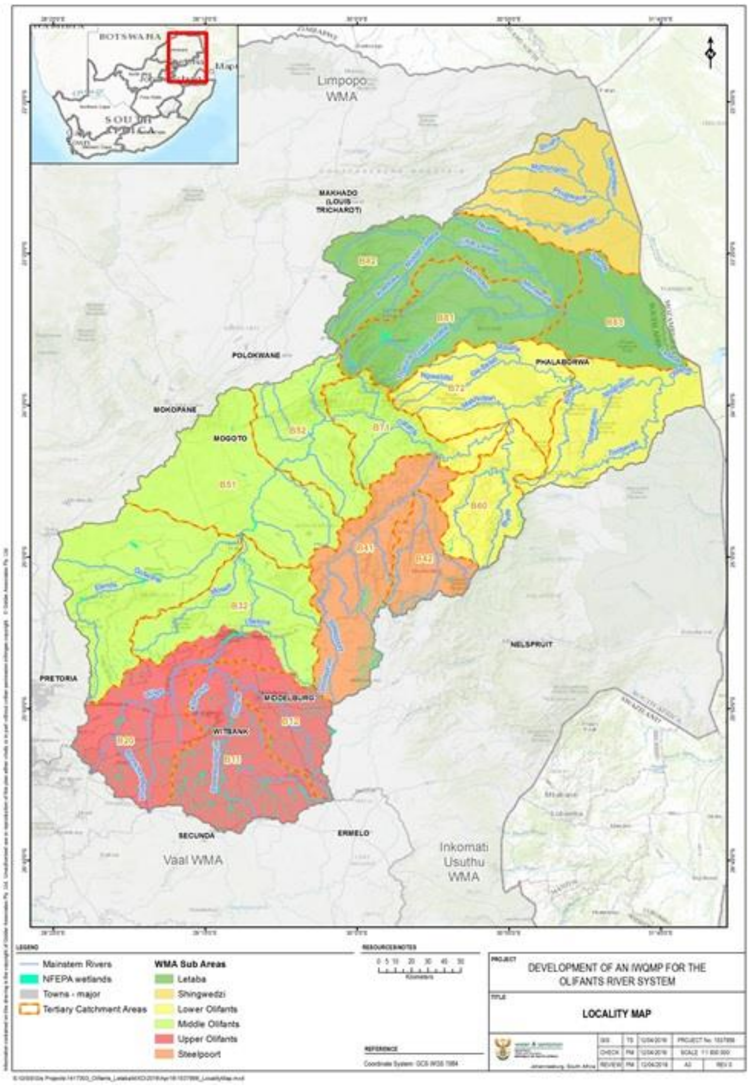


Figure 1: Sub-catchment areas

Table 1: Compliance of 95% data compared against WQPL

MU	WQ MP/WEIR ID	Calcium (dissolved)	Chloride (dissolved)	Total Dissolved Solids	Electrical Conductivity	Fluoride (dissolved)	Potassium (dissolved)	Magnesium (dissolved)	Sodium (dissolved)	Ammonia (unionised)	Nitrate	pH	Ortho-phosphate	Sulphate (dissolved)	Total Alkalinity	Manganese
		mg/L	mg/L	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	90420	23.17	14.42	241.13	32.54	0.40	4.25	15.80	17.10	0.11	0.29	8.40	0.06	32.99	116.60	
2	1000003173	111.40	118.20	1468.53	182.20	1.15	9.43	133.40	194.80	0.15	0.14	8.53	0.02	683.60	228.35	0.13
3	90418	297.31	74.03	2194.78	270.40	0.95	16.72	174.78	138.00	0.32	0.20	8.41	0.05	1468.30	238.05	0.31
4	88607	76.08	27.00	532.00	87.82	0.68	6.46	53.28	40.38	0.18	0.86	8.34	0.04	323.20	122.80	0.77
5	189430	348.43	42.89	2359.54	315.00	0.67	9.17	230.34	58.93	0.03	0.03	8.00	0.10	1210.50	210.68	5.78
6	188537	117.00	33.20	463.41	114.32	0.73	5.04	99.34	48.20	2.40	4.50	7.86	0.78	596.40	87.12	3.66
7	90415	50.70	41.06	624.20	76.20	0.61	6.63	42.16	67.38	0.11	0.31	8.70	0.09	84.93	302.97	0.11
8	188596/ 90416/ 188588	92.41	35.75	950.10	140.60	0.69	8.45	77.90	62.04	0.20	0.51	8.30	0.20	583.70	250.57	0.06
9	188536/ 90412	61.90	24.15	529.37	74.76	0.59	7.66	38.65	36.33	0.10	0.42	8.64	0.04	239.29	113.52	0.25
10	188596	33.57	61.02	542.49	63.37	0.45	9.06	24.10	70.22	0.29	2.09	8.09	1.14	62.63	256.37	
11	188397	59.49	78.40	665.12	103.50	0.54	8.82	32.37	121.00	1.18	4.31	9.38	0.37	286.50	183.75	
12	90421	59.49	78.40	665.12	103.50	0.54	8.82	32.37	121.00	1.18	4.31	9.38	0.37	286.50	183.75	1.3
14	88506	179.11	31.53	1820.05	219.30	0.81	15.06	162.17	56.88	0.10	0.85	8.35	23.96	972.98	124.38	
15	188390	15.79	20.87	147.78	16.91	0.22	4.53	11.02	12.45	0.09	0.94	7.87	0.07	21.56	71.70	
16	188539	36.75	42.60	913.36	106.81	0.33	9.24	36.19	38.34	5.66	1.77	7.88	0.89	825.00	130.53	
17	90430	124.32	161.37	1751.38	277.00	0.67	13.12	70.55	134.34	18.46	0.50	5.68	0.06	1157.70	79.66	
18	90408	97.61	86.45	1008.00	155.98	1.05	13.48	36.07	163.82	7.28	6.58	7.63	0.05	621.90	28.06	
19	189465				95.12						4.76	7.63	2.33			
20	188545	144.60	44.00		121.30	0.57	10.23	55.94	53.36		0.96	7.74	0.10	557.40	119.40	
21	88821	495.90	7.90	252.00		0.54	6.42	144.00	179.80	0.04	0.97	8.05		2256.50	32.00	2.85
22	189470/90441	27.00	14.66	255.45	36.80	0.50	4.53	17.09	18.59	0.09	0.45	8.36	0.05	66.74	107.85	
23	90438	24.45	11.64	200.00	27.07	0.32	3.36	14.80	7.30	0.09	0.41	8.50	0.03	18.33	114.39	
24	90433	23.23	17.99	261.09	35.30	0.42	7.28	18.36	15.61	0.12	0.43	8.45	0.05	21.44	134.93	
25	90442	60.26	13.66	325.21	55.33	0.41	4.66	13.08	15.40	0.09	0.30	8.17	0.05	183.50	73.10	0.19
26	90407	248.98	19.00	2061.71	252.00	0.85	14.02	245.66	37.87	0.25	0.92	8.33	0.04	1548.80	174.19	0.28
27	no mon point															
28	188530	57.72	48.95	635.30	73.40	0.60	14.32	46.62	59.12	0.90	14.76	7.69	2.48	195.54	131.91	
29	no monpoint															
30	no mon point															
31	188574	28.35	20.27	162.11	92.08	0.51	10.47	35.75	17.55	0.64	0.27	8.01	0.08	184.35	59.21	
32	191822/ 90455	36.64	18.86	328.91	50.10	0.46	5.92	21.04	29.59	0.30	0.54	8.20	0.04	146.42	72.29	
33	no mon point															
34	88595	53.99	41.92	618.76	82.42	1.83	4.41	40.15	66.32	0.12	1.94	8.17	0.69	146.15	227.56	
35	189423/ 90448	13.60	25.82	207.93	30.95	1.40	6.74	5.89	34.40	0.08	0.40	8.26	0.05	17.16	93.76	
36	189417/90458	108.93	276.12	1179.49	249.40	1.87	11.82	112.91	224.62	0.14	1.58	8.61	0.09	294.88	295.29	
37	no mon point															
38	191684/90444	51.76	67.97	837.00	112.05	1.36	7.05	39.71	147.92	0.12	1.04	8.53	0.06	129.30	384.50	
39	1000009810	82.75	86.10	774.45	92.32	4.93	3.84	84.50	203.50	1.05	0.61	8.59	1.00	129.30	384.00	
40	no mon point															

41	no mon point															
42	1000009844	90.10	70.40	785.37	95.76	0.20	2.36	405.00	58.64	2.81	2.44	8.80	1.01	20.26	521.10	
43	1000009843	90.10	70.40	785.37	95.76	0.20	2.36	405.00	58.64	2.81	2.44	8.80	1.01	20.26	521.10	
44	192537	41.65	61.80	481.00	74.12	0.54	4.47	40.39	54.25	2.79		8.36	0.33	82.06	177.32	
45	no mon point															
46	no mon point															
47	1000009801/ ..9803	51.05	10.25	174.24	25.95	0.41	1.67	57.40	14.37	1.41	0.64	8.28	0.50	13.00	126.25	
48	1000009806	30.00	5.13	109.55	17.00	0.20	1.05	29.10	4.62	0.67	0.45	7.98	0.50	18.45	54.49	
49	1000009801	135.80	52.72	463.69	62.38	0.54	4.92	161.40	45.80	0.93	1.33	8.60	0.88	71.10	221.80	
50	1000009799	39.50	12.15	162.37	23.72	0.21	1.25	41.50	9.31	0.80	0.34	8.21	0.50	18.24	90.50	
51	1000009795/..9798	11.30	11.25	61.74	10.66	0.18	1.77	8.00	12.05	0.70	0.20	8.30	0.50	6.30	49.25	
52	no mon point															
53	90515	91.93	115.40	905.00	209.65	2.89	53.17	157.73	161.35	0.16	0.71	8.65	0.06	748.60	276.10	
54	100000795	27.18	44.41	300.67	47.84	0.30	2.73	19.04	34.27	0.50	0.38	8.41	0.50	19.84	131.80	
55	1000009786/ 192539	35.44	46.30	388.60	57.40	0.50	113.93	1480.02	1904.73	1.10	0.42	8.53	0.50	51.71	192.00	
56	90508/ 1000009796	115.15	176.05	842.50	149.00	0.60	10.48	191.55	199.10	2.94	3.64	8.22	3.10	94.30	387.60	
57	90508	15.53	13.60	167.92	24.14	0.37	2.35	10.75	13.99	0.14	0.37	8.21	0.04	9.25	92.23	
58	no mon point															
80	1000009797	307.00	245.75	1498.12	269.25	3.18	23.50	671.50	259.00	0.40	0.31	8.50	2.44	664.57	401.90	
59	193279	11.60	23.97	145.68	22.68	0.48	3.69	9.64	15.71	0.20	0.09	8.13	0.04	14.42	60.59	
60	90476/190143	33.10	15.63	305.33	96.19	0.42	2.84	18.73	19.54	0.08	0.53	8.45	0.04	18.55	170.05	
61	1000009848	70.30	7.65	306.30	45.56	0.15	1.63	55.30	13.21	1.83	6.74	8.29	2.16	31.51	169.96	
62	190142/ 190160	28.40	14.20	280.15		0.45	2.76	16.38	17.36	0.11	0.62	8.44	0.04	15.89	155.84	
63	90472/ 1000008357	31.80	5.70	113.36	19.29	0.20	0.98	45.00	5.97	0.41	0.63	8.28	0.10	9.00	85.10	
64	90469/ 90483	16.90	6.57	239.18	29.55	0.37	3.31	22.03	8.69	0.10	0.22	8.46	0.03	10.35	138.09	
65	1000009856	119.00	101.60	457.37	81.67	0.19	1.98	182.00	86.90	3.42	3.17	8.50	2.36	84.00	273.60	
66	90470	13.90	7.00	156.00	20.69	0.32	1.60	11.94	8.40	0.09	0.14	8.26	0.03	9.29	94.21	
67	192622				43.54						1.51		0.12			
68	90473/ 193091	35.14	43.13	458.15	63.68	0.40	3.45	36.36	36.12	0.09	2.97	8.77	0.02	42.51	229.75	
81	90471	43.40	10.50	504.60	60.60	0.31	2.23	44.65	24.92	0.13	7.78	8.62	0.05	17.87	307.05	
69	90525	15.39	29.90	165.95	24.97	0.31	4.06	8.28	17.95	0.11	0.82	8.06	0.05	13.20	66.33	
70	183879	57.60	130.50		133.04	0.55	14.62	43.30	97.50	27.00	22.50	9.24	8.88	47.60	377.60	
71	90536	39.58	172.34	723.48	97.10	0.54	7.15	34.56	120.29	0.25	0.63	8.60	0.07	31.90	235.36	
72	No mon point															
73	No mon point															
74	90529	56.24	145.45	752.88	94.34	0.61	7.05	6.27	56.10	116.21	4.72	8.70	8.64	0.07	22.07	
79	90539	33.37	58.62	430.36	58.98	0.40	4.34	34.06	39.61	0.09	0.31	8.72	0.04	18.28	207.67	
75	90582	46.09	204.59	1003.58	137.60	0.42	16.96	9.18	51.91		0.64	8.70	8.64	0.19	21.18	
76	No mon point															
77	No mon point															
78	90583	65.01	237.34	1076.39	156.40	0.56	20.04	50.53	190.41	0.70	1.23	8.75	0.16	39.74	432.50	

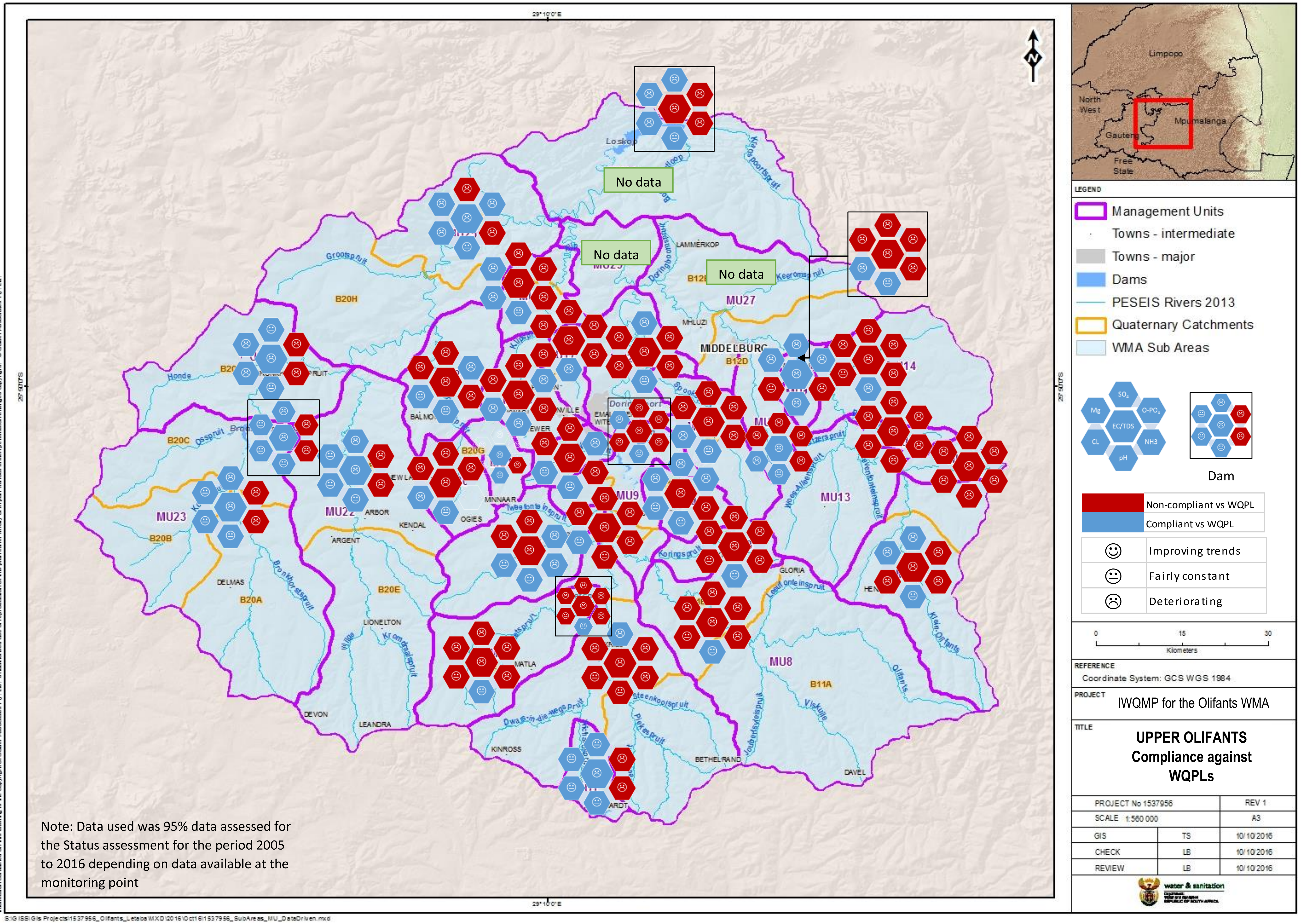


Figure 2: Upper Olifants 95% compliance against WQPLs

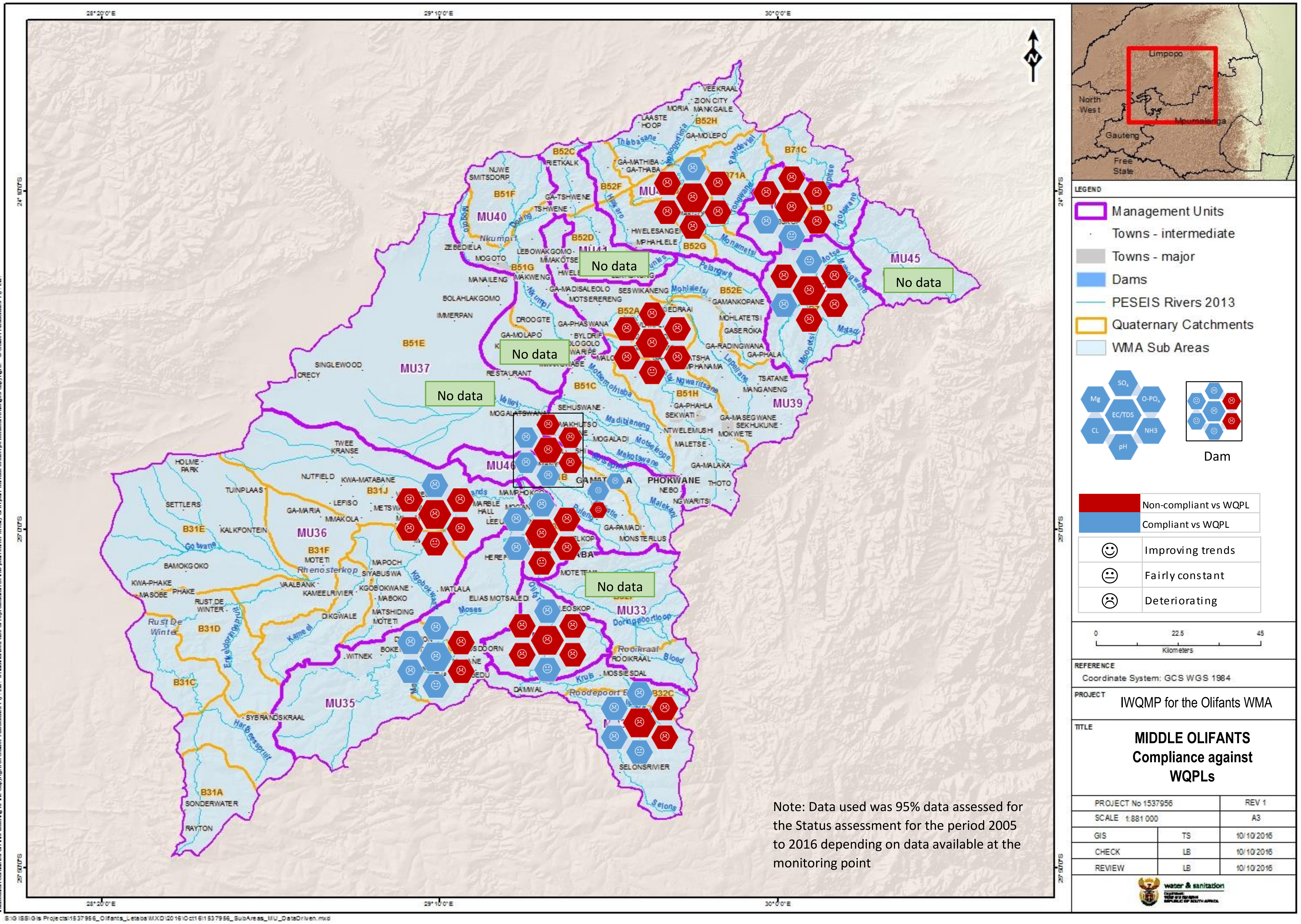


Figure 3: Middle Olifants 95% data compliance against WQPLs

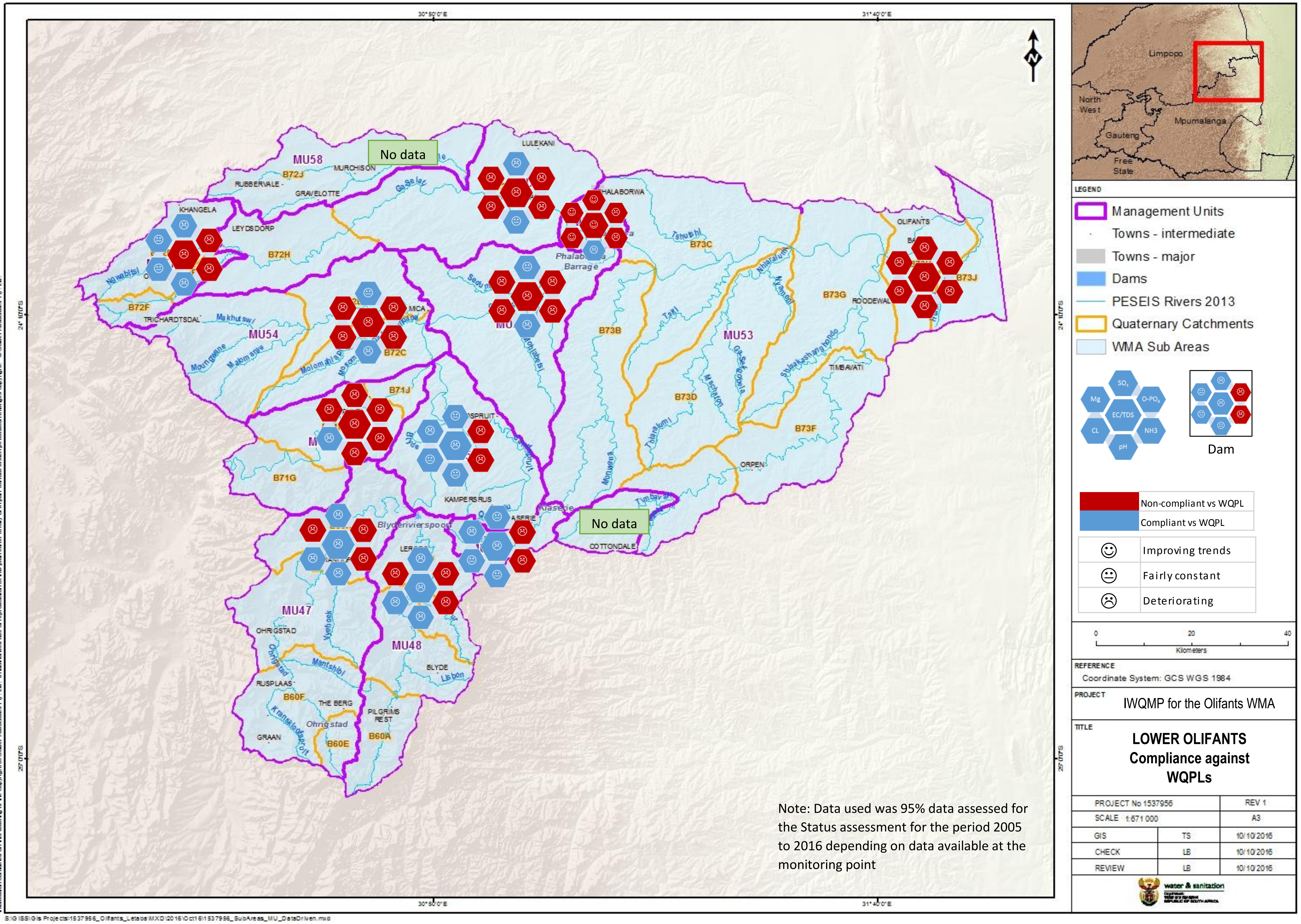


Figure 4: Lower Olifants 95% data compliance against WQPLs

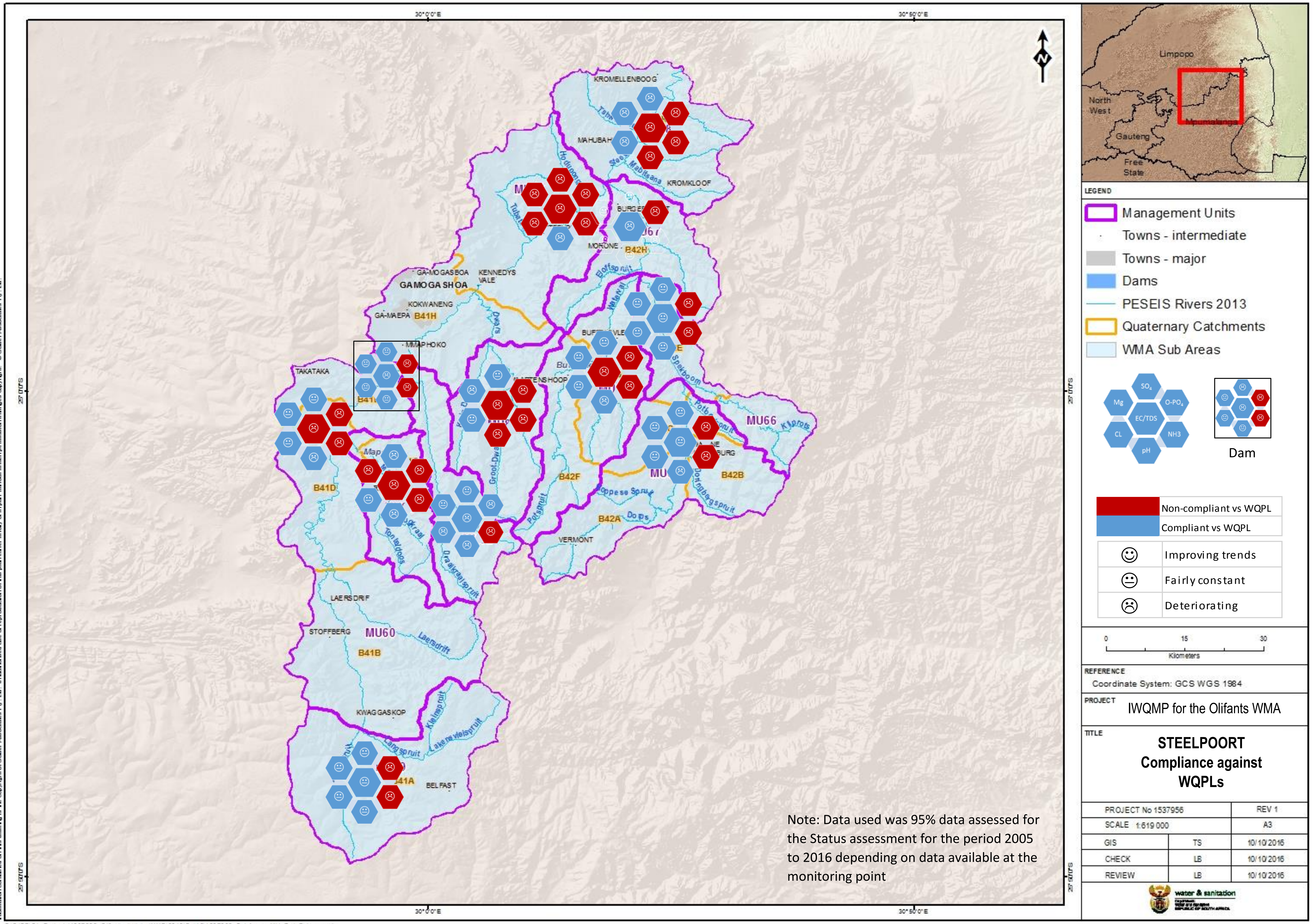


Figure 5: Steelpoort 95% data compliance against WQPLs

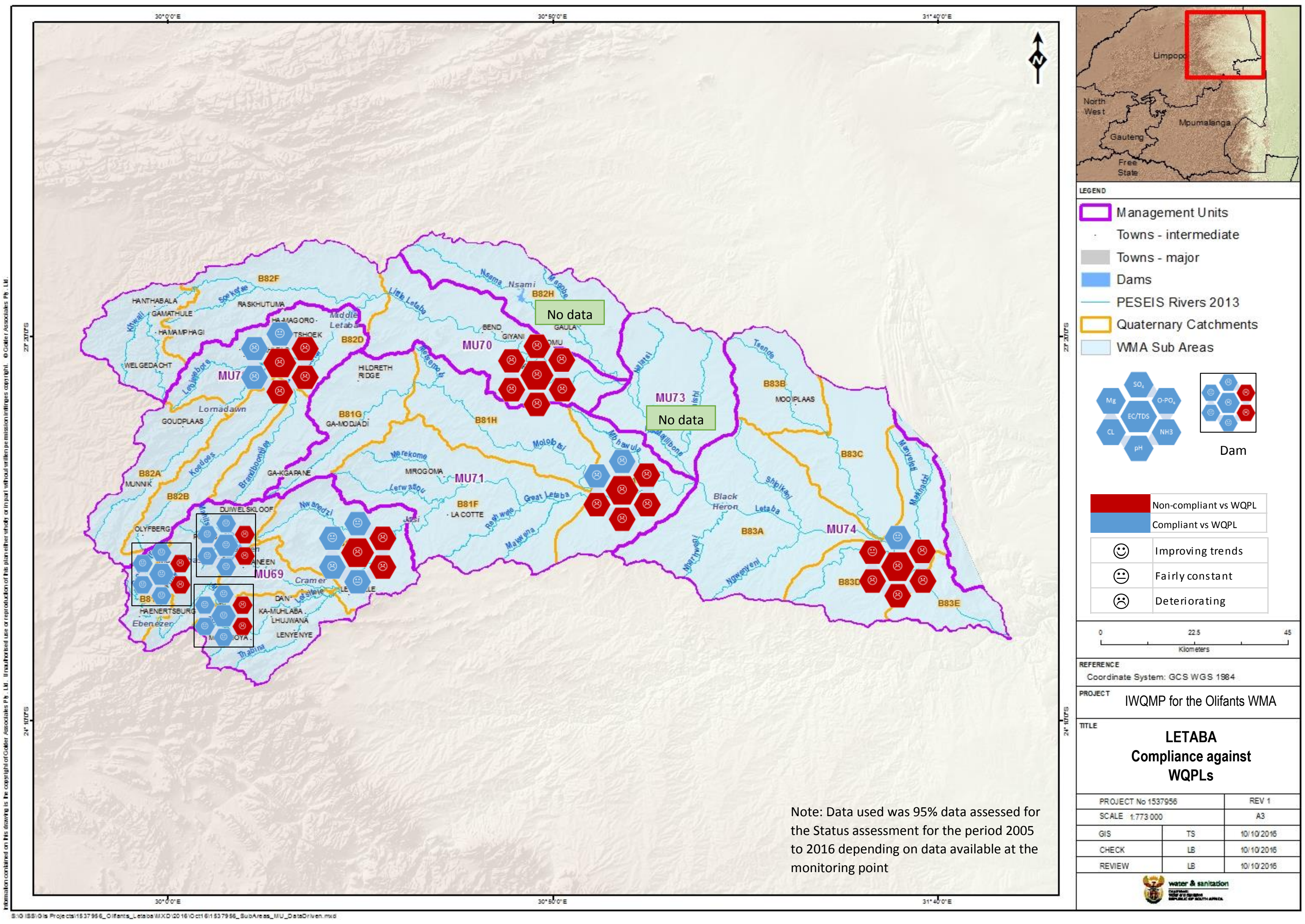


Figure 6: Letaba 95% data compliance against WQPLs

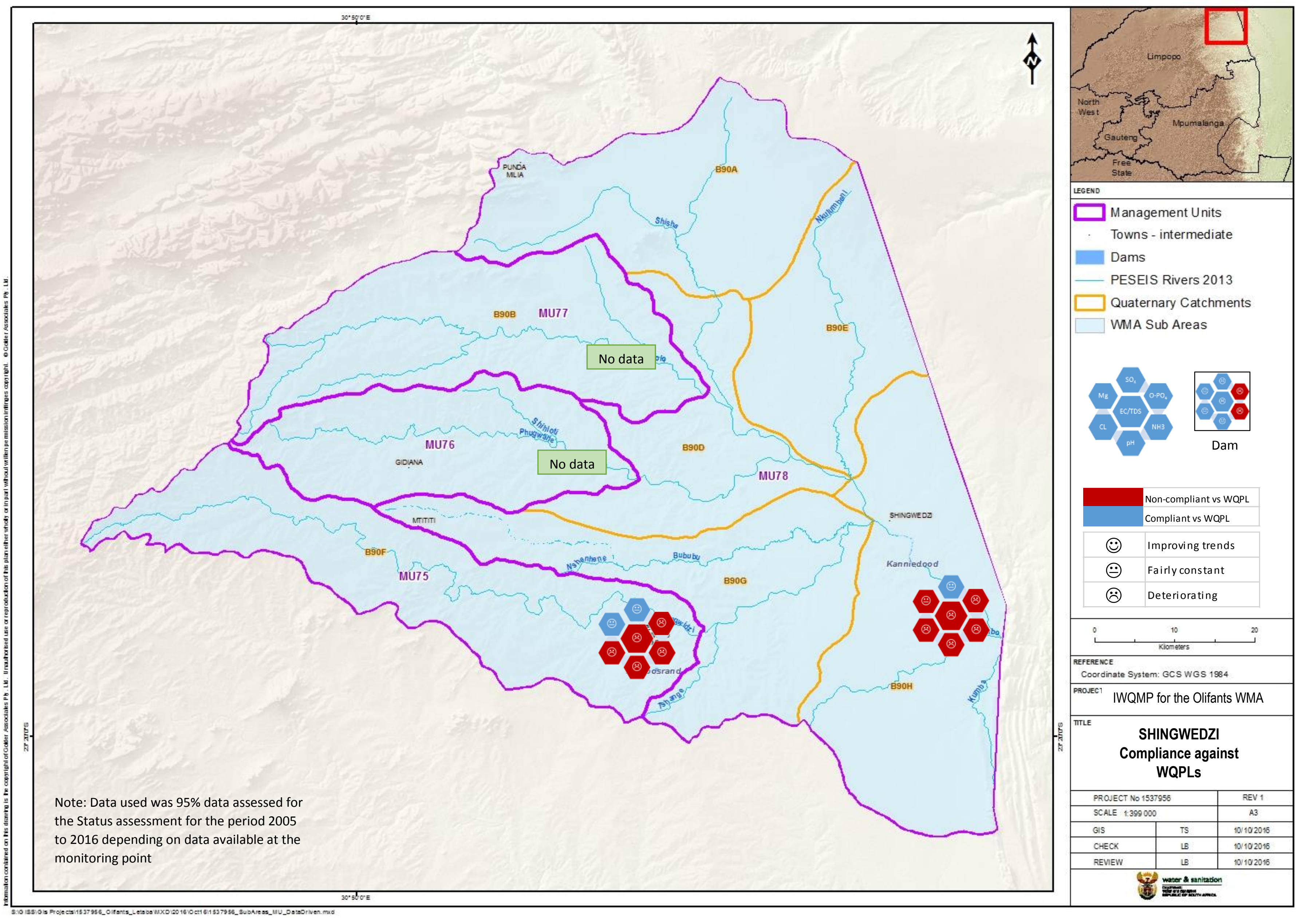


Figure 7: Shingwedzi 95% data compliance against WQPLs

4. DESCRIPTION AND EVALUATION OF PLANNING SCENARIOS FOR SALINITY MANAGEMENT

4.1 Introduction

The main mining activities in the Olifants WMA are related to coal, platinum, vanadium, chrome, copper and phosphate. The coal mining is located in the Upper Olifants sub-catchment of the WMA around eMalahleni, Middelburg and Delmas, associated with large thermal power stations. The platinum, chrome and vanadium mines are located in the Steelpoort and Middle Olifants sub-catchments of the WMA, while the copper and phosphate mining occurs in the lower Olifants sub-catchments around Phalaborwa.

The Mine Water Atlas compiled in 2017 (WRC Project No. K5/2234//3) illustrates various risk maps for the Olifants WMA:

Mineral risk (Figure 8): The mineral risk map reflects the assessed risk of acid production and/or leaching of constituents of concern into the environment.

- ***Very high mineral risk areas:*** Upper Olifants coalfield areas (mainly seams 4 and 5 coal) and Witwatersrand Basin uranium area, the Springbok flats in the Middle Olifants (Coal, uranium and gypsum), the Gravelotte Greenstone Belt in the Lower Olifants (gold, uranium, vanadium, copper and zinc), the Giyani/ Polokwane Greenstone Goldfields in the Letaba sub-catchment (Nickel, gold and iron), the Alkaline Complexes in the Lower Olifants around the town of Phalaborwa and in the Middle Letaba (phosphate), west of Giyani.
- ***High mineral risk areas:*** Upper Olifants Coalfields (mainly seams 1 and 2 coal); Middle Olifants, BIC Eastern Limb (titanium) in the Bloed River quaternary; Steelpoort and Middle Olifants sub-catchments, BIC Eastern Limb (lead, iron, vanadium, platinum and chromium); Transvaal Supergroup (asbestos); Recent sediment phosphates in the Letaba (Klein Letaba quaternaries) and the Tshipise and Pafuri Colafields in the Shigwedzo sub-catchment.
- ***Moderate mineral risk areas:*** Middle Olifants, Limestone near Lebowakgomo running east –west into the Steelpoort sub-catchment; and Lower Olifants, Metamorphic Province Fluorite (fluorspar) running from Gravelotte towards Phalaborwa.

Surface water threat map (Figure 9): This map reflects the assessment of the threat of mining to surface water resources at quaternary catchment level. The assessment is limited to those quaternary catchments that intersect mineral provinces (mineralised zones that are broadly similar in terms of their host rock geology and mineralogy) across South Africa

- *Figure 9* illustrates that more than 50% of the WMAs surface water is under high threat of for potential mining related pollution with approximately 40% having a low to moderate threat rating.

Mine water threat (Figure 10): is the result of the threaded equation, summing the risk and vulnerability ratings of the mineral risk profile, mining activity risk and receiving water resource vulnerability. It presents 3 layers for groundwater (surface mining), groundwater (underground mining), and surface water. The mapping is limited to the extent of the mineral province delineations, focusing the assessment to those areas that either are being mined, or are likely to be mined. These maps have all assisted in the development of scenarios and will help when proposing management options.

The main areas of impact are therefore related to salinity are the Upper Olifants and upper portions of the Middle Olifants sub-catchments, portions of the Steelpoort sub-catchment and Phalaborwa region of the Lower Olifants sub-catchment. Coal mining and industry are the major sources of salinity in the Upper Olifants sub-catchment with limited contribution from irrigation return flows and power stations: excess mine water discharges during wet weather periods and diffuse pollution through seepage from waste facilities and mine workings located adjacent to rivers. Irrigation return flows are the primary source of the high salinity levels in the lower Elands and Moses Rivers.

Details of the load calculations and salinity balances are included electronically as Appendix A to the report.

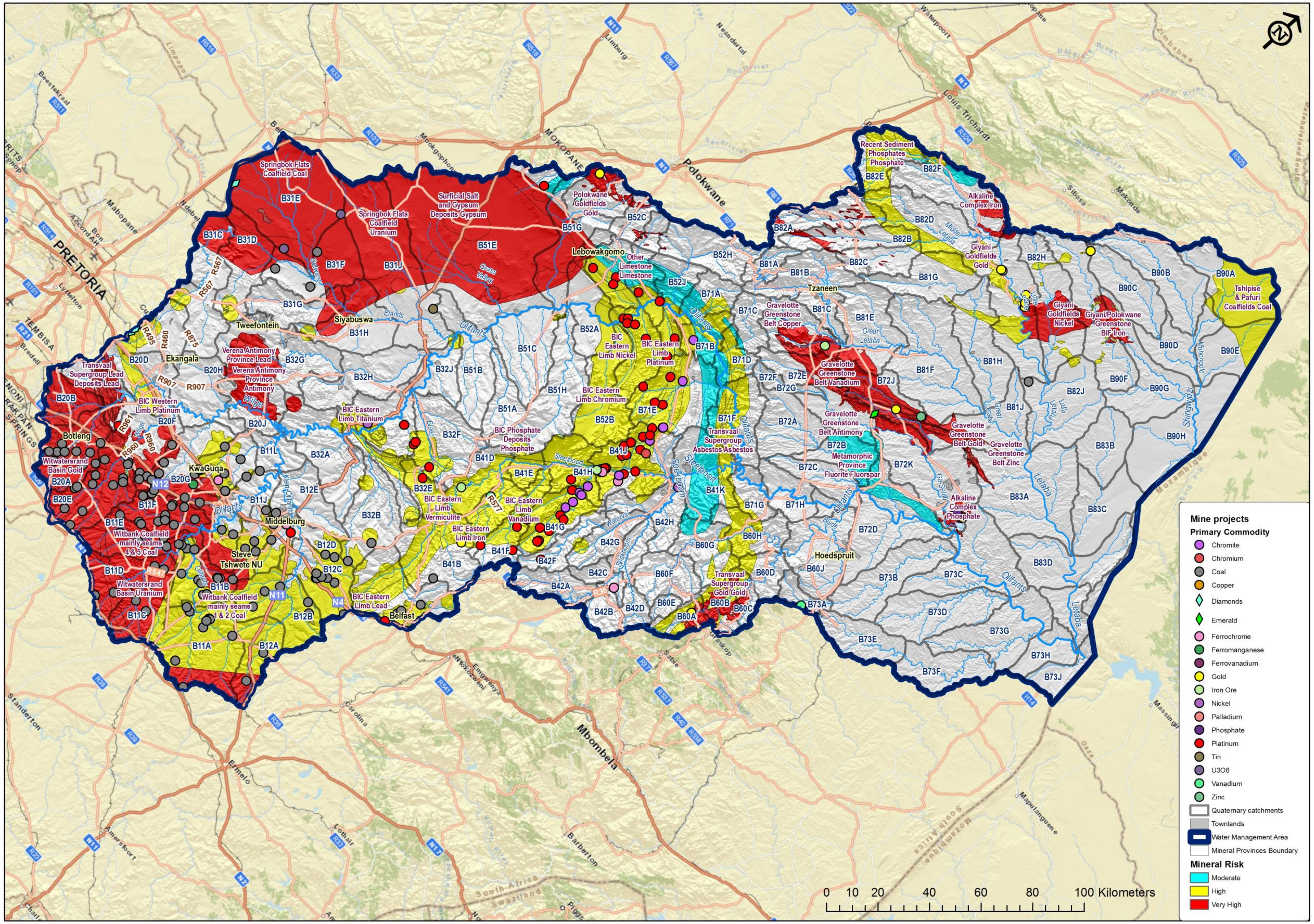


Figure 8: Mineral risk map for the Olifants WMA (WRC Project No. K5/2234//3)

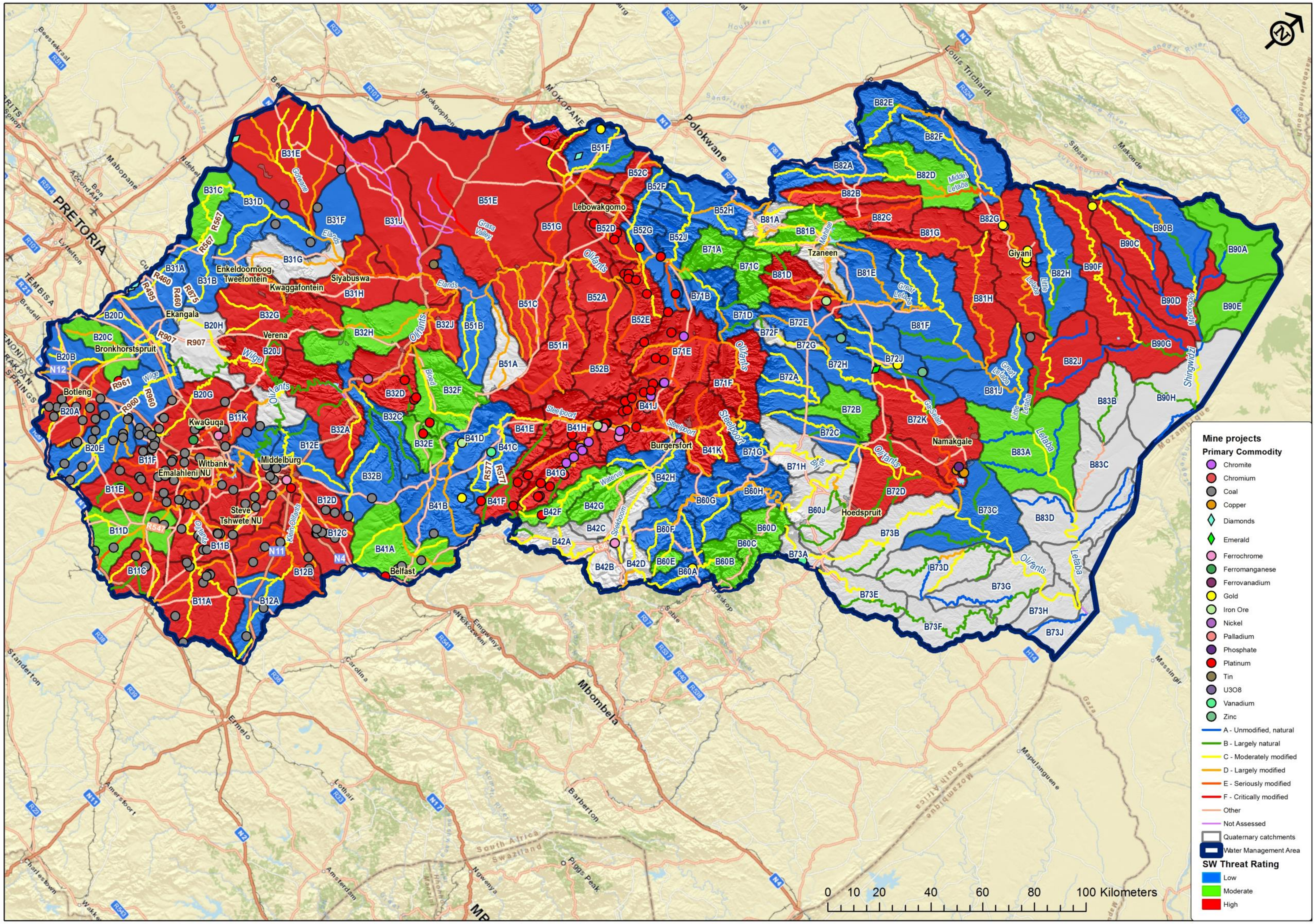


Figure 9: Surface water threat map for the Olifants WMA (WRC Project No. K5/2234//3)

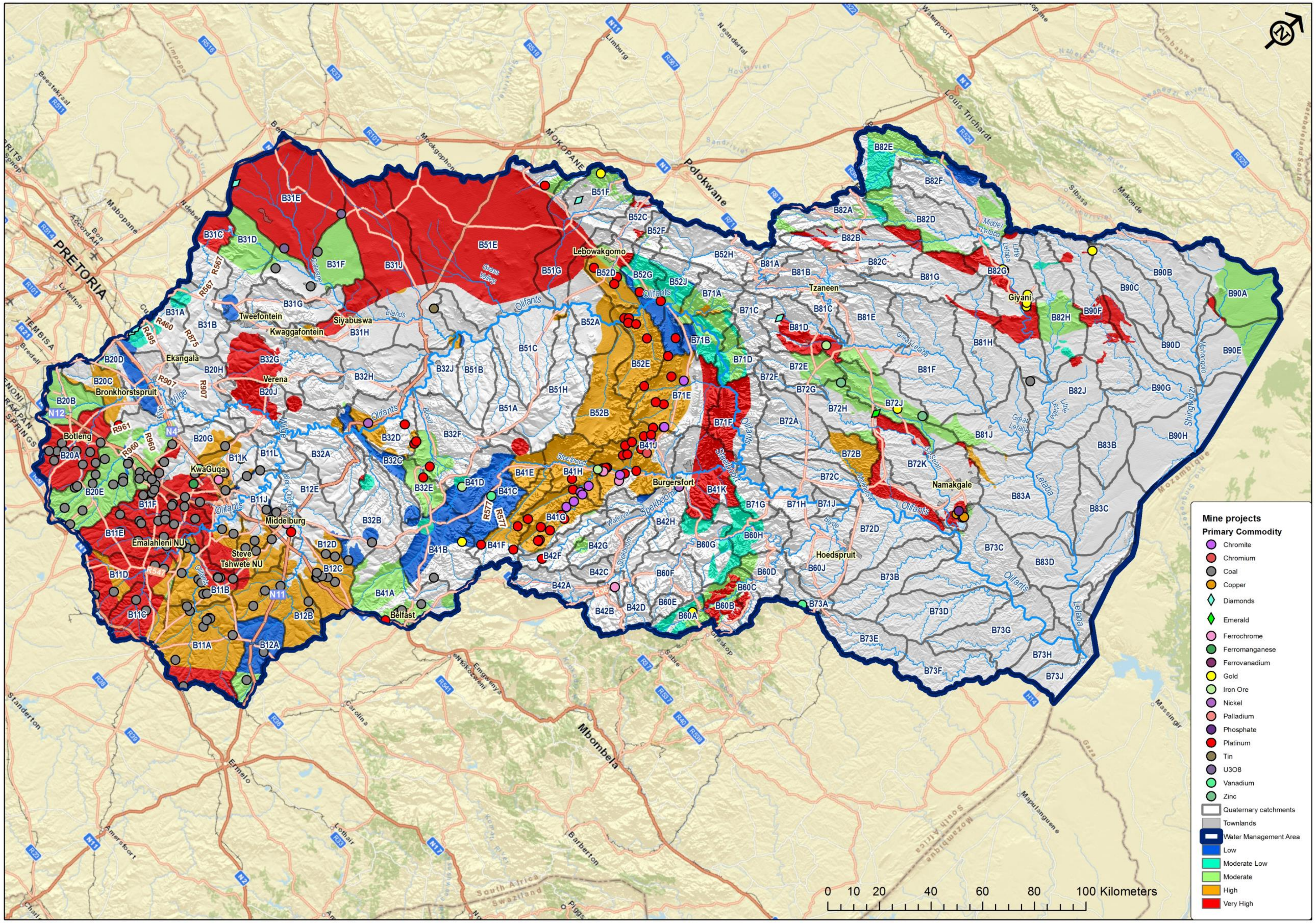


Figure 10: Mine water threat map for the Olifants WMA (WRC Project No. K5/2234//3)

4.2 Salinity balance

The salinity balance for the main stem Olifants River is illustrated in Figure 11 showing the major contributions from the Upper Olifants sub-catchment, some load from the Steelpoort sub-catchments and the Ga-Selati in the lower Olifants sub-catchments.

Table 2: Monitoring stations used to determine a first order sulphate load

Station	Catchments added (not in tributaries)	Location
B1H5	B11A-F	Wolwekrans Weir
B1H10	B11G	Witbank Dam Release
B3R002	B11J; B11L; B32A	Loskop Dam Release
B3H1	B32B-J	U/S of Flag Boshielo
B5H4	B51A-B	Flag Boshielo Release
B7H7	B51C-H; B52; B71; B72A-C	Oxford (D/S Blyde)
B7H15	B72D	Mamba KNP, downstream of the Ga-Selati confluence with the Olifants River

4.3 Compliance

The management units of concern in respect of salinity are illustrated in Figure 12, showing the areas of non-compliance of sulphate against the proposed WQPLs and where load will need to be reduced to achieve an improvement in the water quality of the MU, and ultimately comply with the RQOs gazetted.

The number of mines and the mining operations have grown significantly in the last 15 to 20 years, resulting in growth increases in excess mine water that needs to be managed. The river systems do not have any assimilative capacity for further salinity pollutant loads. In addition, the water reconciliation and dam system operation and effects of the prolonged drought are such that there is no water available in the dams to provide dilution water to maintain the salinity in the downstream rivers at a suitable level. The end result is that to prevent further deterioration no further diffuse or point source loads can be accepted in the river systems. In fact in the Koringspruit, Boesmanskransspruit, Tweefonteinspruit, Noupoortspruit, Woestalleenspruit, Spookspruit and the Klipspruit, salinity load will have to be removed from the system to achieve the WQPLs determined for the specific Management Units and the downstream dams.

Sulphate (2000-2014):

Location	Measured Load: (kg/d)	Measured Flowrate: (Ml/d)	Calculated Concentration: (mg/l)
Wolwekrans Weir	46 805	481	97
Catchment Balance	16 042	59	271
Dam Abstraction	-11 883	-102	116
Witbank Dam			
Dam Release	50 964	438	116
Spookspruit	21 435	40	536
Klein Olifants	42 799	167	256
Klipspruit	37 351	122	306
Wilge	32 672	529	62
Catchment Balance	42 381	802	53
Dam Abstraction	-42 424	-391	108
Loskop Dam			
Dam Release	185 178	1 707	108
Catchment Balance	-29 889	-226	132
Loskop North	155 289	1 481	105
Elands River	5 505	88	63
Catchment Balance	-33 488	-14	2 481
Dam Abstraction	-655	-8	82
Flag Boshielo			
Dam Release	126 651	1 547	82
Steelpoort	13 568	890	15
Blyde River	6 986	626	11
Catchment Balance	3 920	384	10
Oxford	151 125	3 447	44
Ga-Selati	22 757	128	178
Catchment Balance	7 674	-207	-37
Mamba	181 556	3 368	54

Figure 11: Salinity balance along the Olifants main stem (still being updated and confirmed based on patched data)

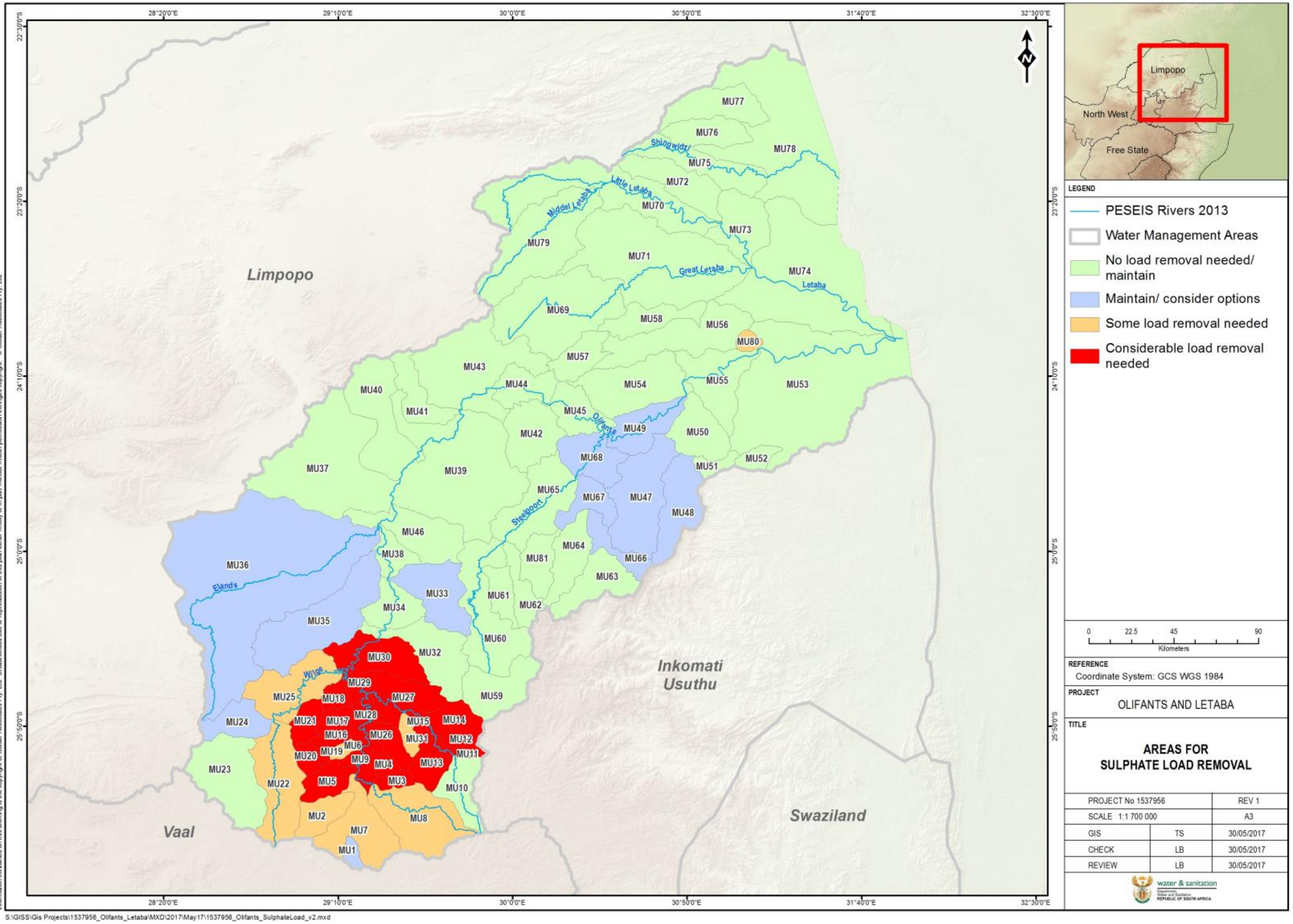


Figure 12: Management Units in the Olifants WMA showing areas of salinity concern where load will need to be removed

4.4 Proposed intervention scenarios for salinity

The Reconciliation Strategy (DWS, 2015) intervention options that relate specifically to salinity management include:

- WC/ WDM (Irrigation, Urban and Mining Sectors);
- Eliminate Unlawful Use; and
- Treatment of mine water.

In respect of water quality the strategy for salinity will need to consider: defunct mines, operating mines, industries and power stations and the irrigation return flows in the case of the Lower Moses and Elands rivers. The main sources of pollution contributing to salinity that need to be addressed, and for which scenarios interventions will be considered are:

- Reduction of load due to seepages from the mine, industrial and power station waste storage facilities and mining operations in the Upper Olifants sub-catchment, some load from the Steelpoort sub-catchments and the Ga-Selati in the lower Olifants sub-catchments.;
- Reduction of load due to excess mine water on the mining operations threatening to decant or starting to flood the coal reserves in the Upper Olifants sub-catchment; and
- Reduction of load from irrigation return flows in the Upper and Middle Olifants.

5. DESCRIPTION AND EVALUATION OF PLANNING SCENARIOS FOR NUTRIENT MANAGEMENT

5.1 Introduction

Throughout the Olifants WMA, the main areas of impact related to nutrients (indicated by orthophosphate and nitrate concentration) are downstream of wastewater treatment works, urbanised areas and agricultural areas (irrigated areas and intensive animal feedlots). The phosphate concentrations (averages) in the Olifants River (main stem) were high and ranged between 0.010 and 1.028 mg/L (average, 0.217 mg/L; median 0.064 mg/L).

5.2 Compliance

The trophic status of the water body is used as a description of the water quality status of a water body, with regard to nutrient enrichment.

Currently WWTWs are managed by a water use authorisation: in many cases a General Authorisation due to size or an integrated water use license. There are at least 103 wastewater treatment works (WWTW) in the Olifants WMA. Of these the following statistics are known:

- Actual hydraulic capacities are only known for 36 of the WWTW;

- 47 are oxidation ponds, of which close to 80% are unlined, therefore contributing to groundwater contamination;
- 34 WWTW are noted to be activated sludge plants, with only the WWTW in Dullstroom having advanced treatment processes;
- 17 WWTW are biofilter plants.

The latest Green Drop data indicates that not one WWTW in this WMA has achieved a Green Drop certificate of which > 70% of the WWTW are rated as being a high risk.

Additional nutrient and sediment loads may be emanating from agricultural areas where buffer strips are limited or ploughed right up to the water resources; and sprawling settlements where storm water management systems are inadequate or missing and run-off creates eroded channels into the water resources.

5.3 Orthophosphate loads

The points described in Table 3 were used to determine a first order phosphate load to the catchment at the weirs noted.

Table 3: Monitoring stations used to determine a first order phosphate load

Station	Catchments added (not in Tributaries)	Location
B1H5	B11A-F	Wolwekrans Weir
B1H10	B11G	Witbank Dam Release
B3R002	B11J; B11L; B32A	Loskop Dam Release
B3H1	B32B-J	U/S of Flag Boshielo
B5H4	B51A-B	Flag Boshielo Release
B7H7	B51C-H; B52; B71; B72A-C	Oxford (D/S Blyde)
B7H15	B72D	Mamba KNP, downstream of the Ga-Selati confluence with the Olifants River

The initial load calculations are currently being revised based on patched data. The figures may therefore change.

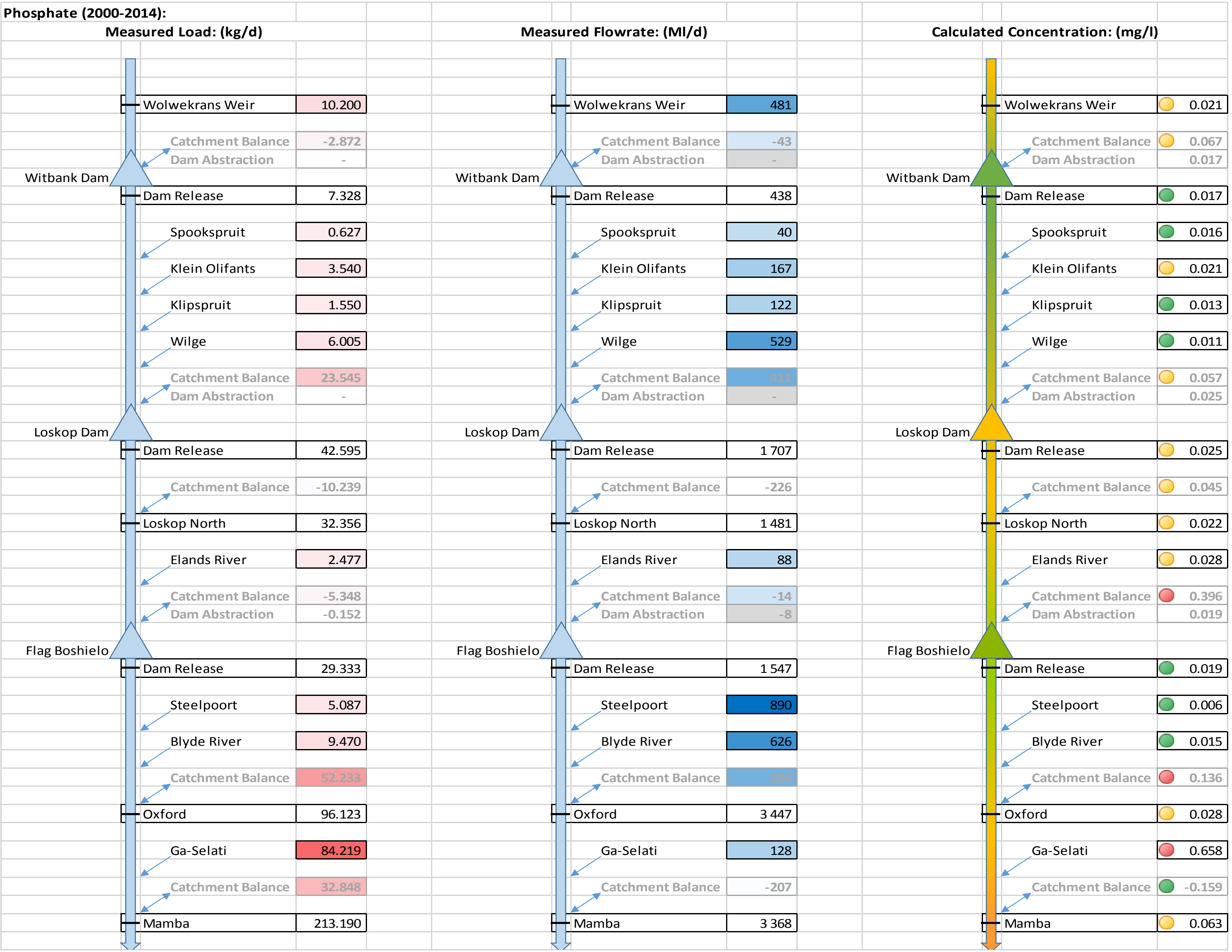


Figure 13: Orthophosphate loads along the Olifants Main Stem (being updated)

5.4 Proposed scenarios

The Reconciliation Strategy (DWS, 2015) intervention options that relate specifically to nutrient management include:

- WC/ WDM (Irrigation and Urban Sectors);
- Eliminate Unlawful Use; and
- Municipal effluent re-use.

These are all important for the IWQMP and management options relating to these will be considered. The nutrient management's strategy is to:

- Provide a clear direction and overarching framework for current and future initiatives to improve management of nutrients from both point and diffuse sources;
- Increase awareness of existing initiatives and opportunities for local councils and state government agencies to work collaboratively with community and industry stakeholders;
- Provide strategic guidance for stakeholders with a role in nutrient management by identifying priority nutrient sources, and opportunities for improvement and actions that complement and integrate with existing programs;
- Encourage natural resource managers to consider nutrient management objectives and priorities in strategic planning and investment decisions;
- Improve coordination of nutrient management in the catchment; and
- Provide support and guidance to decision-makers and grant applicants seeking funding for initiatives that can improve nutrient management.

Improved quality of the sewage effluent will contribute to the environmental sustainability of the Olifants river ecosystem. The scenarios for which interventions will be considered for nutrient management are therefore:

- Reduction of nutrient load from domestic WWTW that discharge to the water resources, by considering a reduction of the orthophosphate concentration to 1 mg/L;
- Reduction of nutrient and sediment load from agricultural areas and areas where changing land uses may be occurring;
- Reduction of nutrient and sediment load from run-off from urban/ densely populated areas; and
- Improved reuse of effluent from domestic wastewater treatment works not designed to meet the general discharge limits.

6. DESCRIPTION AND EVALUATION OF PLANNING SCENARIOS FOR GROUNDWATER QUALITY MANAGEMENT

6.1 Introduction

The groundwater resources in the study area vary from insignificant (<0.1 l/s) to significant (>5 l/s), however, the sustainability of the aquifer systems and replenishment with fresh quality water is directly related to rainfall recharge (with a recurrence rate from 5 to 10 yrs. depending on the geographical setting).

Interaction between groundwater and surface water resources play an important role in the overall water quality signatures in the study area. There is a concern that certain land use activities may impact the water quality of local, shallow groundwater systems which could support the groundwater contribution to base flow in surface water systems. Groundwater contribution of base flow supports the head waters regions of the Letaba River System, as well as the head waters of quaternary catchments (QC's) of the Olifants River System (i.e. Klein Olifants River, Blyde River, Elands River, Wilge River (Grootspruit and Saalboomspruit tributaries) and Steelpoort River (i.e. Grootspruit and Dwars tributaries).

Previous studies highlighted that the groundwater quality in the study area is variable. Most of the water quality risks are related to expanding of point source sanitation systems (pit latrines), mining/industrial related activities, and agricultural (intensive feedlots and irrigation fertilisers application) practices.

The presence of elevated concentrations of nitrate ($NO_3 – N$), sulphate (SO_4), and overall electrical conductivity (EC), decreases the waters' safe use in the long-term for domestic/ drinking supplies. It should be noted that the poor water quality condition in the groundwater could impact on the surface water component.

Of serious concern throughout the study area is the steady increase of nitrates in the groundwater and is directly linked to (i) irrigation practices (i.e. The Springbok Flats) and (ii) high-density populated areas – three specific areas have been identified where regional nitrate pollution as the result of sanitary practices (pit latrines) are probably the cause. They are: (i) the northern part of the Upper Olifants Sub-Catchment (QC's B31's), (ii) the central and lower part of the Middle Olifants Sub-Catchment (QC's B51's and B52's), and (iii) Lower Olifants Sub-Catchment (QC's B72's and upstream B73's). Local groundwater resources in the Giyani Region (QC B82G –Little Letaba River) are significantly impacted by nitrate pollution and the effect is probably irreversible.

6.1.1 Groundwater quality high risk areas

Several high risk areas illustrated in Figure 14, were high-lighted by a study conducted by SATAC (2009) pointing to serious groundwater quality risks in the Olifants River Catchment.

- The Delmas Dolomite Aquifer (B20A and B20B) where irrigation in the order of 6 Mm^3/a is abstracted from a spatially limited aquifer. The risk of sinkhole formation is an important aspect that should be managed.
- Similar to Delmas is the Zebediela Dolomite Aquifer (B51E and B51G) where 3 Mm^3/a is abstracted also from a spatially limited aquifer.
- The Springbok Flats Karoo Aquifer (B51E) where 10-12 Mm^3/a, is abstracted for irrigation.
- Highveld coal mining area at Witbank-Middelburg-Kriel Karoo Coal Aquifers (B11K, B11J, B11H and B12D) where water quality is significantly affected and pose a risk to surface water resources further downstream.
- Steelpoort mining and community water supply aquifer areas (B41J and B41K) where groundwater quantity and quality are significantly affected.
- Kruger National Park and Bushbuckridge Catchments (B73J, B73H, and B73F) where groundwater sustains community water and riparian vegetation.

In addition to these areas, a study conducted for the Department of Water and Sanitation Affairs (DWA, 2014) identified several quaternary catchments in the Letaba Catchment with serious groundwater pollution from sanitary or similar sources resulting in elevated salinity and nitrate concentrations. These QC's are:

- B81B: Salinity (TDS) and nitrate (NO_3–N) with 71% and 75% potability respectively;
- B81F: Nitrate (NO_3–N) with 69% potability;
- B81H: Nitrate (NO_3–N) with 66% potability;
- B82C: Nitrate (NO_3–N) with 70% potability;
- B82H: Nitrate (NO_3–N) with 59% potability;
- B82J: Nitrate (NO_3–N) with 81% potability; and
- B82G: Nitrate (NO_3–N) with 78% potability.

(Note: % potability indicates the percentage of the tested water acceptable for use as domestic water supplies).

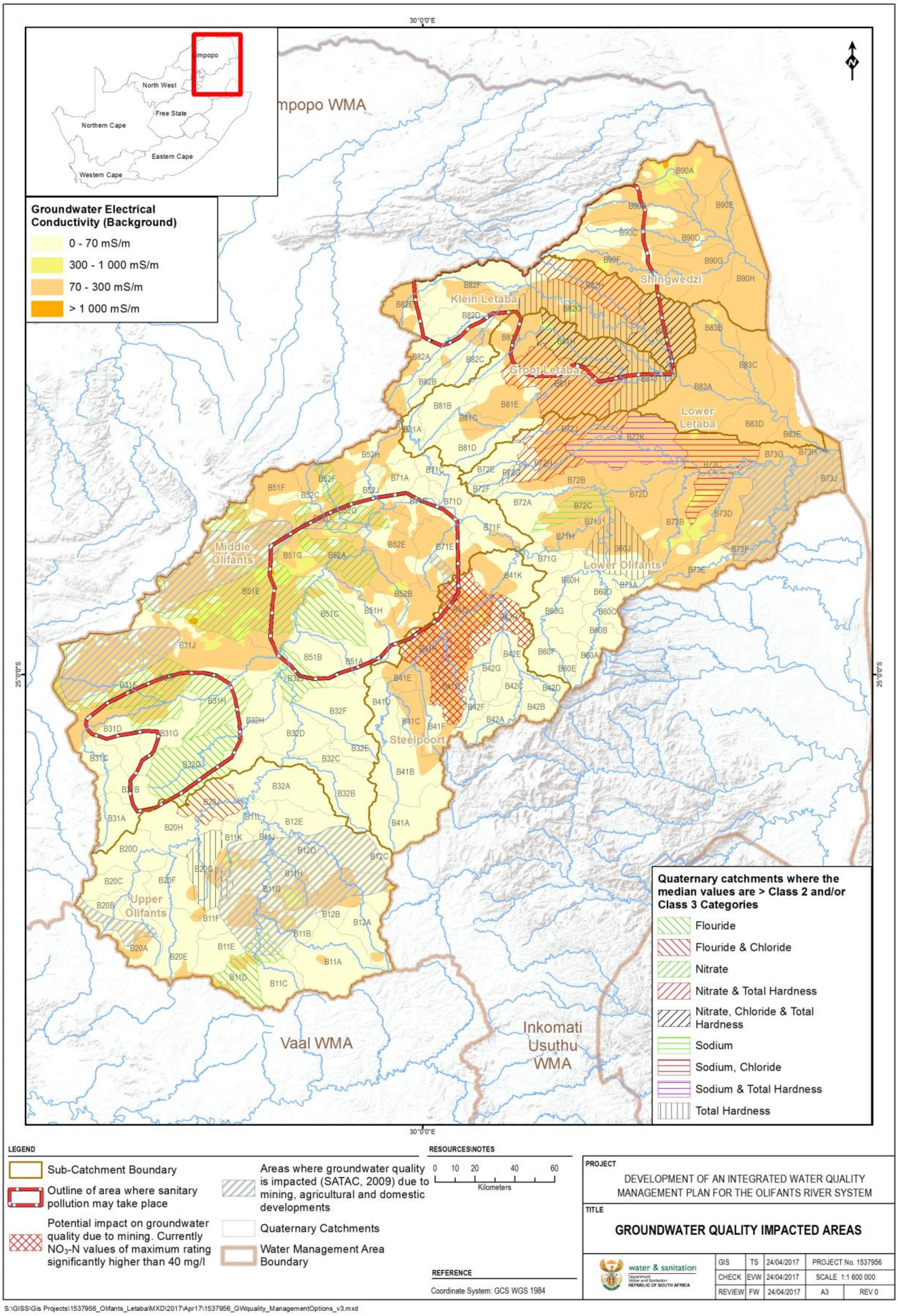


Figure 14: Groundwater areas of concern

5.2 Scenarios for groundwater management

The current status of the groundwater is impacted specifically by the following constituents:

- Total Hardness – not specifically a health risk up to Class 2 maximum concentration levels, however, warm water systems and certain industrial water uses may be impacted significantly;
- Salinity (TDS due to mainly dissolved Na/Mg-Cl salts) – Health and aesthetic (taste) ;
- Toxic nitrate concentrations due to anthropogenic activities; and
- Toxic fluoride concentrations due to specific rock-aquifer decomposition (or weathering, specifically certain granites and granite-gneisses.

The scenarios to be considered for groundwater management are therefore related to protection of groundwater in supply areas and treatment options for potable supply.

5 RECOMMENDATIONS AND CONCLUSIONS

The following scenarios will be taken forward into the Management Options component.

In respect of water quality the strategy for salinity will need to consider: defunct mines, operating mines, industries and power stations and the irrigation return flows in the case of the Lower Moses and Elands rivers. The main sources of pollution contributing to salinity that need to be addressed, and for which scenarios interventions will be considered are:

- Reduced load due to seepages from the mine, industrial and power station waste storage facilities and mining operations in the Upper Olifants sub-catchment, some load from the Steelpoort sub-catchments and the Ga-Selati in the lower Olifants sub-catchments.;
- Reduced load from excess mine water on the mining operations threatening to decant or starting to flood the coal reserves in the Upper Olifants sub-catchment; and
- Reduced load from irrigation return flows in the Upper and Middle Olifants.

In terms of nutrients the largest impacts are from poorly managed wastewater treatment works and contaminated run-off from urban and agricultural areas. The main sources of pollution contributing to nutrients in the system that need to be addressed, and for which interventions will be considered are: The following scenarios to be considered are likely to have the biggest impact on controlling nutrients (and microbiological contamination):

- Reduction of nutrient load from domestic WWTW that discharge to the water resources, by considering a reduction of the orthophosphate concentration to 1 mgP/l;
- Reduction of nutrient and sediment load from agricultural areas and areas where changing land uses may be occurring;
- Reduction of nutrient and sediment load from run-off from urban/ densely populated areas; and
- Improved reuse of effluent from domestic wastewater treatment works not designed to meet the general discharge limits.

Groundwater is addressed separately and will include the scenario around the protection of groundwater and the treatment of groundwater for potable supply.

6 REFERENCES

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APPENDIX A:

LOAD CALCULATIONS (ELECTRONIC)

APPENDIX B:

PROJECT STEERING COMMITTEE MEMBERS

Title	Surname	First Name	Organisation
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Mr	Harris	James	Olifants River Forum
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Mrs	Kobe	Lucy	Dept. of Water and Sanitation
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Ms	Kubashni	Mari	Shanduka Coal
Mr	Le Roux	Roelf	Magalies Water
Mr	Leballo	Labane	Lepelle Water
Mr	Lee	Clinton	South 32
Mr	Linstrom	Charles	Exxaro
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APPENDIX C:

STAKEHOLDERS WHO PARTICIPATED IN THE PROJECT

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Betty Nguni	DWS
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Caroline Shai	DWS, Compliance
Cecilia Mkhatshwa	City of Tshwane
Celiwe Ntuli	DWS
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Jaques Venter	SANparks
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Zama Ramokgadi	Tubatse Chrome
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