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Annexure to Scientific Review Report

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REVIEW, EVALUATION AND OPTIMISATION OF THE SOUTH AFRICAN WATER RESOURCES MONITORING NETWORK

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Final
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INTRODUCTION

Contained in the main Scientific Review report is a summary of the recommendations regarding the existing surface and groundwater monitoring sites for all the Water Management Areas (WMAs) following the nine Regional Network Design Workshops held in Nelspruit, Cape Town, Durban, King Williams Town, Bela-Bela and Bloemfontein from March to June 2016.

During these workshops theoretical monitoring network considerations for each WMA were presented to various stakeholders, and the considerations were used to review the existing networks and obtain changes and improvements to the networks as recommendations.

The main objectives of the workshops were to review the existing monitoring networks against the prioritised National Monitoring Objectives in terms of:

- Existing sites meeting the identified objectives;
- Redundancies in the existing monitoring network;
- Gaps in the spatial coverage with regards to meeting important monitoring objectives; and
- Possible physical constraints associated with existing and potential new monitoring sites.

Reported in **Annexures 1** to **9** of this document are the detailed outcomes, comments and prioritisation of all existing and proposed monitoring sites per WMA. The WMAs are reported as per the second National Water Resources Strategy *(DWS, 2013e)* (see **Figure A.1**).

The annexures are structured as follows:

- Annexure 1: Limpopo WMA
- Annexure 2: Olifants WMA
- Annexure 3: Inkomati-Usuthu WMA
- Annexure 4: Pongola-uMzimkulu WMA
- Annexure 5: Vaal WMA
- Annexure 6: Orange WMA
- Annexure 7: Mzimvubu-Tsitsikamma WMA
- Annexure 8: Breede-Gouritz WMA
- Annexure 9: Berg-Olifants WMA

Figure A.1 South African Water Management Areas as per NWRS-2

ANNEXURE 1

WMA 1: LIMPOPO

1. WMA 1: LIMPOPO

The Limpopo WMA is the northern most Water Management Area (WMA) in the country and represents part of South African portion of the Limpopo Basin which is also shared by Botswana, Zimbabwe and Mozambique. The WMA borders on Botswana and Zimbabwe, where the Limpopo River forms the entire length of the international boundary before flowing into Mozambique (DWS, 2013a).

The region is semi-arid, with economic activity mainly centred on livestock farming and irrigation, together with increasing mining operations. Approximately 760 rural communities are scattered throughout the WMA, with local economic activity to support these population concentrations.

There are numerous tributaries that contribute to the Limpopo WMA. The Marico and Crocodile Rivers form the headwaters of the Limpopo at their confluence. The Marico, Upper Molopo and Upper Ngotwane River catchments make up the western part of the WMA. The Crocodile West River catchment forms part of the Limpopo WMA. The Crocodile River is a major tributary of the Limpopo River which discharges into the Indian Ocean in Mozambique, while the Pienaars, Apies, Moretele, Hennops, Jukskei, Magalies and Elands rivers are the major tributaries of the Crocodile River (DWS, 2013a).

While the topography of the WMA is mostly flat, the Waterberg Mountain range forms an escarpment along the south-western border with altitudes in excess of 1 800 m. The Crocodile River and some of its main tributaries rise in the South of the catchment in the Witwatersrand topographical features at an altitude close to 2 000 masl, where the rivers wind their way through the Daspoort Ridge to the Magaliesburg Mountain range at the Hartbeespoort Dam where the altitude is around 1 200 masl (DWS, 2013a).

The climatic conditions vary within the Limpopo WMA, which ranges from the Waterberg Mountains in the south, northwards to the hot, dry Limpopo River valley on the border with Zimbabwe. The mean annual temperature of the Limpopo WMA ranges from 16°C in the south to 22°C in the north, with an average of 20°C for the WMA as a whole (DWS, 2013a).

The mean annual precipitation (MAP) ranges from as little as 200 mm/a in the north to over 1 200 mm/a in the Soutpansberg Mountains. In general, the rainfall decreases from the south to the north, with the lowest rainfall occurring in the Limpopo valley in the north-east of the WMA. Rainfall occurs mainly in summer with the peak rainfall months being January and February (DWS, 2013a).

During the driest year, the annual rainfall in the Limpopo WMA ranges generally between 100 to 200 mm in the extreme north with the majority of the catchment ranging between 200 to 400 mm increasing up to 600 mm in the south. Rainfall in the Soutpansberg watershed ranges between 800 to 1 200 mm/a.

Water resources in the Limpopo sub area are nearly fully developed with all available water being highly utilised. Moreover, limited options for further resource development exists. Although the resources and requirements approximately in balance at present, the implementation of the reserve is expected to result in serious deficits in some of the main rain catchments (DWS, 2013a).

1.1 SITE REVIEWS

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps with the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

1.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Limpopo WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. **Table** 1.1 provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

Table 1.1 Number of surface water quantity monitoring sites per secondary catchment

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
A1	**4**	0	1	0	0	1	0	**2**
A2	**57**	9	2	6	45	11	0	**73**
A3	**28**	3	2	2	4	5	0	**16**
A4	**4**	0	0	1	7	1	0	**9**
A5	**4**	0	0	0	2	2	0	**4**
A6	**15**	1	0	0	20	2	0	**23**
A7	**6**	0	0	0	3	1	0	**4**
A8	**7**	7	0	1	5	4	0	**17**
A9	**6**	4	0	3	12	3	0	**22**
Total	**131**	**24**	**5**	**13**	**98**	**30**	**0**	**170**

According to **Table 1.1** there are 98 active river flow, 5 eye monitoring and 30 reservoir monitoring sites in the Limpopo WMA that were evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

The number of sites with water quality constituents being monitored in the Limpopo is provided in **Table 1.2**.

Table 1.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
A1	**0**	3	0	0	0	0	0	0	0	**3**
A2	**9**	50	14	2	0	51	13	20	0	**111**
A3	**0**	13	4	0	0	2	0	4	0	**21**
A4	**1**	4	5	0	0	0	0	1	0	**10**
A5	**2**	3	2	0	0	0	0	0	0	**5**
A6	**3**	14	2	0	0	0	0	2	0	**18**
A7	**2**	1	2	0	0	0	1	2	0	**6**
A8	**2**	7	1	0	0	1	0	2	0	**10**
A9	**4**	7	5	0	0	0	0	3	0	**15**
Total	**23**	**102**	**35**	**2**	**0**	**54**	**14**	**34**	**0**	**199**

Notes:
(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.
(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

As can be seen from Table 1.2 the main water quality programmes in the WMA include chemical, eutrophication, microbial and also radioactivity monitoring. As stated earlier, the water quality parameters and frequencies will be reviewed during the strategy development and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

1.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 1.4**.

1.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or needing to be upgraded. Reported in **Table 1.3** are the theoretical objectives that have been assigned to these existing river sites.

Table 1.3 Objectives and relative priorities assigned to existing river monitoring stations with no recommended actions

Site number	Description	Theoretical objective	Relative priority[#]
A9H006	Livhungwa River @ Barotta	PMC|HR,Base,Ir,Rur,F	10.5
A9H005	Luvuvhu River @ Nooitgedacht	PMC|IR,WWTW,HR,Base	10.0
A9H028	LUVUVHU AT NOOITGEDACHT	PMC|IR,WWTW,HR,Base	10.0
A2H060	Krokodil River @ Nooitgedacht	PMC|Base,ExistResR,Ir	9.5
A4H014	Mogol River	PMC|Base,Esk,MI	9.5
A2H010	Maloney's-Eye @ Steenekoppie	PEC|Base,HR,ExistResR	8.5
A2H049	Bloubank Spruit@Riet Spruit @ Zwartkop	PE|MI,UR,IR,Rur,AMD	8.5
A2H050	Krokodil River @ Zwartkop	PE|MI,UR,IR,Rur,AMD	8.5
A7H007	Sand River @ Pietersburg	PC|WWTW,IR,Urb,Rur,MI,Base	8.0
A1H001	Upper Eye Dinokana @ Dinokana	PE|HR,Base,Rur	7.5
A2H012	Krokodil River @ Kalkheuwel	PC|ExistResR,WWTW,UR,Inf,IR	7.5
A3H021	Malmanieloop@Upper-Eye @ Paardenvallei	PE|HR,Base,Urb	7.5
A2H045	Krokodil River @ Vlakfontein	P|Base, AMD,MI,Urb,Ir	6.5
A2H128	Faure Crocodile River	PC|Base,ExistResR,IR	6.5
A2H132	Krokodil River @ Haakdoringdrift	PC|Base,IR,ExistResR	6.5
A6H023	Tobias Spruit @ Saratoga	PC|WWTW,UR,IR	6.5
A9H027	Latonanda at Levubu settlement	P|EcoImpSen,F,Ir,Base,HR	6.5

Site number	Description	Theoretical objective	Relative priority[#]
A2H034	Skeerpoort River @ Scheerpoort	P|EcoImpSen,HR,Base,Ir	6.0
A3H017	Rhenosterfontein @ Rhenosterfontein	P|HR,Base,Ir,MI	6.0
A4H004	Matlabas River @ Haarlem East	PC|ExistResR,Base	6.0
A4H008	Sterkstroom @ Doornspruit	P|Base,Ir,EcoSenImp	6.0
A2H024	Brandvlei River @ Brandvlei	P|Base,Ir,Rur	5.5
A2H099	Buffels Spruit @ Roodepoort	P|Base,Urb,Rur	5.5
A6H036	Sterk River @ Appingen Dam	P|Base,EcoImpSen,Ir	5.5
A2H033	Nouklip-Eye @ Hartbeeshoek	P|HR,Base	5.0
A2H038	Waterkloof-Lower @ Rietvallei	P|Base,Baseline	5.0
A2H039	Waterkloof-Upper @ Rietvallei	P|Base, Baseline	5.0
A2H063	Wonderboom Spruit @ Mayville Pretoria	P|Base,Ur	5.0
A9H003	Tshinane River @ Chibase	P|IR,Rur	5.0

[#] *Sites are listed in descending order based on relative priority*

1.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 1.4** are all the proposed monitoring sites for the Limpopo WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

1.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, site descriptions, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 1.4 Proposed new river monitoring sites

Site number	Lat	Long	Theoretical objective	Comment	Relative priority[#]
N26	-23.511	27.714	PMC|Base,MI,Esk,Ir,ExistResR	This site is required to assess flows and return flows from Medupi as well as to replace A4H007.	10.5
N4	-23.88	28.69	PM|Base,Rur,MI,Ir, WTW	Tributaries of the Mogalakwena River in the upper reaches are not measured and this station will measure the contributions of the Groot-Sandsloot, Rooisloot and Dorps rivers.	9.5
N2	-22.443	31.076	PEC|UpPA, EcoSenImp,,Base	To replace A9H013 and take on the associated objectives.	8.5
N20	-25.544	26.099	PMC|WWTW	Return flows needs to be measured.	8.5
N21	-25.952	27.986	PMC|WWTW	Return flows needs to be measured.	8.5
N13	-25.688	26.444	PC|HR,Base,Rur,Ir, ExitResR,MI	This site is recommended to measure the groundwater springs contribution to Marico Bosveld Dam.	8
N3	-23.669	29.596	PC|Base,Ir,Urb,MI, Rur	There are very few station on the Sand River and this station will take into consideration the contributions of the Diep and Turfloop rivers.	7.5
N12	-24.628	27.311	PC|Base, ExistResR,MI,Ir	This station is recommended as a potential monitoring site for the proposed Lesotho Highlands-Botswana transfer scheme.	7
N5	-24.398	28.106	PC|Base,HR, ExistResR,Ir	There is currently no monitoring on the upper reaches of the Mokolo River. This station will take into consideration the effects of the Sand, Grootspruit and Klein-Sand rivers. Access to the site may be a problem.	7
N8	-25.978	27.993	P|Ur,Base,Ir	Potential new site due to new development, prone to vandalism.	5.5
N18	-25.021	26.414	P|Base, MI	There is currently almost no monitoring on the Sehubyane River and it is recommended that a station be installed to measure low to medium flows.	5

[#] *Sites are listed in descending order based on relative priority*

Table 1.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Relative priority
A9H029	Mutale River @ Mutale pump station	PME|HR,Base,Ir,Rur,WTW	An alternative for this site needs to be identified. Continuous measurement of use need to be implemented.	11.5
A2H061	Apies River @ Rondavel	PEC|IR,UR,MI,Inf,Base,WTW,Rur	The data from this station is exhibiting poor accuracy and it is therefore recommended that this station be upgraded.	10.5
A6H006	Little Nyl River @ Nylstroom	PEC|Base,WWTW,UR,IR,Rur,UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant. Site has poor upstream pool conditions.	10.0
A7H008	Limpopo River @ Beit Bridge	PEC|IntObl,WWTW,Urb,Ir,Base,Rur	The data from this station is exhibiting poor accuracy and it is therefore recommended that this station be upgraded.	10.0
A2H014	Hennops River @ Skurweberg	PEC|Base,WWTW,Ir,Urb,Rur	Needs to be replaced / relocated, higher flows experienced.	9.5
A6H002	Nyl River @ Deelkraal	PEC|IR,Base,Ur,UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	9.0
A9H012	Luvuvhu River @ Mhinga	PM|HR,Base,WTW,Rur	The data from this station is exhibiting poor accuracy and it is therefore recommended that this station be upgraded.	9.0
A2H013	Magalies River @ Scheerpoort	PEC|Base,WWTW,Ir	Replacement site required upstream from current location	8.5
A6H035	Mogalakwena River @ Leniesrus	PM|Base,WTW,Ir	Site requires satellite telemetry .	8.5
A9H013	Mutale River @ Kruger National Park	PEC|UpPA,EcoSenImp,,Base	New site required downstream. Environmental approval will be difficult. New site N2 is proposed downstream.	8.5
A9H025	Mutshindudi River @ Vredenburg	PE|HR,Base,Rur,Ir,UpPA	This gauge need to be replaced.	8.5
A6H037	Nyl River @ Vogelfontein	PEC|Base,UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	8.0
A2H044	Jukskei River @ Vlakfontein	PC|Base,ExistResR,Ir,Urb,Mi	If new development on Jukskei happens then not necessary to upgrade stations, but if upgrade station.	7.5

Site number	Description	Theoretical objective	Comment	Relative priority
A4H002	Mokolo River @ Zandrivier	PC|WWTW, UR,IR,Base, ExistResR	This station is subjected to vandalism and security measures should be upgraded or the station relocated. Also investigate direct measurement of return flows. If station N5 is constructed might become redundant.	7.5
A5H004	Palala River @ Muisvogelkraal	PC|HR,Bas e,Ir,ExistRe sR,EcoImpS en	This station requires constant maintenance and can possibly be upgraded.	7.5
A7H010	SAND RIVER AT WATERPOORT	PC|WWTW, Ir,Urb,Base, Rur	Downstream water level should be measured at this site.	7.5
A6H033	Nyl River @ Moorddrift	P|Base,Ir,Ml ,Rur, Urb,WWTW	Investigate possible formalisation or new site further downstream.	7.0
A2H106	Pienaars River @ Klipvoor	PC|ExistRe sR,Base,Ru r	Investigate the increase of capacity of this W-component	6.5
A6H039	Nyl River @ Middelfontein	PC|WWTW, Base,Rur	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	6.5
A5H006	Limpopo River @ Botswana	P|Base,Ir	This station is an illegal structure and it is recommended that a different location be investigated for the station.	6.0
A5R002	Palala River @ Susandale	P|Base,Ir	Investigate possible measurement of use at the weir.	6.0
A6H011	Great-Nyl River @ Modderpoort	P|EcoImpSe n,Base,Ir,U pPa	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant. Very small catchment.	6.0
A6H012	Olifant Spruit @ Olifantspoort	P|EcoImpSe n,Base,Ir,U pPa	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	6.0
A3H011	Vergenoegd-Eye @ Vergenoegd	P|HR,Base,I r	Re-establish monitoring at this eye.	5.5
A3H023	Malmanie-Eye @ Eye Of Malmanie	P|HR,Base, Ir	Investigate why this eye measurement was closed and re-establish.	5.5
A3H035	Left Furrow From Malmanie Eye @ Eye Of Malmanie	P|HR,Base, Ir	Investigate why this eye measurement was closed and re-establish.	5.5
A6H010	Badseloop River @ Vischgat	P|Base,Ir, UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	5.5

Site number	Description	Theoretical objective	Comment	Relative priority
A6H018	Rasloop River @ Sussensvale	P|Base,Ir,UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant, Very small catchment.	5.5
A6H019	Hessie Se Water @ Rietspruit	P|Base,Ir, EcoImpSen, UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	5.5
A6H020	Middelfontein Spruit @ Middelfontein	P|Base,Ir, UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	5.5
A2H059	Krokodil River @ Vaalkop	P|Base,IR	This station requires constant maintenance due to reeds in the area and can possibly be upgraded.	5.0
A6H001	Nyl River @ Moorddrift	P|Base,Ir	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	5.0
A6H021	De Wet Spruit @ Groenvaley	P|Base,UpPA	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	5.0
A6H038	Nyl River @ Du Toits Kraal	P|Base	Forms part of the Nylsvley monitoring. Re-evaluate accuracy, role and importance regarding wetlands and DEA perspective. If not then redundant.	4.5

[#] *Sites are listed in descending order based on relative priority*

1.3.4 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Reported in **Table** 1.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 1.6 Monitoring sites that are not of national importance

Site Number	Description	Comments
A2H027	Pienaars River @ Baviaanspoort	This station is located directly upstream of Roodeplaat Dam and is considered, from a water resources perspective, not of national importance because

Site Number	Description	Comments
		measurements can be conducted at the dam.
A2H029	Edendale Spruit @ Leeuwfontein	This station is located directly upstream of Roodeplaat Dam and is considered, from a water resources perspective, not of national importance because measurements can be conducted at the dam.
A2H030	Roodeplaat Spruit@Louwsbaken Se Loop @ Roodeplaat	This station is located downstream of Roodeplaat Dam (on a relatively small stream) and is considered, from a water resources perspective, not of national importance.
A2H054	Hartbees Spruit @ Wolmaranspoort	This station is located directly upstream of Roodeplaat Dam and is considered, from a water resources perspective, not of national importance because measurements can be conducted at the dam.
A2H055	Moretele River @ Derdepoort Pretoria	This station is located directly upstream of Roodeplaat Dam and is considered, from a water resources perspective, not of national importance because measurements can be conducted at the dam.
A2H056	Steenoond Spruit @ Belle Ombre Sta.	-
A2H058	Swart Spruit @ Rietfontein	This station is located directly upstream of Hartbeespoort Dam and is considered, from a water resources perspective, not of national importance because measurements can be conducted at the dam.
A2H064	Plat River @ Buffel Spruit	-
A2H065	Frisgewaag Spruit @ Buffel Spruit	-
A2H036	Koster River @ Steenbokfontein	Just upstream from Kosterrivier Dam.

1.3.5 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, site description and comments that resulted in the site classification.

Table 1.7 Redundant river flow monitoring sites

Site number	Description	Comment
A2H006	Pienaars River @ Klipdrift	-
A2H021	Pienaars River @ Buffelspoort	-
A2H023	Jukskei River @ Nietgedacht	This station is possibly redundant if A2H044 can be upgraded and the return flow is measured at N21.
A2H032	Selons River @ Moedwil	This station is downstream of a low runoff area and is, from a water resources perspective, redundant.
A2H047	Little Jukskei River @ Klipfontein	Small urban catchment.
A2H048	Krokodil River @ Krokodilpoort	-
A2H053	Sterkstroom @ Grootfontein	This station is directly upstream of Buffelspoort Dam and is therefore, from a water resources perspective, redundant.
A2H057	Skinner Spruit @ Daspoort Pretoria	This station was subjected to high vandalism and has been closed.
A2H062	Walker Spruit @ Sunnyside Pretoria	This station has a small upstream catchment and is, from a water resources perspective, redundant.
A4H005	Mokolo River @ Dwaalhoek	This station is possibly redundant if telemetry monitoring can be established at Mokolo Dam.
A4H007	Tambotie River @ Blakeney	This station is possibly redundant if a new site is identified downstream of Mokolo Dam (N26).
A5R001	Palala River @ Hope Town	This station has low accuracy and is possibly redundant.
A6H024	Kootjie Se Loop@Spruit @ Waterval	Extremely small catchment area.

1.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must therefore be monitored efficiently. Listed in **Table 1.8** are all the required W-components as well as changes and potential improvements to existing reservoir monitoring within the WMA.

1.5 ESTUARIES

There are no estuary / tidal stations in this WMA.

1.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.1.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

Table 1.8 New and changes to W-components for dams as well as changes to existing reservoir monitoring.

Site number	Lat*	Long*	Theoretical objective	Comment	Relative priority#
A2R001	Krokodil River @ Hartbeesfontein - Hartbeespoort Dam		PMEC|Base, ExistResR,Ir, Urb,Rur	Improve measurements of canal, outlet to be improved for Medupi Transfers.	12.5
A2R009	Pienaars River @ Roodeplaat - Roodeplaat Dam		PMEC|Base, ExistResR,Ir, Urb,Rur	Improve measurements of canal releases.	12.5
A2H083	Krokodil River @ Hartbeesfontein		PMEC|Base, ExistResR,Ir, Wcomp	The W-component needs to be upgraded/replaced - High priority.	12.0
A2H094	Hex River @ Boschpoort		PMEC|Wcomp, ExistResR,Rur,MI	W-component must be moved closer to the dam.	12.0
A2R006	Hex River @ Bospoort - Bospoort Dam		PMEC|ExistResR,Rur,MI	Security needs to be improved on all the components.	11.5
A8H010	Nwanedzi River @ Nwanedzi Nat. Res		PME|HR,Base,WTW,Rur	W-component needs fixing.	11.0
N27	-22.85	30.52	PME|HR,Base,WTW,Rur	Investigate full measurement at Mvuwe Dam.	11.0
A2H107	Elands River @ Brakfontein		PMC|Wcomp, Base,ExistResR, MI	The W-component needs some minor improvements.	10.0
A3H029	Groot-Marico River @ Riekers Dam		PMC|Wcomp, IR,ExistResR, Base	Urgent replacement of this W-component required.	10.0
N10	-25.78	27.49	PMC|Wcomp, ExistResR,Ir, Urb	A W-component is required for Buffelspoort Dam.	10.0
N11	-25.50	26.69	PMC|Base,ExistResR,Wcomp,Ir	A W-component is required for Lindleyspoort Dam.	10.0
N23	-24.86	28.24	PMC|ExistResR, Base, Urb,Rur	Investigate measurement options and implement. A2H099 could serve as possible W-component.	10.0
A3R001	Groot-Marico River @ Riekers Dam - Marico-Bosveld Dam		PMC|Base,Ir, ExistResR	Improved measurement of canal and other components required.	9.5
A3R002	Klein Marico River @ Kalk Dam		PMC|Base,Ir, ExistResR	Improved measurement of canal required.	9.5
N19	-24.87	26.45	PMC|Wcomp, Base, ExistResR	Investigate W-component for Molatedi Dam, taking into account the return flows. If W-component is downstream of retroflex, include improved measurement of Return flows .	9.5
N24	-25.79	27.26	PM|Base,Ir,Rur,MI,W-Comp	Establish a W-component for Olifantsnek Dam.	9.5

Site number	Lat*	Long*	Theoretical objective	Comment	Relative priority#
A1R001	Ngotwane River @ Moilwas Gopane Mogomane-Ngotwane Dam		PEC|Base,WWTW,Rur,Ir	Investigate full measurement including W-component, use and water quality.	9.0
A2R003	Hex River @ Commissiesdrift - Olifantsnek Dam		PM|Base,Ir,Rur,Ml	Start monitoring canal releases.	9.0
A2H019	Krokodil River @ Beestkraal		PM|Wcomp, Base, Ir	The W-component needs to be upgraded.	8.5
A2H104	Koster River @ Waterkloof		PM|Base,Ir,Urb	W-component needs to be replaced.	8.5
A3H037	Sehujane River @ Buispoort		PM|Base,Wcomp,Rur	This W-component needs to be replaced.	8.5
A3R005	Sehujane River @ Buispoort		PM|Base, Rur	Improvement of use measurement required.	8.0
A7R002	Hout River @ Houtriver Dam		PM|Base,Rur	Investigate full measurement and review survey.	8.0
N16	-25.40	26.58	PM|Ddam, Rur	It is recommended that the measurements of Madikwe Dam levels be implemented as well as a survey done.	8.0
N17	-25.47	26.45	PM|Ddam, Rur	It is recommended that the measurements of Pella Dam levels be implemented as well as a survey done.	8.0
N25	-25.69	27.54	PE|Ml,Ir,Rur	Dam planned to be monitored.	7.5

Notes:

(#) Sites are listed in descending order based on relative priority

(*) Proposed coordinates are reported for the new station recommendations only. Station descriptions, as per DWS, database are used for all existing stations

1.7 GROUNDWATER MONITORING

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring station points does not plot on top of mountains.
- Increase spatial density over groundwater control areas to 500 km^2 to set baseline monitoring points. This rule applies to all groundwater control areas throughout the country.
- Set all springs as baseline monitoring points.
- Set the following as additional baseline monitoring stations:

A2N0087	A4N0507	A6N0589-
A2N0146	A4N0515	A6N0593
A2N0642	A4N0509	ZQMALL2
ZQMPIL1	A4N0513	ZQMEVA1
A3N0504	A4N0504	A6N0591
A3N0503	A4N0503	ZQMPTB3
A3N0010	A4N0505	A7N0525
A3N0001	A5N0014	A7N0629
A3N0006	A5N0014	A7N0638
A3N0005	ZQMVNA1	A7N0634
A3N0002	A5N0009	A7N0651
A3N0501	A5N0012	A7N0649
A3N0511	A6N0544	A7N0630
A3N0016	A6N0547	A8N0507
A3N0015	A6N0545	ZQMSOU1
A3N0013	A6N0553	A8N0513
A3N0012	A6N0023	A8N0506
A3N0505	A6N0585	A8N0510
ZQMGNO1	A6N0069	A8N0504
A1N0001	A6N0581	A9N0014
A1N0002	A6N0560	A9N0011
A4N0516	ZQMMOZ1	A9N0012
A4N0512	A6N0578	A9N0001
ZQMTHA4	A6N0606	A9N0010

A4N0506	A6N0595	A9N0017
A4N0508	A6N0594	A9N0002
A9N0016	A9N0003	A9N0020
ZQMTZN2	A9N0004	ZQMNKW1

- Convert the current monitoring points to trend monitoring station. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring stations that fall within the buffer.

A2N0710	A2N0592	A2N0752	A2N0647	A2N0001
A2N0782	A2N0586	A2N0657	A2N0656	A2N0747
A2N0632	A2N0632	A2N0658	A2N0029	A3N0009
A2N0631	A2N0631	A2N0659	A2N0017	A3N0004
A2N0630	A2N0630	A2N0660	A2N0014	A3N0003
A2N0628	A2N0628	A2N0552	ZQMSGS1	ZQMSRG1
A2N0791	A2N0202	A2N0528	A2N0045	A3N0506
A2N0788	A2N0756	A2N0678	ZQMBTS1	A3N0510
A2N0576	A2N0779	A2N0679	ZQMDI1	A3N0512
A2N0616	A2N0780	A2N0680	ZQMPSP1	ZQMZRS1
A2N0615	A2N0778	A2N0676	ZQMPSP2	ZQMMIE1
A2N0614	A2N0702	A2N0692	ZQMBTS3	ZQMMIE3
A2N0612	A2N0704	A2N0693	ZQMBTS3	ZQMLRE2
A2N0566	A2N0705	A2N0143	ZQMBKL1	A4N0511
A2N0567	A2N0703	A2N0125	ZQMPNR1	ZQMVAW1
A2N0610	A2N0706	A2N0139	ZQMMKE2	ZQMVAW2
A2N0571	A2N0714	A2N0121	ZQMASN1	ZQMCUM1
A2N0572	A2N0713	A2N0138	ZQMKVD1	A4N0514
A2N0573	A2N0709	A2N0729	A2N0775	ZQMMELS1
A2N0580	A2N0707	A2N0131	ZQMPNR2	ZQMSBP1
A2N0583	A2N0715	A2N0641	ZQMPRN4	ZQMSBP2
A2N0553	A2N0784	A2N0639	ZQMMRE1	A4N0510
A2N0556	A2N0699	A2N0638	ZQMNHM2	A5N0015
A2N0554	A2N0694	A2N0637	A2N0005	A5N0013
A2N0606	A2N0687	A2N0535	ZQMWBD2	A5N0011
A2N0607	A2N0624	A2N0543	A2N0116	A5N0018
A2N0605	A2N0627	A2N0526	ZQMWBD1	ZQMTBK1

A2N0600	ZQMMRN1	A2N0524	A2N0786	ZQMTBK2
A2N0590	A2N0201	A2N0034	A2N0091	A5N0017
A2N0602	A2N0757	A2N0534	ZQMTHA3	ZQMSWW2
A6N0550	A6N0586	ZQMPDF1	A7N0633	A7N0645
A6N0603	A6N0598	A7N0639	A7N0654	A7N0650
ZQMNAB4	A6N0605	A7N0631	A7N0661	A8N0508
ZQMNAB2	A6N0544	A7N0632	A7N0653	A8N0509
A6N0611	A6N0580	ZQMPTB2	A7N0641	A8N0515
A6N0602	ZQMBLT2	A7N0636	A7N0656	A8N0514
A6N0610	ZQMBLT3	A7N0539	A7N0041	A8N0505
A6N0059	A6N05582	A7N0549	A7N0643	ZQMTPS1
A6N0044	A6N0590	A7N0639	ZQMDDN1	A9N0007
A6N0079	A6N0579	A7N0561	A7N0524	A9N0018
A6N0534	ZQMHK1	A7N0635	A7N0657	ZQMLEV2
A6N0083	ZQMHK2	A7N0637	A7N0640	A9N0008
A6N0587	A6N0608	A7N0655	A7N0659	ZQMTOY1
A6N0588	A6N0592	A7N0642	A7N0644	A9N0013
A6N0599	ZQMMALL1	A7N0646	A7N0593	A9N0015
A6N0597	ZQMTUG4	A7N0029	ZQMLTR1	ZQMTPS2
A6N0584	ZQMTUG2	A7N0538	A7N0652	A9N0005
A6N0604	A6N0583	A7N0647	A7N0660	A9N0006

APPENDIX A.1

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 1: LIMPOPO

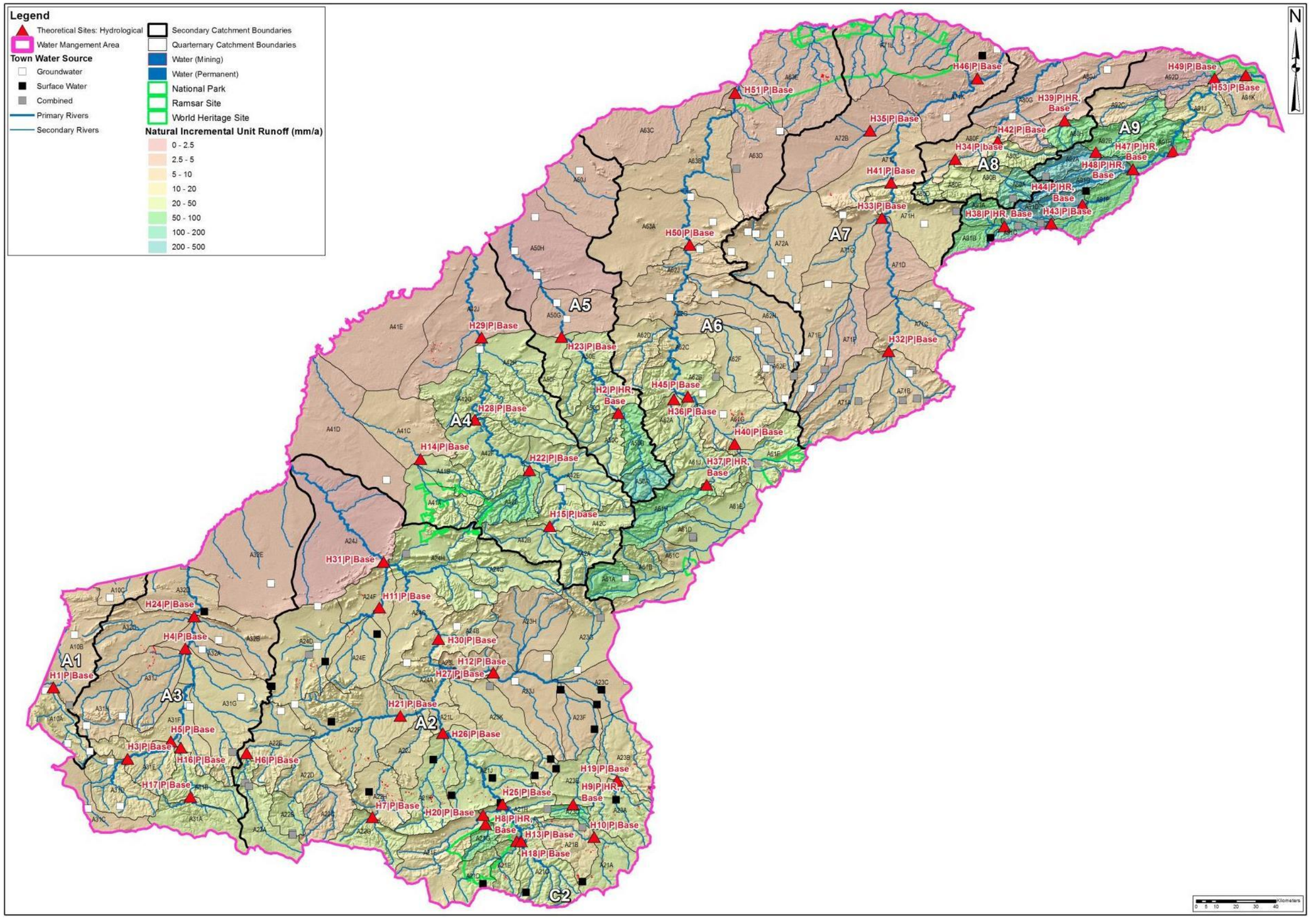


Figure A.1.1 Theoretical surface water sites based on hydrological (runoff) considerations

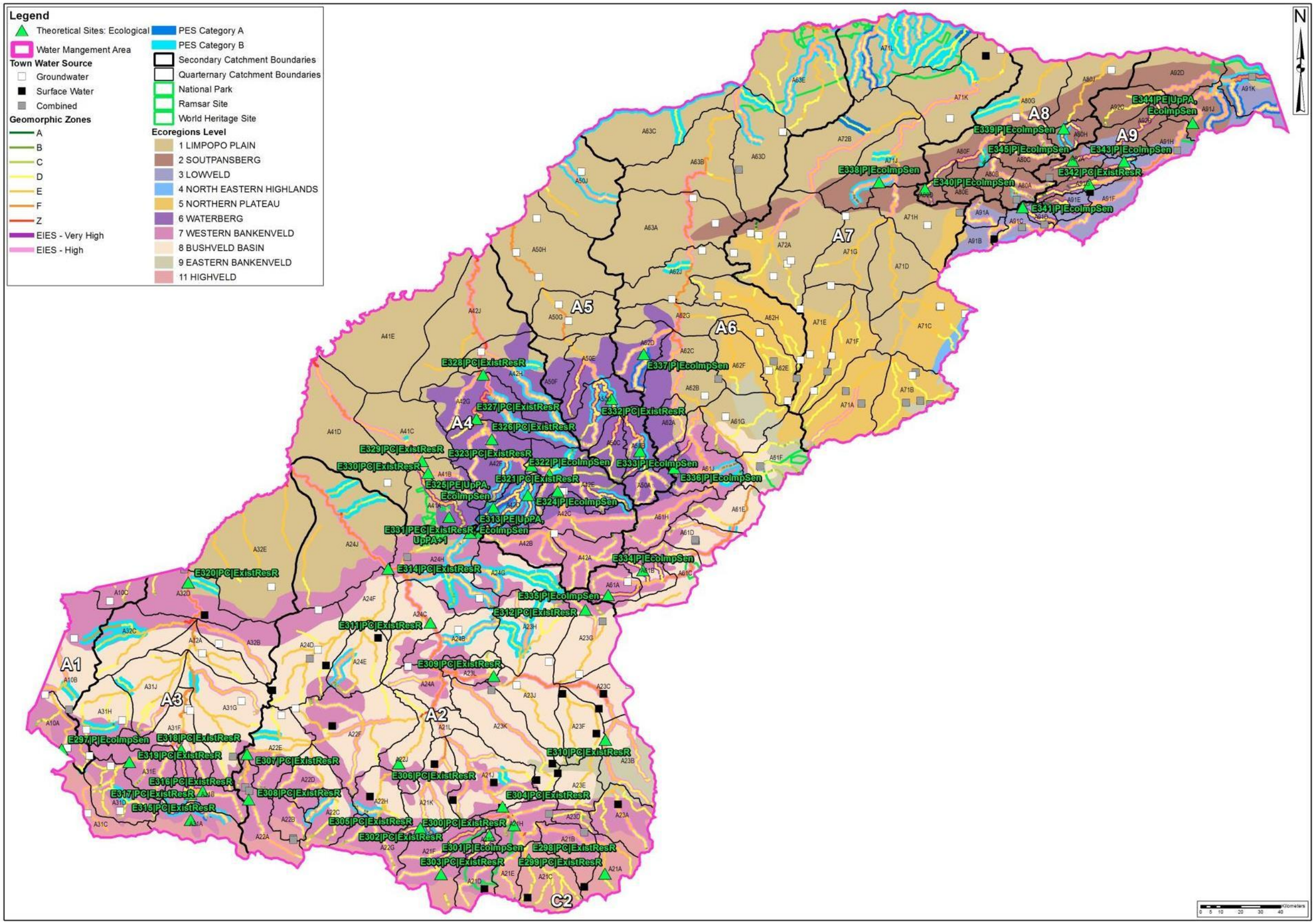


Figure A.1.2 Theoretical surface water sites based on ecosystem considerations

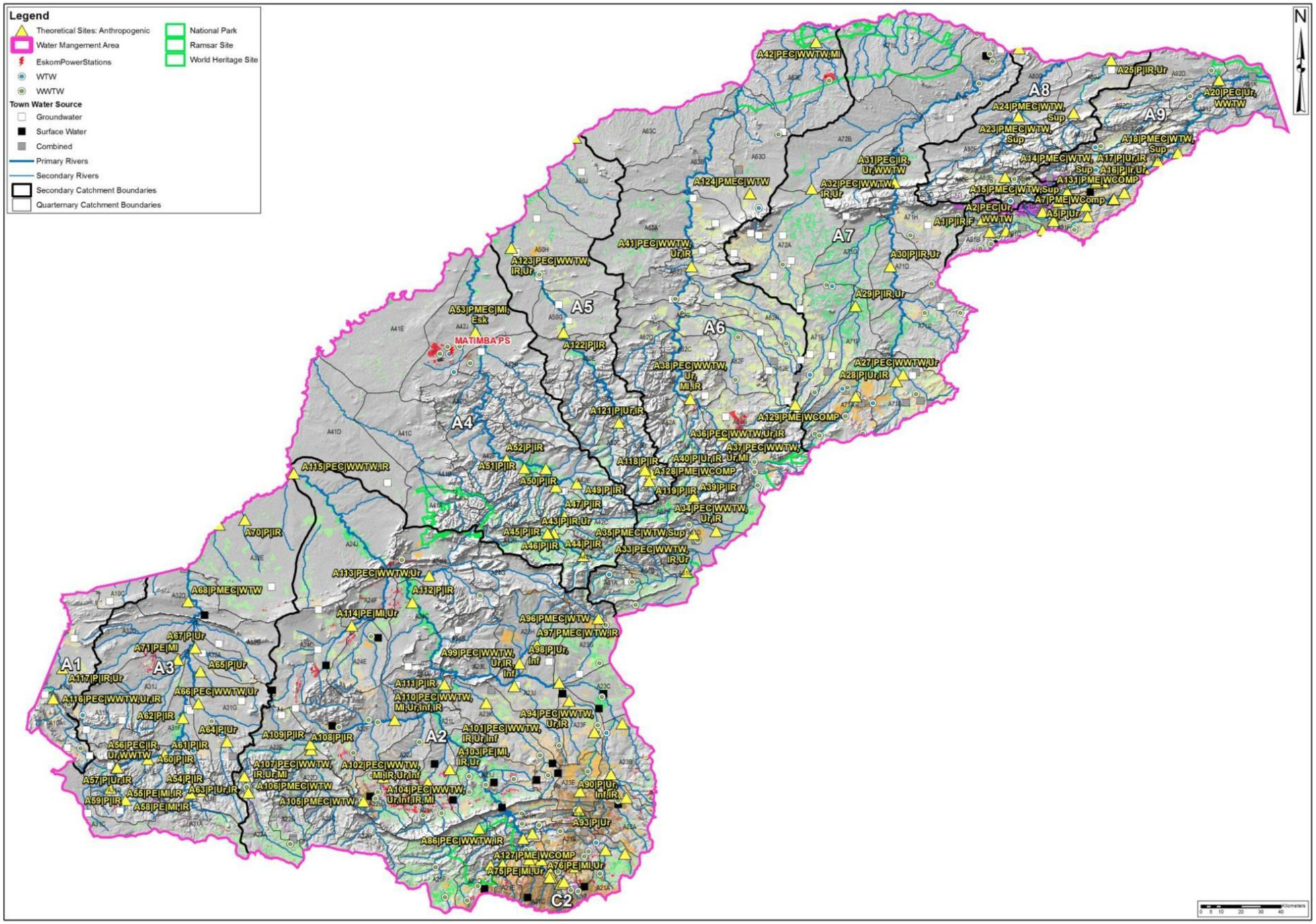


Figure A.1.3 Theoretical surface water sites based on anthropogenic considerations

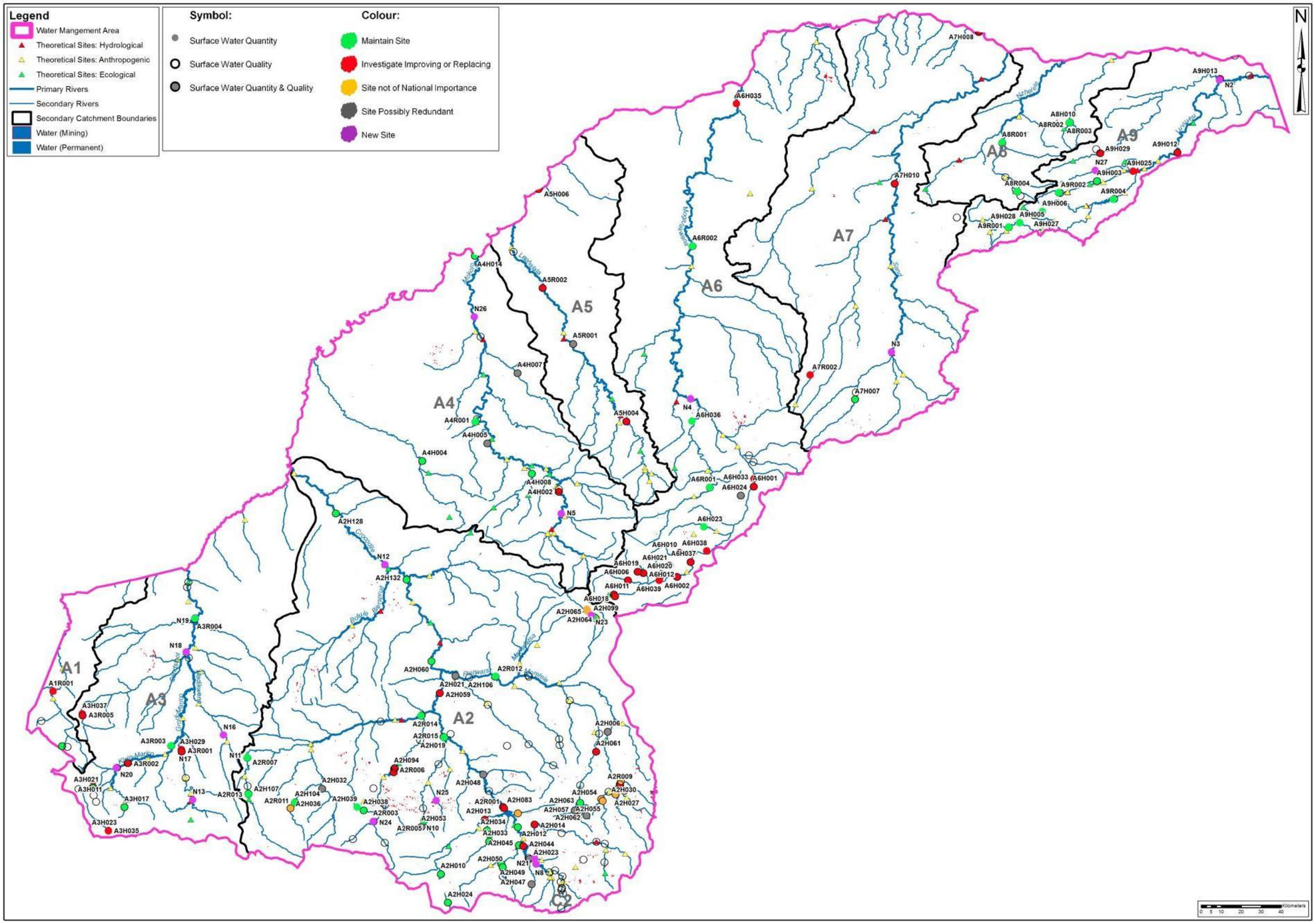


Figure A.1.4 All theoretical and actual surface water monitoring sites with recommended actions

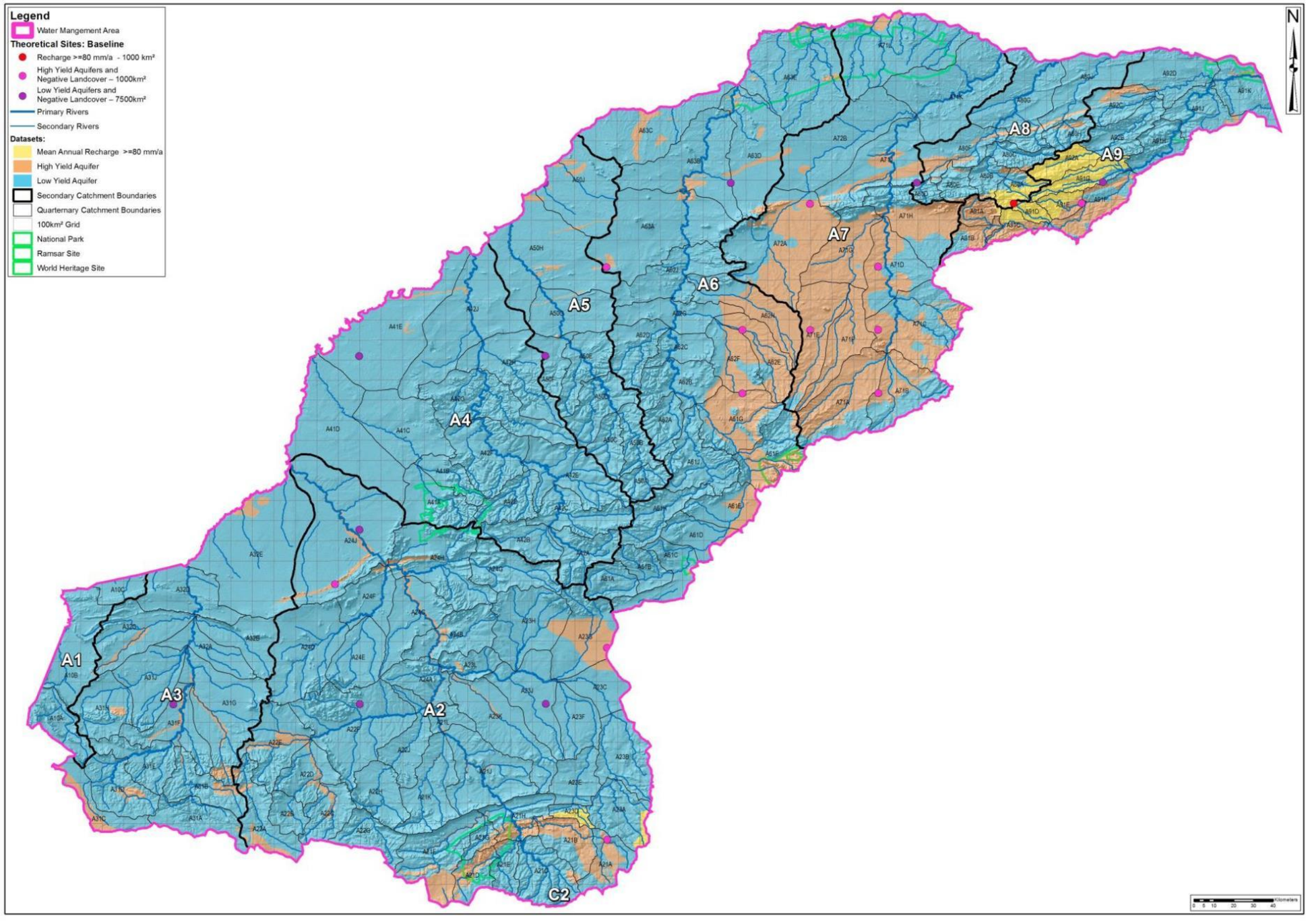


Figure A.1.5 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

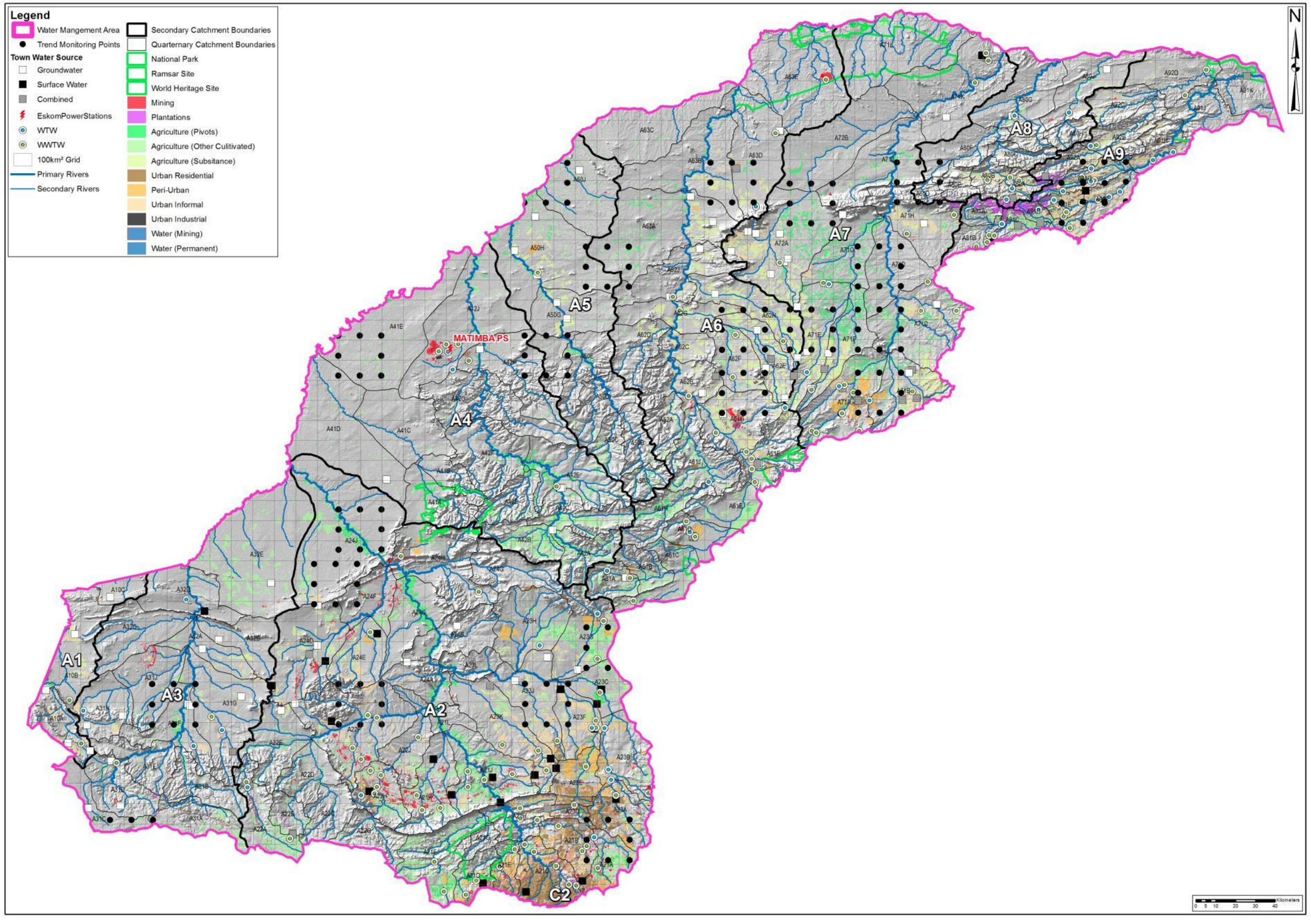


Figure A.1.6 Theoretical groundwater sites based on anthropogenic considerations (Trend)

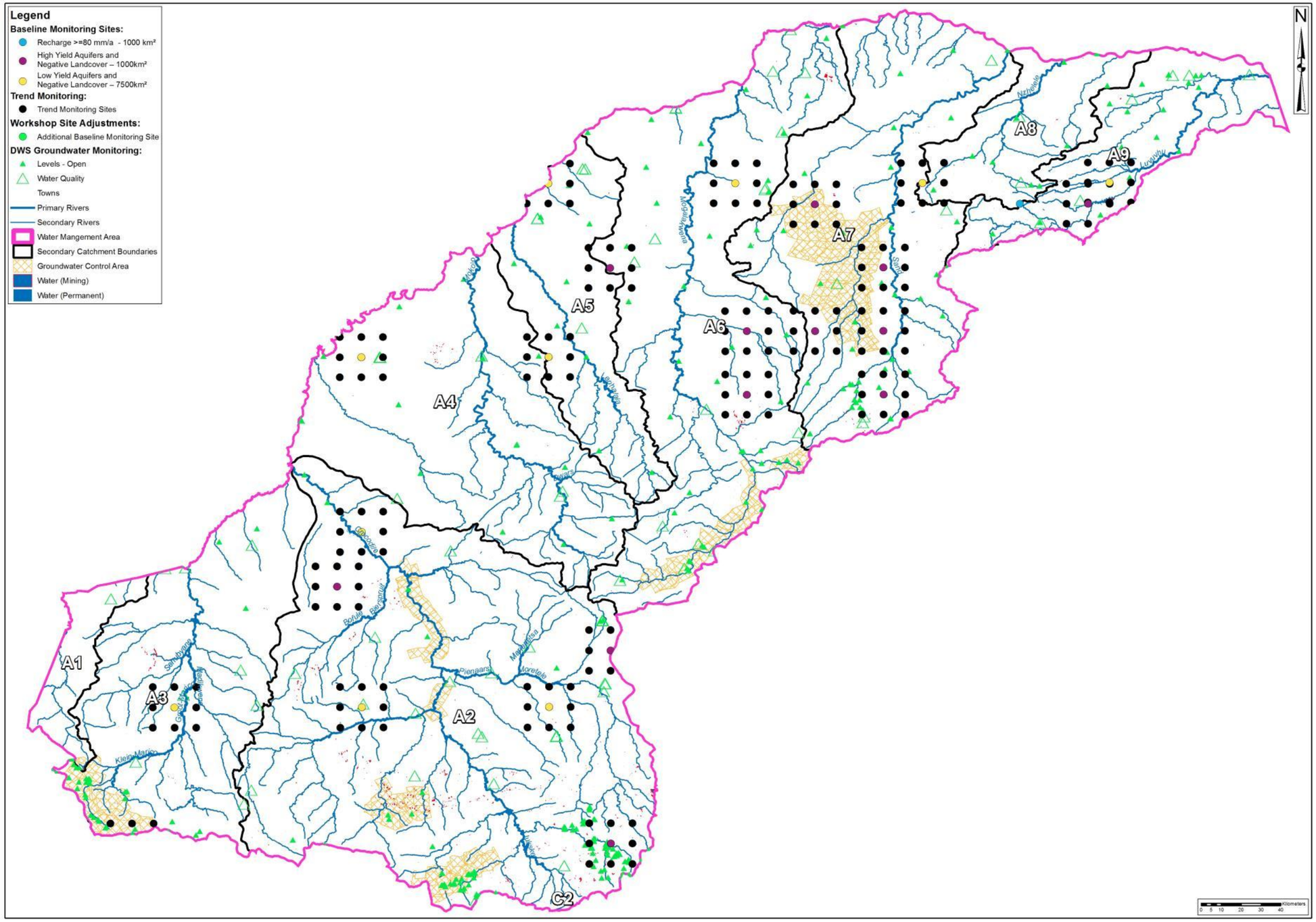


Figure A.1.7 Theoretical and exiting groundwater monitoring sites including additional recommended sites

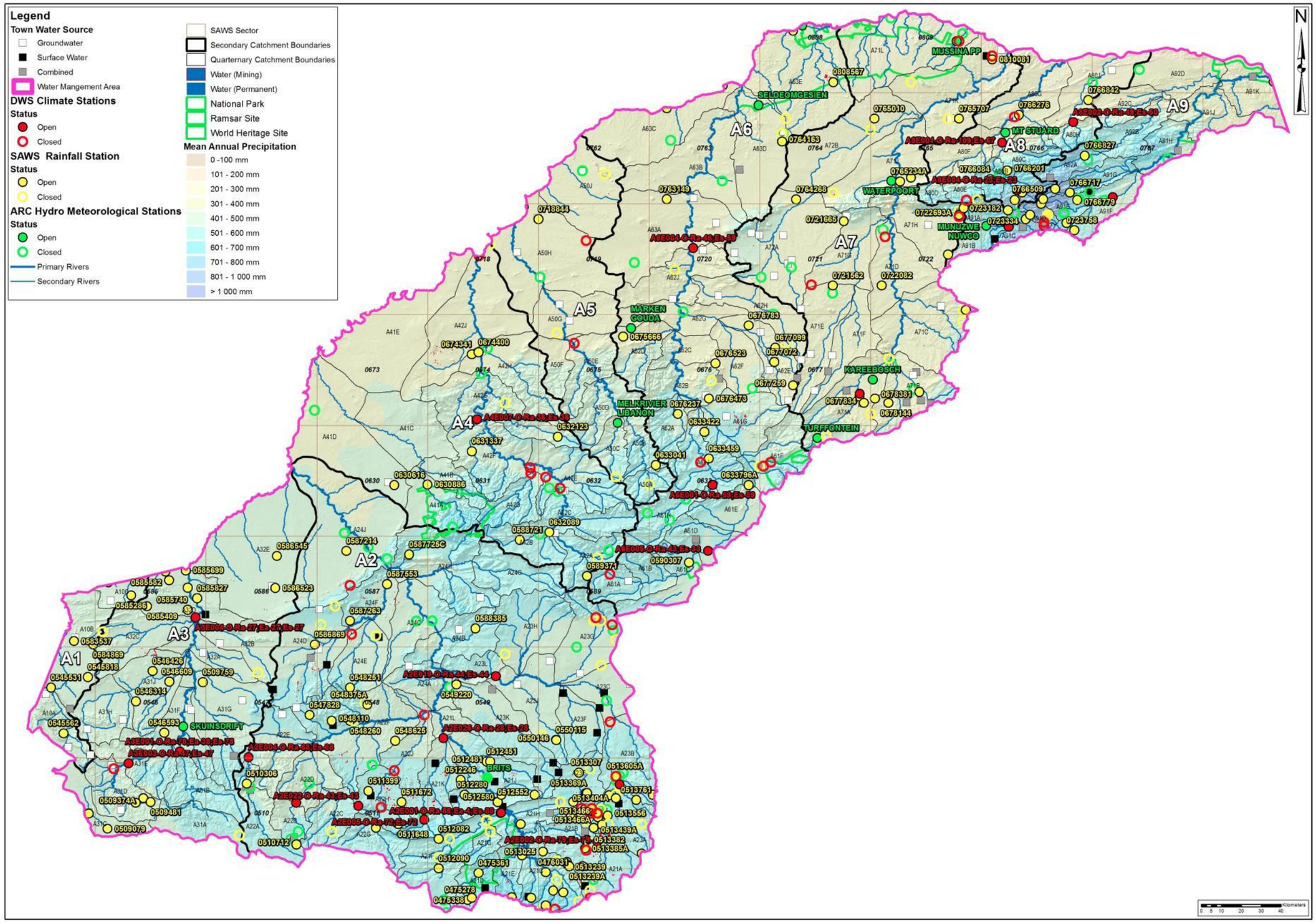


Figure A.1.8 Climatic information for the WMA

ANNEXURE 2

WMA 2: OLIFANTS

2. WMA 2: OLIFANTS

The Olifants Water Management Area (WMA) is located on the north eastern part of South Africa and includes the eastern part of Gauteng, northern parts of Mpumalanga and south eastern parts of Limpopo. The main stem of the Olifants River originates in the far southern Mpumalanga Highveld region of the WMA. The river initially flows northwards through the Mpumalanga and Limpopo provinces until at the confluence with the Letaba River in the Kruger National Park (DWS, 2013).

Large areas of the WMA are covered with scattered communities most of whom do not have secure access to water and sanitation. Water has become a scarce resource in the catchment and therefore intensive management of the resource will be necessary to ensure the much required sustainable development in the area (DWS, 2013).

Previously the Olifants WMA has been divided into four sub-areas namely the Upper, Middle, Steelpoort and Lower Olifants, however, the three zones in terms of the Reconciliation strategy for the Olifants River Water Supply system are as follows:

- Upper Olifants sub area constitutes the catchment of the Olifants River down to Loskop Dam.
- Middle Olifants sub-area comprises the catchment of the Olifants River downstream from the Loskop Dam to the confluence with Steelpoort River.
- Lower Olifants sub-area represents the catchments between the Steelpoort confluence, the Letaba River and the Mozambique border.

The topography in the WMA is characterized, in the southern part of the catchment, by rolling gently sloped hills, before the river cuts through the Drakensberg to enter the Lowveld region. In the Lower Olifants, in particular the Letaba, the topography varies from a zone of high mountains in the west through low mountains and foothills to the low lying plains in the east. The mountainous zone includes the northern portion of the Drakensberg Mountains and the eastern Soutpansberg. The topography in this region is deeply incised by the major tributaries (DWS, 2013).

The Letaba River and its major tributaries including the Middle Letaba, Klein Letaba, Nsami and Molototsi rivers drain the lower Olifants catchment area, before joining the Olifants River.

The geology in the catchment consists of mainly hard rock formations, with the occurrence of the Bushveld Igneous Complex as the most prominent feature. The eastern limb of this formation cuts through the northern part of the WMA. Rich coal deposits occur in the Upper Olifants sub-catchment area in the vicinity of Witbank and Middelburg. A large dolomitic intrusion extends along the Blyde River, curving westwards along the northern extremity of the WMA (DWS, 2013).

The climate in this WMA covers four climatic regions, namely:

- The Highveld, with moderate maximum temperatures and cold winter nights, with severe frost occurring regularly;
- The Bushveld, with high maximum temperatures and cool winter nights without severe frost occurring;
- The escarpment, which partly lies in the mist belt, with moderate maximum temperatures and cool winter nights; and
- The eastern Lowveld with a hot sub-tropical climate.

The rainfall for this WMA is, however, highly seasonal and occurs mainly in summer. The mean annual precipitation (MAP) varies greatly, with the most dry areas receiving 325 to 550 mm/a. In the Highveld region and the southern part of the eastern Lowveld the rainfall varies between 550 and 750 mm/a. The escarpment receives a higher rainfall of between 750 and 1 000 mm/a (DWS, 2013).

2.1 SITE REVIEWS

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

2.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Olifants WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. Table 1.2 provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

According to **Table 2.1** there are 71 active river flow and 24 reservoir monitoring sites in the Olifants WMA that were evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

Table 2.1 Number of surface water quantity monitoring sites per secondary catchment

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
B1	**6**	0	0	2	11	2	0	**15**
B2	**8**	1	0	1	6	1	0	**9**
B3	**13**	3	0	0	7	3	0	**13**
B4	**3**	1	0	0	11	4	0	**16**
B5	**1**	0	0	2	1	1	0	**4**
B6	**11**	0	0	0	5	2	0	**7**
B7	**11**	0	0	2	10	2	0	**14**
B8	**23**	6	0	6	16	9	0	**37**
B9	**1**	0	0	0	4	0	0	**4**
Total	**77**	**11**	**0**	**13**	**71**	**24**	**0**	**119**

The number of sites with water quality constituents being monitored in the Olifants WMA is provided in **Table 2.2**.

As can be seen from Table 2.2 the main water quality programmes in the WMA include chemical, eutrophication and microbial monitoring. As stated earlier, the water quality parameters and frequencies will be reviewed during the strategy development and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

Table 2.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
B1	**0**	12	3	0	0	7	0	3	0	**18**
B2	**2**	8	1	0	0	5	0	2	0	**11**
B3	**0**	7	2	0	0	6	0	0	0	**10**
B4	**2**	10	2	0	0	3	0	5	0	**19**
B5	**1**	2	1	0	0	2	0	0	0	**3**
B6	**0**	8	2	0	0	2	0	0	0	**10**
B7	**2**	8	4	0	0	2	0	0	0	**12**
B8	**4**	15	4	0	0	5	0	4	0	**25**
B9	**0**	0	2	0	0	0	0	0	0	**2**
Total	**11**	**70**	**21**	**0**	**0**	**32**	**0**	**14**	**0**	**110**

Notes:

(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

2.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 2.4**.

2.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or to be upgraded. Reported in **Table 2.3** are the theoretical objectives that have been assigned to these existing river sites.

Table 2.3 Objectives and relative priorities assigned to existing river monitoring stations with no recommended actions

Site number	Description	Theoretical objective	Relative priority[#]
B8H018	Letaba River @ Kruger National Park	PMEC|Base,IntObl,ExistResC,EcoImpSen	12.0
B8H034	Great-Letaba River @ Kruger National Park	PMEC|Base,ExistResC,EcoImpSen,Rur	12.0
B1H021	Steenkoolspruit @ Middeldrift	PEC|MI,Esk,WWTW,IR,Urb,Rur,Base	10.5
B7H019	Ga-Selati River @ Loole	PEC|ExistResR,WWTW,Base,MI,Rur,Urb,UpPA	10.5
B2H016	Wilger river at Waterval	PMC|Base,ExistResC,Ir	9.5
B4H009	Dwars River @ Dwars River	PEC|HR,MI,Ir,Base,ExistResC	9.5
B1H002	Spookspruit @ Elandspruit	PEC|Base,HR,MI,ExistResC	9.0
B2H014	Wilge River @ Onverwacht	PEC|Ir,Esk,MI,Base	9.0
B7H015	Olifants River @ Kruger National Park	PEC|ExistResR,Base,UpPA,EcoImpSen	9.0
B7H007	Olifants River @ Oxford	PE|Base,HR,Rur,Ir,UpPA	8.5
B7H009	Olifants River @ Finale	PC|WWTW,IR,Rur,HR,Base,ExistResC,WTW	8.5
B1H004	Klipspruit @ Zaaihoek	PC|Base,WWTW,MI,Ur,Rur	7.5
B1H018	Olifants River @ Middelkraal	P|Base,HR,MI,Ir,Base	7.5
B6H003	Treur River @ Willemsoord	PC|ExistResC,Base,HR,EcoImpSen,F	7.5
B8H011	Tsende River@Mooiplaas @ Kruger National Park	PE|Base,Rur,EcoImpSen	7.5
B8H019	Tsende River @ Kruger National Park	PE|Base,Rur,EcoImpSen	7.5
B4H007	Klein-spekboom River @ Potloodspruit	PC|HR,Base,ExistResC,BaselineEcoImp	7.0
B9H001	Shisha River@Vlakteplaas @ Kruger National Park	PE|UpPA, EcoImpSen	7.0
B1H022	Trichardtspruit @ Trichardsfontein	PC|Base,MI,Urb	6.5
B4H010	Dorps River @ Lydenburg Nat Res	P|UR,Base,Urb,Rur,Ir	6.5
B3H007	Moses River @ Uitspanning	P|Base,WWTW,Rur,IR	6.0
B3H021	Elands River @ Skerp Arabie	P|Base,WWTW,Ir,Rur	6.0
B7H020	Timbavati River @ Kruger National Park	P|Base,UpPA,EcoImpSen	5.5
B2H008	Koffiespruit Tributary @ Rietvallei	P|IR,Base	5.0

[#] *Sites are listed in descending order based on relative priority*

Please note that this list does not include W-components that are functioning adequately.

2.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 2.4** are all the proposed monitoring sites for the Olifants WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

Table 2.4 Proposed new river monitoring sites

Site number	Lat	Long	Theoretical objective	Comment	Relative priority#
N4	-23.86	30.39	PMEC|Base,Ir,Ur,Rur,MI	This site is recommended as a possible replacement for B8H009.	12.5
N11	-25.38	29.84	PC|HR,Base,Ir,ExistResC,F,Urb,Rur,MI	There is currently no monitoring on the upper reaches of the Steelpoort River and it is recommended that a site be installed upstream of the confluence with the Masala River.	9.0
N12	-24.70	30.37	PC|HR,Base,Ir,ExistResC,F,Urb,Rur,MI	A monitoring site is recommended on the Spekboom River upstream of the confluence with the Steelpoort River.	9.0
N2	-23.09	31.42	PEC|IntObl,Base,EcoImpSen,UpPA	This site is recommended as a possible replacement for B9H003.	9.0
N8	-24.21	29.99	PC|Base,Ir,ExistResC,Rur,WTW,GW	A new monitoring site is recommended on the Olifants River, upstream of the confluence with the Mohlapitse River to monitor future plans of dolomitic abstraction downstream.	8.0
N1	-22.96	31.25	PE|Base,EcoImpSen,UpPA	A replacement site for B9H004 is required downstream from this site.	7.5
N19	-23.27	29.98	PC|Base,HR,EcoImpSen,Rur,ExistResC	There is currently no monitoring on the Little Letaba River upstream of the confluence with the Middel Letaba River. It is recommended that a monitoring site be installed on this reach of the river.	7.5
N14	-26.05	29.72	PC|Base,MI,WTW,WWTW	There is currently no monitoring on the upper reaches of the Klein-Olifants River and it is recommended that a site be installed upstream of the confluence with the Woes-Alleenspruit River.	7.0
N9	-24.18	30.62	P|HR,Base,rur	There is currently no monitoring on the Makhutswi River and it is recommended that a site is investigated and implemented at or upstream from this site.	5.5

Site number	Lat	Long	Theoretical objective	Comment	Relative priority#
N13	-25.14	29.44	P|Base,Ir	There is currently no monitoring on the Bloed River or any of its tributaries. A monitoring site is required as far downstream as possible, but before the confluence with the Olifants River.	5.0
N5	-23.67	30.99	P|Base	This site is recommended as a replacement for B8H008.	4.5

[#] *Sites are listed in descending order based on relative priority*

2.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 2.5** are the identified site numbers, site descriptions, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 2.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Relative priority
B8H008	Great-Letaba River @ Letaba Ranch	PMEC|Base,IntObl,Ir,Rur, WTW	This site requires urgent replacement with site N5.	12.5
B8H009	Great-Letaba River @ The Junction	PMEC|Base,Ir,Ur,Rur,MI	This site needs to be replaced due to variable submergence with other site more upstream or downstream from confluence (possibly Junction Weir - N4).	12.5
B8H010	Letsitele River @ Mohlabas Location	PEC|HR,Base,Urb,Rur,Ir,F,WWTW,Exist ResC	Investigate if sub-merged. If station is to be selected higher up, then the Letsitele should be measured, rather than the Thabina. Overall improvement of measurement is recommended even if not replaced.	11.0
B6H005	Blyde River @ Driehoek	PMC|HR,Base,Exist ResC,Ir,Rur	This site is possible redundant if the W-component at Blyderivierpoort Dam is installed (N17).	10.5
B8H014	Great-Letaba River @ Grysappel	PMC|IR,F,ExistResC,Base,HR	Very important stations to measure the remaining water after all the canal offtakes. Upgrade or replace.	10.5

Site number	Description	Theoretical objective	Comment	Relative priority
B8H017	Great-Letaba River @ Prieska	PMC|Base,ExistResC,Ir,Rur	This site is for flood purposes only. There is a large sluice that has been permanently damaged. This site will possibly be redundant with the building of the Nwamitwa Dam and W-component upstream.	10.0
B8H033	Little-Letaba River @ Locatie Van Tabaan	PMC|Base,ExistResC,Ir,Rur	The inlet measurements at this site must be upgraded.	10.0
B2H003	Bronkhorstspruit @ Bronkhorstspruit	PE|Base,WTW,WWTW,Urb,Rur,Ir,MI	This site is possible redundant once a W-component at Bronkhorstspruit Dam is installed.	9.5
B7H026	Olifants River @ Kruger National Park	PEC|ExistResR,Base,UpPA,IntObl,EcoImpSen	Existing site, requires a DT	9.5
B7H013	Mohlapitse River @ Mafefes Location	PE|HR,Base,BaselineSen,Rur,GW	Investigate upgrade or replacement at other position.	8.5
B6H001	Blyde River @ Willemsoord	PC|WWTW,F,Ir,Rur,HR,Base	The data reported from this site is of poor quality and it is recommended that it be upgraded.	8.0
B9H002	Shingwidzi River @ Kruger National Park	PE|Base,UpPA,EcoImpSen	Satellite telemetry is required for this site.	7.5
B7H004	Klaserie River @ Fleur De Lys	P|UR,Base,Ir,Rur,F,Ir	If Jan Wassenaar Dam (N10) can be measured then B7H004 must become redundant.	7.0
B7H002	Ngwabitsi River @ Tours	P|HR,Base,EcoImpSen, Rur,Ir	If measurement at Tours Dam can be improved, then B7H002 should be made redundant.	6.5
B7H014	Selati River @ Calais	P|Ir,Rur,EcoImpSen,Base,HR	Improve or replace more upstream.	6.5
B7H010	Ngwabitsi River @ Harmony	P|Base,Rur,Ir	If measurement at Tours Dam (N23) can be done, then B7H010 should be made redundant.	5.5
B2H004	Osspruit @ Boschkop	P|Base,Ir	The data reported from this site is of poor quality and it is recommended that it be upgraded..	5.0
B2H007	Koffiespruit @ Waaikraal	P|Base,Ir	The data reported from this site is of poor quality and it is recommended that it be upgraded.	5.0

[#] *Sites are listed in descending order based on relative priority*

2.3.4 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Reported in **Table 2.6** are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 2.6 Monitoring sites that are not of national importance

Site Number	Description	Comments
B1H005	Olifants River @ Wolwekrans	If the measurements at Witbank Dam are upgraded then this site will be, from a water resources perspective, not of national importance.
B1H012	Little Olifants@River @ Rondebosch	Regional importance.
B1H017	Steenkoolspruit @ Aangewys	This site is, from a water resources perspective, not of national importance, but needs upgrading for regional purposes.
B1H019	Noupoortspruit @ Naauwpoort	From a water resources perspective, not of national importance. Especially when the measurements at Witbank Dam are upgraded.
B3H025	Loskop Noord	This is an operational site and is, from a water resources perspective, not of national importance.
B3H026	Eagle's Flight	This is an operational site and is, from a water resources perspective, not of national importance.
B4H024	Steelpoort River @ De Hoop Upper	This site is located upstream of De Hoop Dam and is, from a water resources perspective, not of national importance because measurements can be made by the dam.
B4H025	Steelpoort River @ Taung	Weir has very small capacity, but is needed for operational purposes, not resource deteminations.

2.3.5 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in **Table 2.7** are the site numbers, site description and comments that resulted in the site classification.

Table 2.7 Redundant river flow monitoring sites

Site number	Description	Comment
B4H003	Steelpoort River @ Buffelskloof	This site is scheduled to be closed.
B4H005	Waterval River @ Modderspruit	This site is redundant.
B6H012	Ohrigstad River @ Naauwpoort	This site is scheduled to be closed.
B8H074	Merensky Downstream of Dam Weir	This site has a small upstream catchment and is considered to be redundant.
B8R002	Hans Merenski Dam	Possibly redundant.
B9H003	Shingwidzi River @ Kruger National Park	This site has been decommissioned and must be replaces by N2.
B9H004	Mphongola River @ Kruger National Park	This site has been decommissioned and must be replaces by N1.

2.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must therefore be monitored efficiently. Listed in **Table 2.8** are all the required W-components as well as changes and potential improvements to existing reservoir monitoring within the WMA.

Table 2.8 New and changes to W-components for dams as well as changes to existing reservoir monitoring

Site number	Lat*	Long*	Theoretical objective	Comment	Relative priority#
B8H064	Great-Letaba River @ Onverwacht		PMEC|HR,Base,Ir,Urb,F,Wcomp, WTW, ExistResC	This site is subjected to submergance. It should be upgraded to include continous monitirng of HP to improve Ebeneser Dam dam balance.	14.0
N3	-23.80	30.17	PMEC|Base,HR, Wcomp,Ir,Rur,MI ,Urb,WTW	A W component is required for Tzaneen Dam once the dam has been raised.	14.0
B8H050	Great-Letaba River @ Doornhoek		PMEC|HR,Base,Ir,Urb,Rur,WTW	To be replaced. Possibly redundant when Tzaneen Dam gets a new W-component (N3).	13.5
N21	-23.75	30.50	PMEC|Wcomp,Base,HR,Ir,Rur,ExistResC	Very important site for measuring flows downstream from Tzaneen Dam. Will most probably become W-component for Nwamitwa Dam.	13.5
B1H010	Olifants River @ Witbank		PMEC|HR,Base, Urb,Rur,MI,Exist ResC	B1H010 should be upgraded.	13.0
B1R001	Olifants River @ Witbank		PMEC|HR,Base, Urb,Rur,MI,Exist ResC	All other components should be reviewed/upgraded by instruction from DWS, Especially the use monitoring.	13.0

Site number	Lat*	Long*	Theoretical objective	Comment	Relative priority[#]
N22	-24.03	30.17	PMEC|Base,HR, Rur,WTW,ExistResC,Ir	Investigate full measurement at Thabina Dam.	13.0
B1H015	Little Olifants@River @ Rondebosch		PMEC|Base,Urb, Rur,MI,ExistResC	The capacity of the W-component must be investigated for upgrade.	12.5
B5R002	Olifants River @ Flag Boshielo		PMEC|Base,Ir,Rur,Urb,MI	Flag Boshielo require urgent metering of the use.	12.5
B8H071	Middel Letaba rivier @ Middel Letaba Dam		PMEC|Base,Ir,Rur,Wcomp,WTW	This W-Comp is being upgraded and improved.	12.5
B8R006	Broederstroom River @ Woodbush Forest Res.		PMEC|Base,HR,Ir,Urb,F	Dap Naude Dam requires a new survey to confirm actual volume and revise all previous surveys if inaccurate.	12.5
B7R003	Ngwabitsi River @ Tours		PME|Base,HR, Rur,Ir,EcoImpSen	Investigate full measurement at Tours Dam, including metering. If this can be done, B7H010 and B7H010 could become redundant.	11.5
N17	-24.52	30.80	PMC|Wcomp,HR,Base,ExistResC,Ir,Rur	Investigate this site as W-component for the Blyderivierspoort Dam.	11.0
N15	-25.89	28.72	PMC|Base,Ir,Wcomp,Urb,Rur	A W component is required for Bronkhorstspruit Dam.	10.5
N16	-25.23	28.53	PM|Base,Wcomp,Ir,Rur,WTW	A W component is required for B3R001 (Rust de Winter) since the dam balance is highly inaccurate.	9.5
B8R009	Nsama River @ Nsama		PM|Base, RuR,Urb,WTW	Investigate full measurement including a W-component.	9.0
B8R011	Molototsi River @ Modjadjes 424 Lt Ga-Matswe		PM|HR,Base,Rur,WTW	Spillway needs to be calibrated and a dam balance established.	9.0
N6	-23.48	30.12	PM|HR,Base,Ir,Rur	It is recommended that full measurement is started at Lorna Dawn Dam. Important for quantifying lower flows upstream from Middel Letaba Dam assessments.	9.0
N7	-23.56	30.15	PM|HR,Base,Ir,Rur	It is recommended that full measurement is started at this dam. Important for quantifying lower flows upstream from Middel Letaba Dam.	9.0
N10	-24.52	31.08	P|Wcomp,Base, HR,Rur,Ir,UpPA	Fleur De Lys Dam (B7R001) needs W-component and then B7H004 can be made redundant.	7.0

Notes:

(#) Sites are listed in descending order based on relative priority

(*) Proposed coordinates are reported for the new station recommendations only. Station descriptions, as per DWS, database are used for all existing stations

2.5 ESTUARIES

There are no estuary / tidal stations in this WMA.

2.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.2.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

2.7 GROUNDWATER MONITORING

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring station points does not plot on top of mountains.
- Increase spatial density over the whole WMA to 500 km^2 to generate additional baseline monitoring points. This is due to the land-use activities in the WMA generating pollutant loads e.g. power-generation, mining, agriculture etc.
- Set all springs as baseline monitoring points.
- Set the following as additional baseline monitoring stations:

ZQMMAB1	ZQMNKW4
ZQMHAZ1	B8N0518
B5N0057	ZQMNKW9
B5N0013	B8N0503
ZQMPRS1	B8N0509
B5N0052	ZQMSGD1
B5N0068	B9N0002
B7N0009	A9N0009
B7N0011	ZQMNKW2
B7N0007	

- Convert the current monitoring points to trend monitoring station. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring stations that fall within the buffer.

B1N0003	ZQMLYD1	ZQMGIY1
B1N0007	B4N0002	B8N0507
B1N0005	ZQMNEB2	B9N0003
ZQMWIT1	ZQMNEB3	B9N0001
B1N0008	ZQMSKH1	B9N0004
B1N0006	B5N0067	
B2N0073	B5N0057	
B2N0051	B5N0056	
B2N0050	B5N0069	
B2N0055	ZQMRTN2	
B2N0721	B5N0055	
B2N0053	B5N0051	
B2N0720	B5N0013	
B2N0719	B5N0054	
B2N0069	B6N0001	
B2N0506	ZQMPNG1	
B2N0003	B7N0014	
B2N0001	B7N0015	
ZQMDLS1	B7N0004	
B2N0061	B7N0005	
B2N0031	ZQMMRS1	
B2N0032	B8N0502	
B2N0034	B8N0513	
B2N0039	B8N0514	
B2N0037	B8N0523	
B2N0038	B8N0520	
B2N0063	B8N0515	
B2N0021	B8N0510	
ZQMMAB2	B8N0524	
ZQMRSL2	B8N0504	

APPENDIX A.2

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 2: OLIFANTS

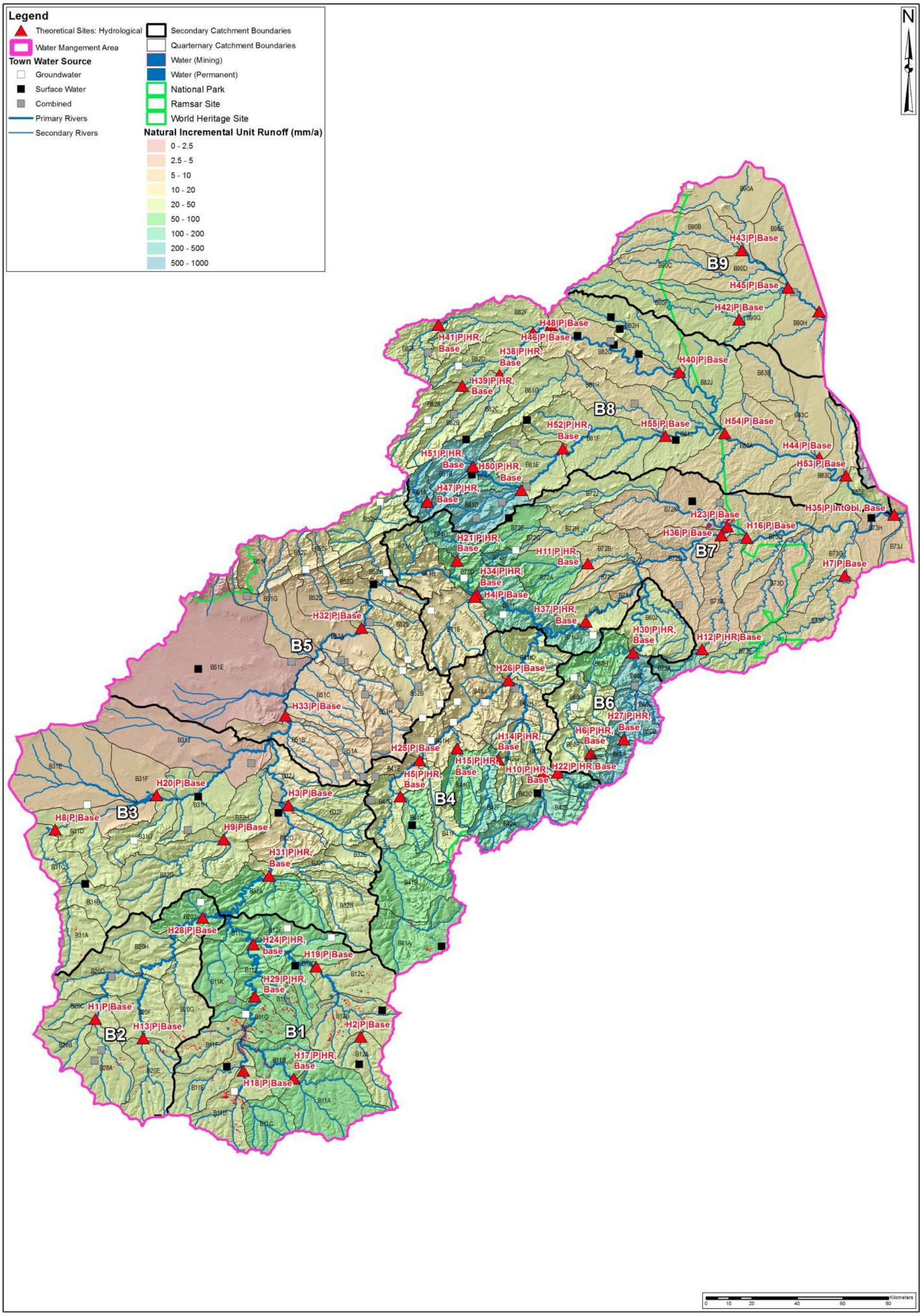


Figure A.2.5 Theoretical surface water sites based on hydrological (runoff) considerations

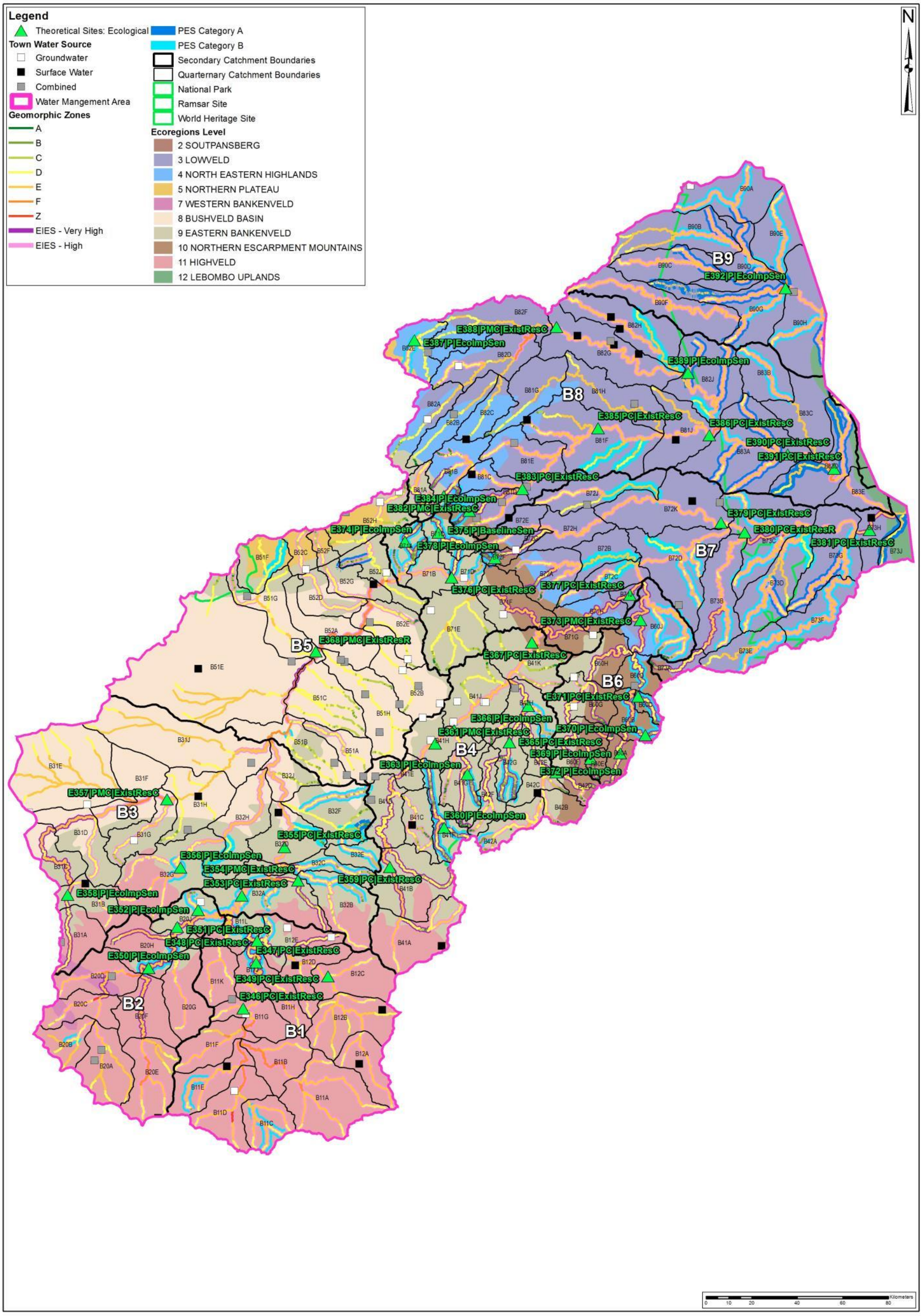


Figure A.2.6 Theoretical surface water sites based on ecosystem considerations

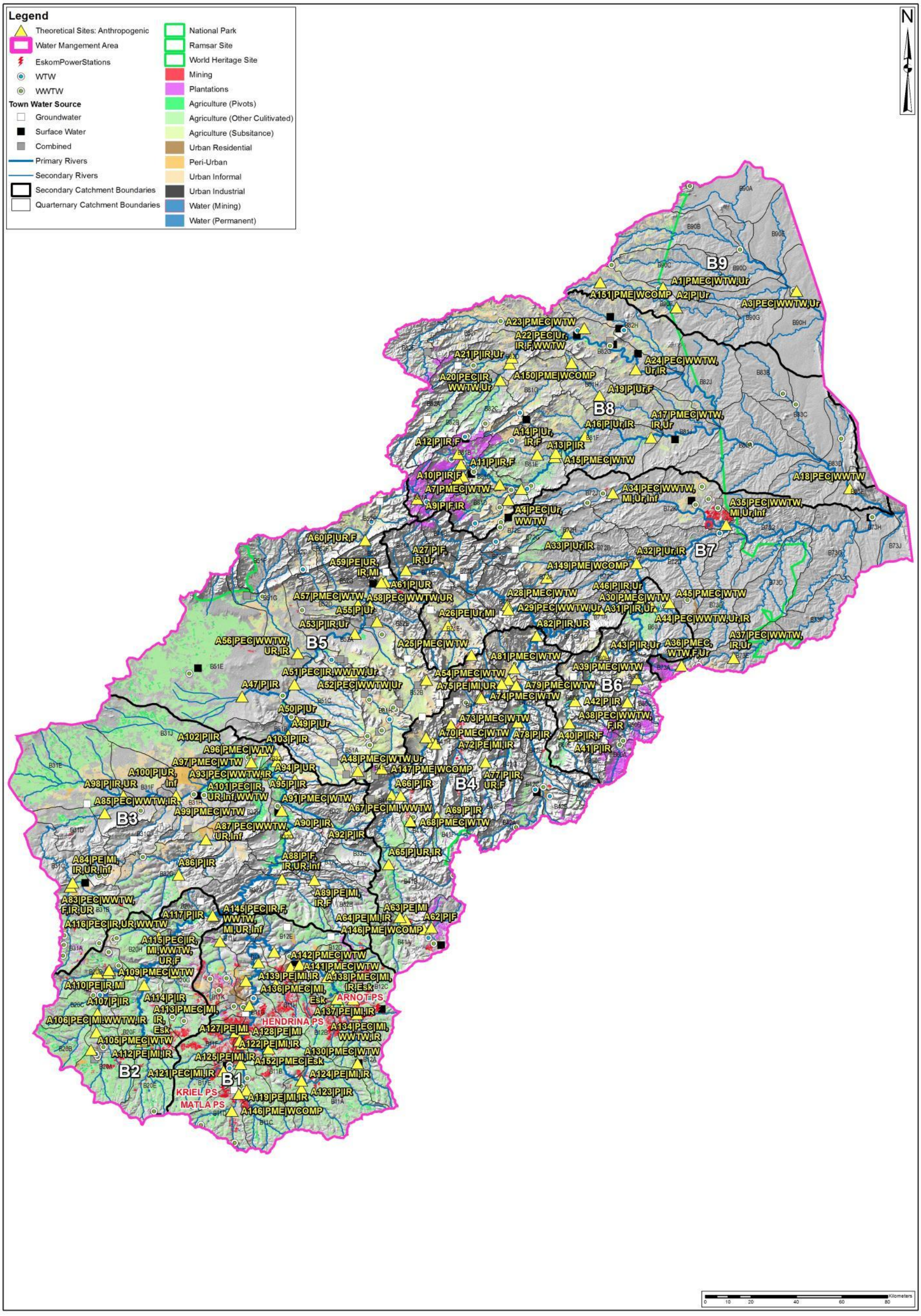


Figure A.2.7 Theoretical surface water sites based on anthropogenic considerations

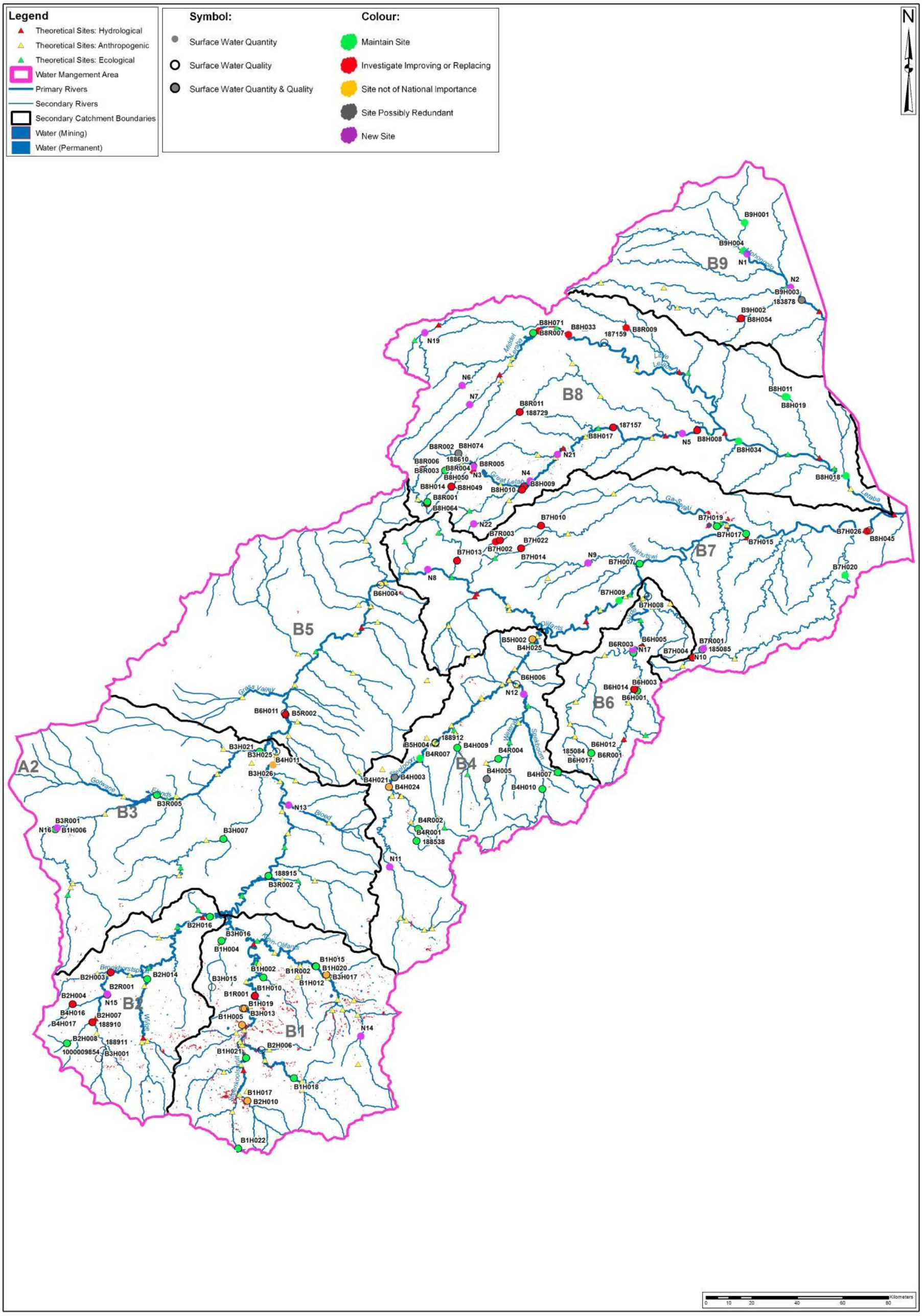


Figure A.2.8 All theoretical and actual surface water monitoring sites with recommended actions

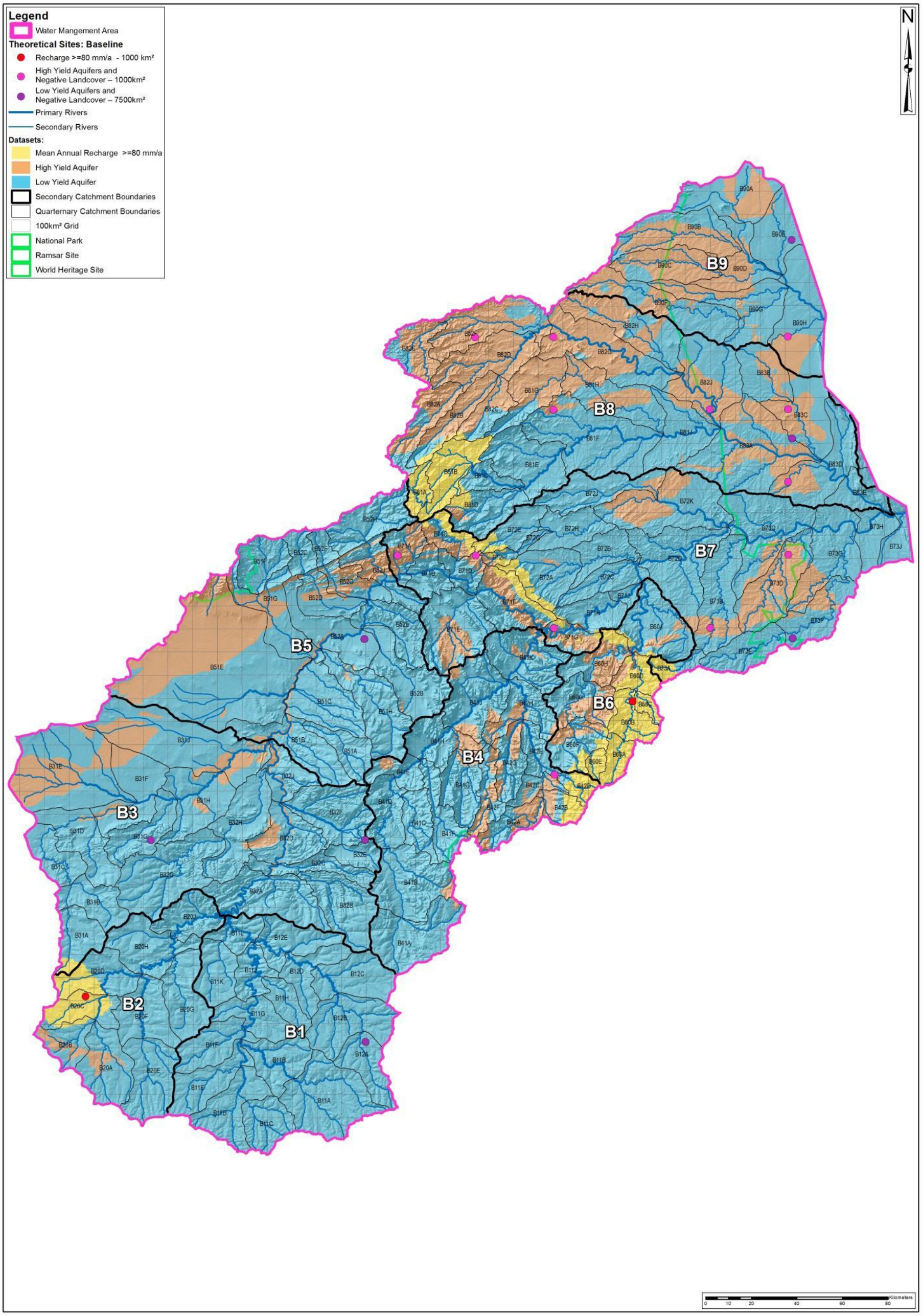


Figure A.2.5 Theoretical groundwater sites based on geohydrological considerations (Baseline)

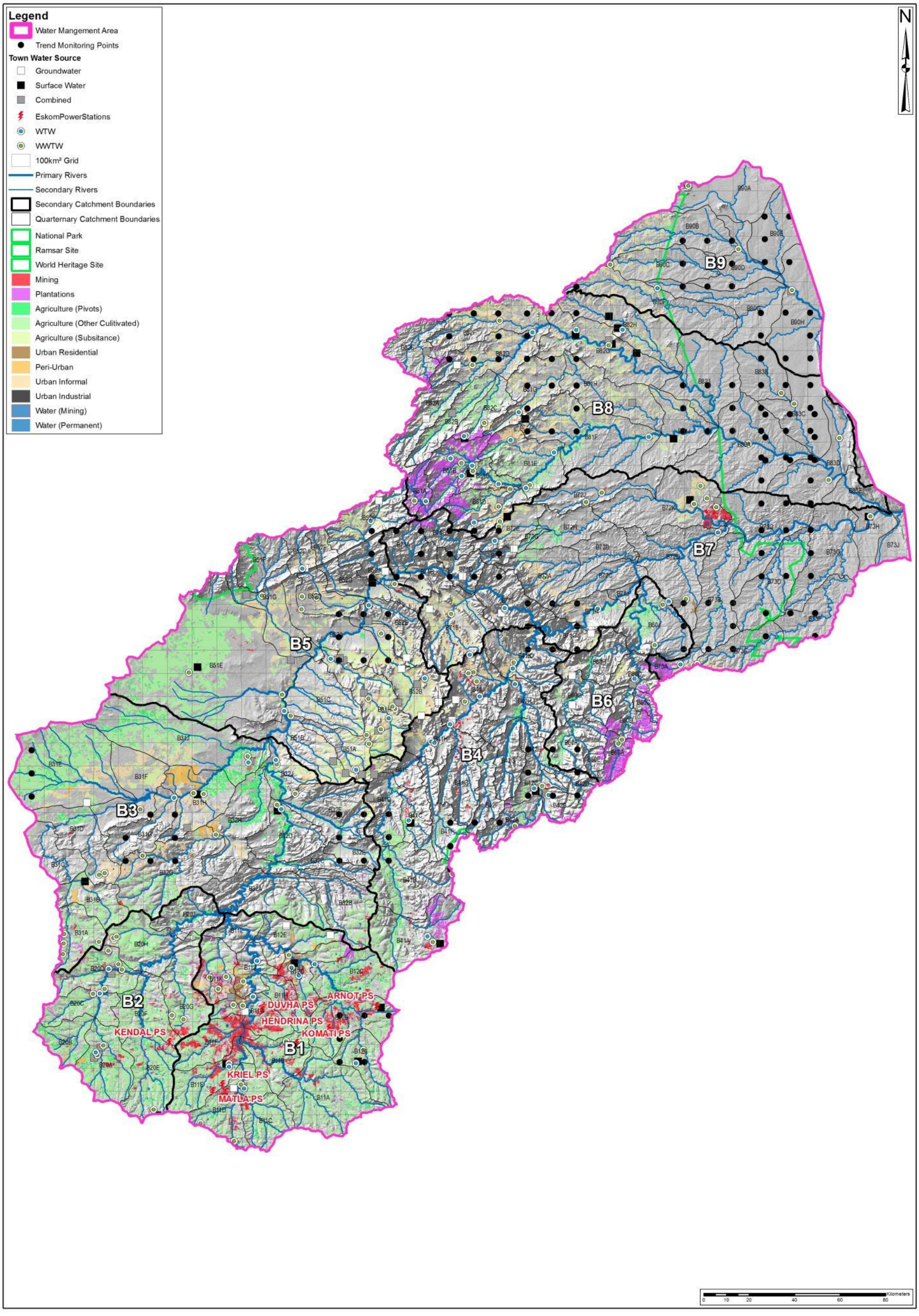


Figure A.2.6 Theoretical groundwater sites based on anthropogenic considerations (Trend)

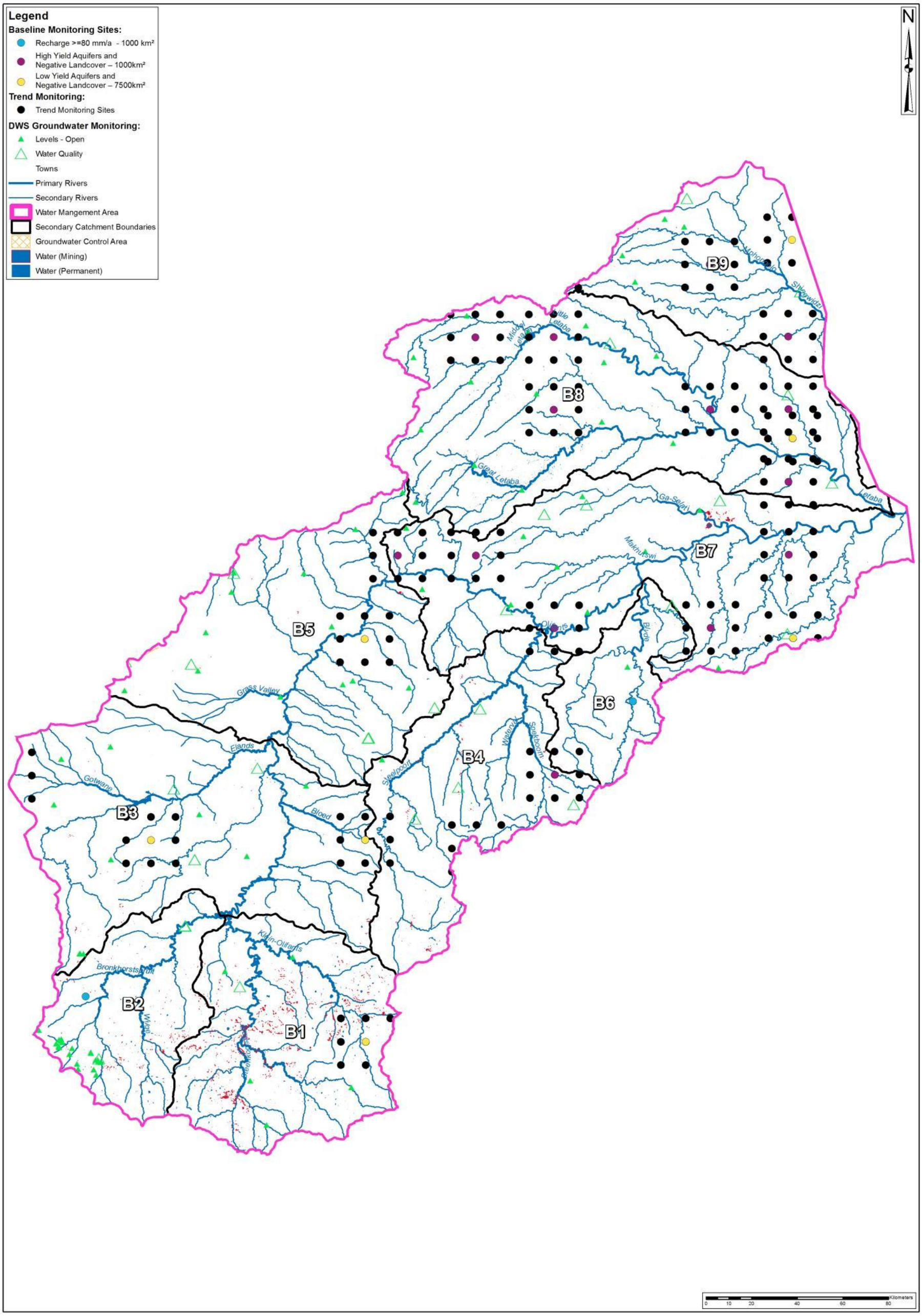


Figure A.2.7 Theoretical and exiting groundwater monitoring sites including additional recommended sites

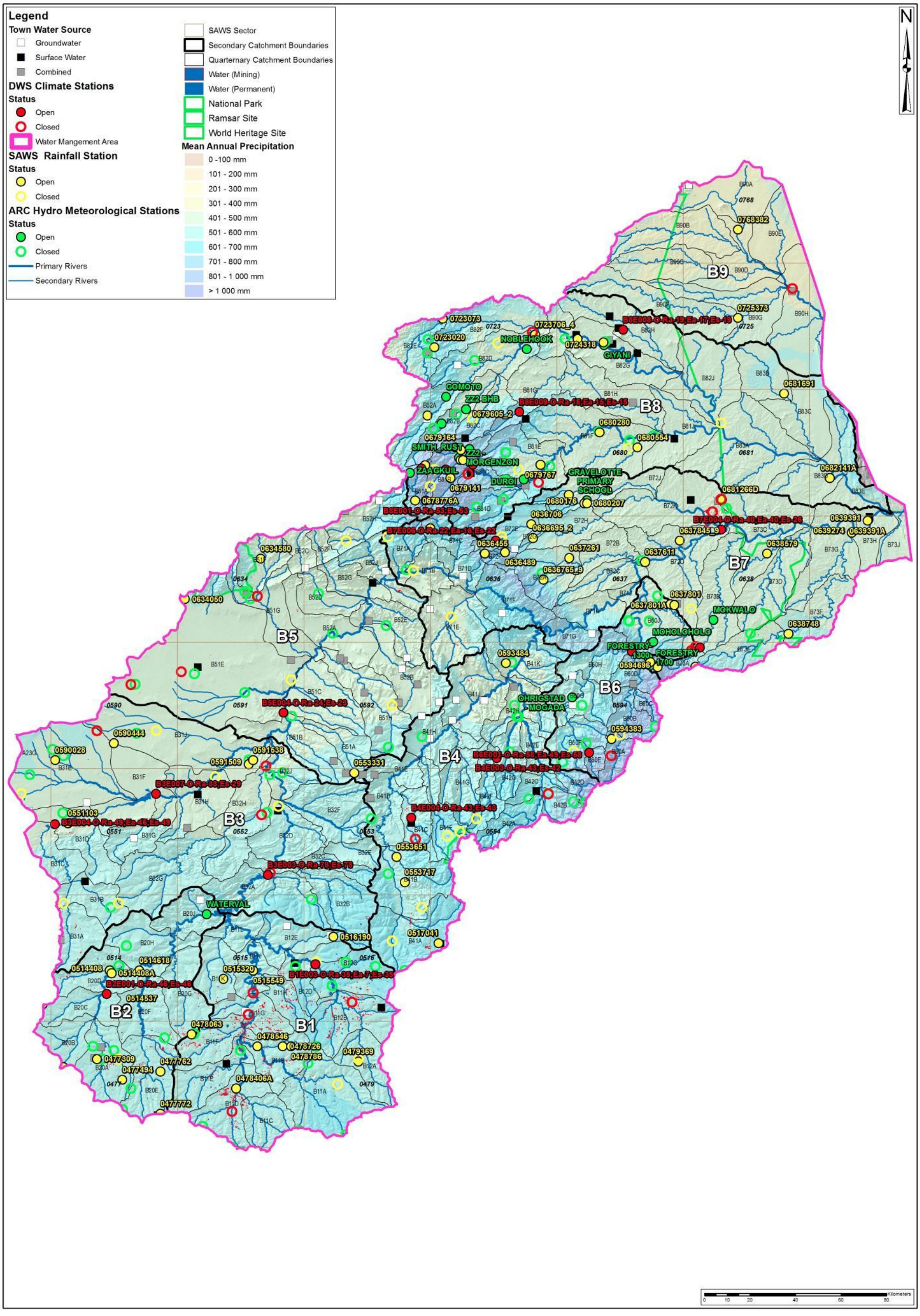


Figure A.2.8 Climatic information for the WMA

ANNEXURE 3

WMA 3: INKOMATI-USUTHU

3. WMA 3: INKOMATI-USUTHU

The Inkomati-Usuthu Water Management Area (WMA) is located in the north-eastern part of South Africa and borders on Mozambique and Swaziland. It also occupies the south-eastern corner of the Mpumalanga Province, west of Swaziland. Its main rivers include the Sabie-Sand, the Crocodile (East), Komati and Usuthu rivers. The Komati River first flows into Swaziland and re-enters South Africa before flowing into Mozambique. Three of the four rivers draining the WMA join to form the Incomati River in Mozambique, which flows into the Indian Ocean, while the Usuthu River joins the Pongola River just before the Mozambican border. This WMA can be divided into four distinct areas, namely:

- **The Sand and Sabie River system**

  This system is largely ex homeland area with large concentrations of people living in semi-rural context. The Sand River has very little mountain catchment area producing runoff and is generally poorly watered. While there is some groundwater still available for domestic use, all other available water from within the catchment has been used and the catchment is dependent on transfers from Inyaka Dam on the Mariti River.

- **Crocodile River (East)**

  The Crocodile River (East), located in the north east of South Africa is a relatively large river basin and is one of the most economically productive basins in the country. This river has a total main stem length of approximately 320 km draining a catchment area of about 10 450 km^2. The lower reaches of the Crocodile River (East) receive poor water quality from agricultural runoff and return flows, and from mining activities in the area.

- **Komati and Lomati River system**

  The upper Komati is an important source of water for power generation on the Highveld, with Eskom requiring the full yield from both Vygeboom and Nooitgedacht dams. Irrigation is also a significant water user in this catchment, while domestic water use is very limited. There is, under current operations, an apparent surplus of water available in this system, however, making provision for the ecological reserve results in a deficit.

- **Usuthu River catchment**

  The Usuthu River catchment is close to being fully utilised, with just a small quantity of water still available for domestic use. As in the case with the Komati system, much of the available water within the system's dams (Jericho, Westoe, Heyshope and Morgenstond) is transferred out of the catchment for use by Eskom power stations on the Highveld. The upper Usuthu is not a densely populated area and the topography, poor soils, altitude and distance from markets are a limitation on growth and development. Afforestation is the dominant land use, but expansion is limited by water availability.

The Inkomati sub-catchment includes the Albert Luthuli, Emakhazeni, Umjindi, Mbombela, Thaba Chewu, Bushbuckridge and Nkomazi Local Municipalities. The Usuthu sub-catchment falls entirely under the Govan Mbeki District Municipality and encompasses the towns of Amsterdam and Piet Retief.

The Inkomati-Usuthu WMA is divided by the Drakensberg Mountains into the western plateau and the sub-tropical Lowveld in the east, with altitudes ranging from over 2 000 m in the west to as low as 140 m in the east.

The Inkomati sub-catchment of the WMA has rainfall that varies from over 1 200 mm/a along the eastern escarpment to as little as 400 mm/a in the east. It comprises areas with rainfall around 1 000 mm/a in the elevated western and southern portion and a much lower rainfall of around 500 mm/a in the lower lying eastern portion.

The Usuthu sub-catchment has rainfall that ranges between 550 mm in its eastern areas to 850 mm on the eastern escarpment of the Drakensberg.

The greater portion of the WMA is underlain by crystalline igneous and metamorphic rocks, comprising granite and gneisses, with many diabase dyke intrusions in place. Primary porosity groundwater aquifers are very limited in this WMA, as sand of up to 6 m deep in major river beds does not represent very significant exploitable groundwater resources. The greatest portion of groundwater in this WMA occurs in the secondary porosity aquifers of the weathered and fractured classes, this being especially so in the very large area of crystalline igneous and metamorphic rocks that comprises most of the WMA.

Groundwater mean annual recharge ranges from 100 to 150 mm in the higher rainfall elevated areas along the western boundary and in the south of the WMA to about 15 mm in its low rainfall portion. The depth of the water table in this WMA generally varies from about 10 to 20 m below ground level. Yields of boreholes drilled in the region generally vary from about 0.1 ℓ/s to 3 ℓ/s, higher yields ordinarily being obtained from boreholes scientifically sited in hydro geologically favoured situations.

3.1 SITE REVIEWS

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

3.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Vaal WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. **Table 3.1** provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

Table 3.1 Status of surface water quantity stations per secondary catchment

Catchment	Total number of closed stations	Number of open stations							Coverage of open stations (km²/station)
		Canals	Eyes	Pipeline	River Flow	Dam volumes	Tidal	Total	
WMA 3: Inkomati-Usuthu & Part of Swaziland									
X1	12	5	0	6	17	3	0	**31**	363
X2	25	3	0	1	24	5	0	**33**	317
X3	6	2	0	2	10	2	0	**16**	396
X4	0	0	0	0	1	0	0	**1**	3 203
W5	14	3	0	2	12	5	0	**22**	770
W6	0	0	0	0	0	0	0	**0**	-
TOTAL	**57**	**13**	**0**	**11**	**64**	**15**	**0**	**103**	**501**

According to Table 3.1 there are 56 active river flow, 10 eye monitoring and 28 reservoir monitoring sites in the Vaal WMA that was evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

The number of sites with water quality constituents being monitored in the Vaal WMA is provided in **Table 3.2**.

As can be seen from Table 3.2 the main water quality programmes in the WMA include chemical, wetland, eutrophication microbial and estuarine monitoring. As stated earlier, the water quality parameters and frequencies will be reviewed during the strategy development and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

Table 3.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
X1	**0**	11	5	0	0	3	0	5	0	**26**
X2	**2**	20	7	0	0	0	0	5	0	**34**
X3	**0**	9	3	0	0	0	0	5	0	**18**
X4	**0**	0	0	0	0	0	0	0	0	**0**
W5	**0**	9	6	0	0	1	0	0	0	**15**
W6	**0**	0	0	0	0	0	0	0	0	**0**
Total	**2**	**49**	**21**	**0**	**0**	**4**	**0**	**15**	**0**	**93**

Notes:

(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

3.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 3.3**.

3.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or needing to be upgraded. Reported in **Table 3.3** are the theoretical objectives that have been assigned to these existing river sites.

3.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Table 3.3 Objectives for existing river monitoring stations with no recommended actions

Station Number	Lat	Long	Theoretical objective	Relative priority
X1H003	-25.682	31.782	PMEC|ExistResC,GW,WTW,Sup	12.0
W5H022	-27.065	30.994	PMEC|ExistResC,Base,IntObl	11.5
X1H016	-25.948	30.569	PMEC|Base,WTW,Sup	11.5
X3H015	-25.150	31.941	PME|EcoImpSen,Base,IntObl,ExistResR	11.0
W5H025	-26.513	30.786	PME|EcoImpSen,Base,IntObl	10.5
W5H026	-26.677	30.702	PME|ExistResR,Base,IntObl	10.5
X1H053	-25.451	31.952	PME|Base,IntObl,IR	10.5
X1H049	-25.711	31.534	PMC|Base,HRO,IntObl	9.5
X2H059	-25.462	31.083	PME|WComp	9.5
X1H014	-25.674	31.575	PMC|ExistResC,GW	9.0
X1H001	-26.036	30.998	PMC|ExistResC	8.5
X2H015	-25.490	30.699	PE|Base,HRO,IR,EcoImpSen,ExistResC	8.5
W5H038	-26.705	30.545	PM|Base,IntObl	8.0
X2H012	-25.659	30.261	PEC|WWTW,MI	8.0
X2H016	-25.364	31.956	PE|IR,Base,IntObl,ExistResC	8.0
X3H008	-24.770	31.389	PE|Base,ExistResC,UpPA,Inf	8.0
X2H032	-25.514	31.225	PE|ExistResC,UpPA,GW	7.5
X3H023	-25.031	31.028	PE|F,Ur,ExistResC	7.5
X2H097	-25.498	31.476	PE|ExistResC,UpPA	7.0
X3H001	-25.089	30.778	P|Base,HRO,ExistResC,GW	6.0
X3H002	-25.088	30.778	P|Base,HRO,ExistResC,GW	6.0
W5H024	-26.387	30.845	P|Base,HRO,ExistResR	5.5
X3H021	-24.968	31.515	P|Base,HRO,Inf	5.5
W5H005	-26.828	30.728	P|EcoImpSen,F	5.0
X1H019	-25.838	30.674	P|Base,HRO	5.0
X1H036	-25.884	30.621	P|Base,HRO	5.0
X2H008	-25.786	30.924	P|Base,F	5.0
X2H010	-25.611	30.875	P|Base,HRO	5.0
X2H014	-25.382	30.702	P|Base,HRO	5.0
X2H022	-25.543	31.317	P|Base,HRO	5.0
X2H065	-25.280	31.003	P|Base,HRO	5.0
X3H011	-24.888	31.091	P|Base,HRO	5.0
X1H021	-26.009	31.080	P|Base	4.5
X2H006	-25.470	31.088	P|Ur	4.5
X2H031	-25.730	30.978	P|Base	4.5
X2H070	-25.360	30.387	P|Base	4.5
X2H072	-25.272	31.256	P|Base	4.5
X3H020	-25.142	31.018	P|Base	4.5

[#] *Sites are listed in descending order based on relative priority*

Reported in **Table 3.4** are all the proposed monitoring sites for the Vaal WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

XXXXXXX

3.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table** 1.5**3.3** are the identified monitoring site numbers, coordinates, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 3.4 Proposed river flow monitoring stations

Site number	Lat	Long	Theoretical objective	Comment	Relative priority
N10	-26.85	30.85	PEC|IR,Inf,ExistResC,GW, WWTW	Important monitoring point due to surrounding mining operations and AMD issues.	9.5
N4	-27.19	30.26	PM|EcoImpSen,IR,Base	Recommended as possible station for operational purposes near Inyaka Dam.	8.5
N5	-25.41	30.32	PE|ExistResC,IR,Base		7.5
N2	-24.69	31.06	P|ExistResC, GW,HRO	Recommended that this station be integrated with the location and objective of the 1st Ecosystem theoretical monitoring point (E1).	5.5
N1	-24.76	31.13	P|ExistResC, GW	Recommended that this station be integrated with the location and objective of the 2nd Ecosystem theoretical monitoring point (E2) .	5.0
N8	-25.67	31.10	P|ExistResC, GW	Recommended that all upstream objectives be assigned to this station.	5.0
N3	-25.02	31.17	P|Ur		4.5
N6	-25.46	30.72	P|Base	Proposed as a replacement station for X2H096 and X2H013.	4.5
N7	-25.63	30.40	P|Ur		4.5
N9	-26.10	30.09	P|Base	Important monitoring point for surface- and groundwater interaction.	4.5

[#] *Sites are listed in descending order based on relative priority*

Table 3.5 Monitoring sites that require changes

Site number	Lat	Long	Theoretical objective	Comment	Relative priority
X1H017	-25.90	30.28	PMC|ExistResC	This monitoring station is not accurate for high flows.	8.5
X1H018	-25.84	30.41	PE|Base,IR	The diversion weir is not accurate for low flows.	7.0
X2H005	-25.43	30.97	P|Base,HRO	Monitoring station is only accurate for low flows.	5.0
W5H034	-26.66	30.49	P|Base	Requires upgrading in order to improve the dam balance.	4.5
X1H033	-25.95	30.10	P|Base	This monitoring station is important to improve the W-component.	4.5

[#] *Sites are listed in descending order based on relative priority*

3.3.4 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Reported in **Table** 1.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 3.6 Monitoring sites that are not of national importance

Site Number	Description	Comments
X3H022	-	This monitoring point is currently being used for monitoring a domestic water supply system. Due to this system being relatively small, the monitoring point does not have a huge influence from a national perspective.

3.3.5 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, coordinates and comments that resulted in the site classification.

Table 3.7 Redundant river flow monitoring stations

Site number	Lat	Long	Comment
X2H013	-25.449	30.712	Data produced from this station is of poor quality and the amount of upgrade that would be required to fix this would not be financially feasible. The station is also located close to X2H096.
X2H096	-25.455	30.726	Data produced from this station is of poor quality and the amount of upgrade that would be required to fix this would not be financially feasible. The station is also located close to X2H013

3.4 RESERVOIR STATIONS

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must therefore be monitored efficiently.

Two DWS dams were identified in this WMA that are currently not being monitored. It is recommended that a reservoir monitoring station and possibly a W-component monitoring point be installed for the following dams:

- Acornhoek Dam
- Edinburgh Dam

3.5 ESTUARIES

There are no estuary / tidal stations in this WMA.

3.6 RAINFALL STATIONS

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.3.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

3.7 GROUNDWATER MONITORING

The current groundwater monitoring network in the Inkomati-Usuthu WMA is uneven in spatial distribution and measures groundwater level fluctuations. The groundwater monitoring points are mostly confined to the Lowveld region of the Inkomati-Usuthu WMA. No knowledge about the reasons for the placement of these points is available because of a lack of corporate memory (DWAF, 2008).

The following criteria were made in reviewing the current groundwater monitoring network:

- An elevation rule was applied to the initial proposed sites so that baseline and trend monitoring station points do not plot on top of mountains.
- Proposed sites in Swaziland were discarded.
- Current groundwater quality monitoring point 90135 was converted into a groundwater baseline monitoring point.
- Current groundwater quality monitoring point 90136 was converted into a groundwater baseline monitoring point. A buffer around the baseline 90136 point of 30 km x 30 km was applied and superimposed onto the 100 km^2 grid points. Only those sites that intersected the individual envelopes were selected.
- All current groundwater level and quality monitoring points were converted to trend monitoring stations. A buffer of 100 km^2 was applied and the theoretical trend monitoring stations that fell within the buffer were removed.
- Baseline monitoring points in pristine areas using the 100 km^2 rule were applied upstream of dams.
- No recommendations were made for closing current monitoring points.
- No recommendations were made for improvements.

At baseline monitoring stations both groundwater level and quality measurements will be taken

APPENDIX A.3

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 3: INKOMATI-USUTHU

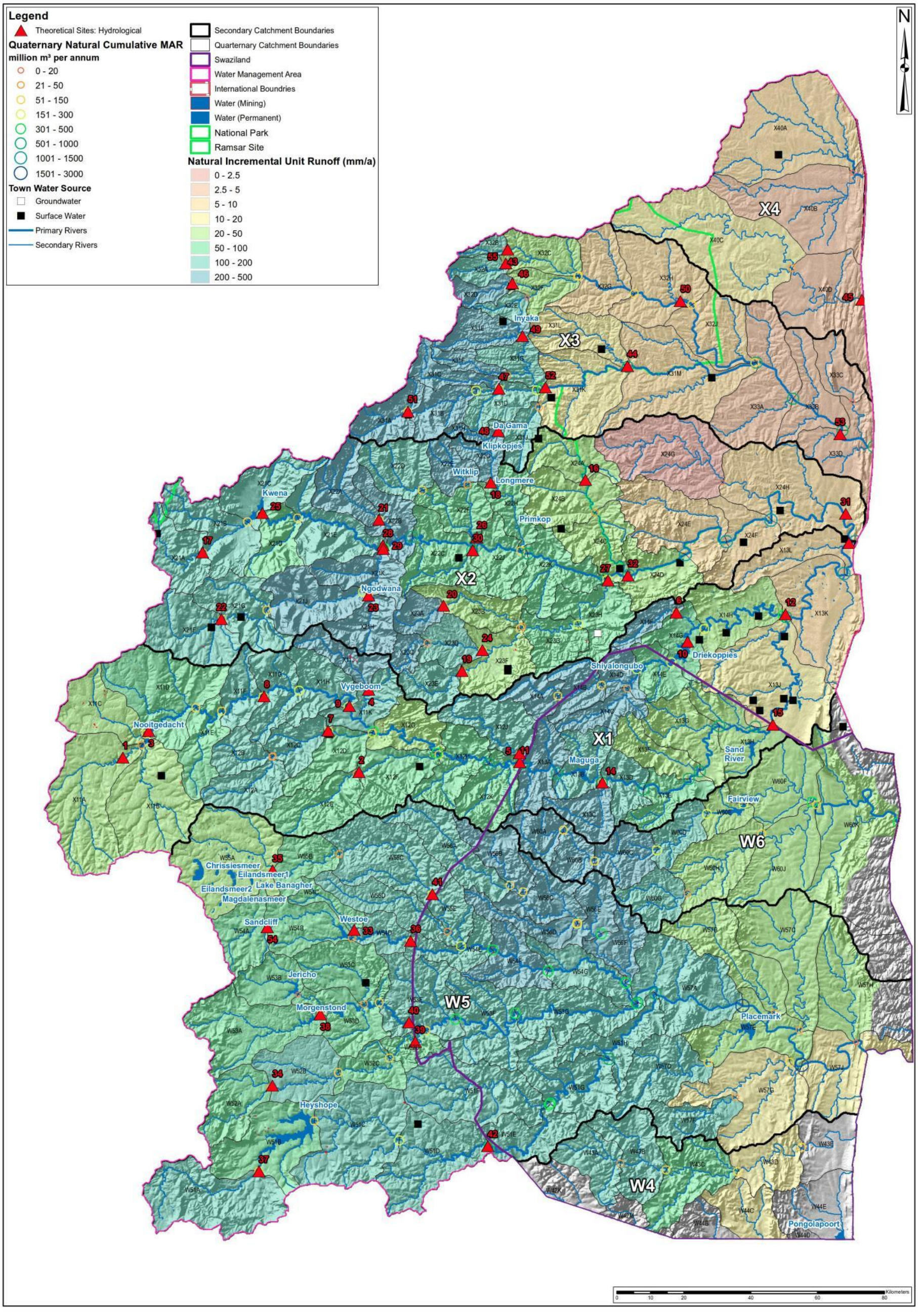


Figure A.3.9 Theoretical surface water sites based on hydrological (runoff) considerations

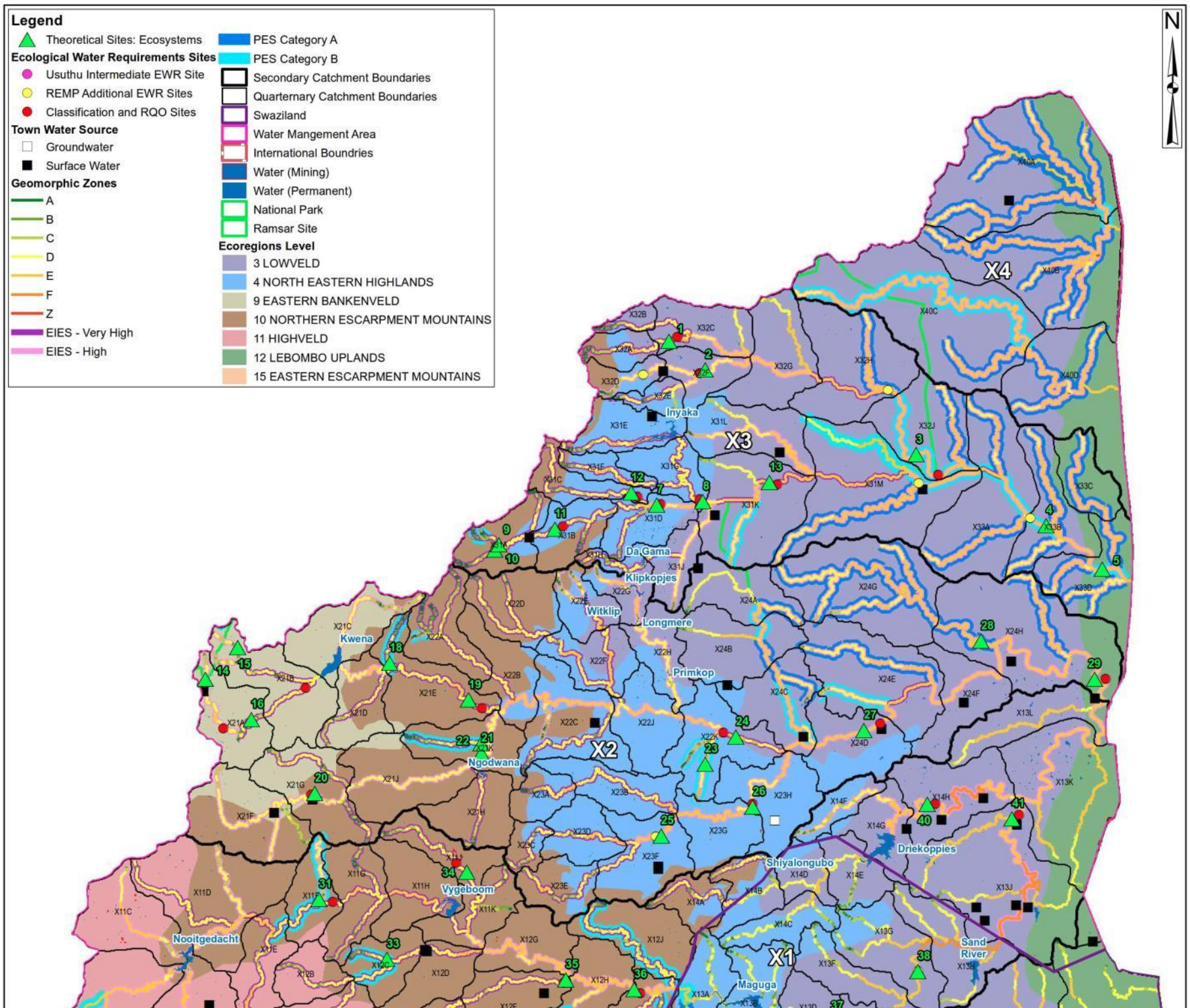


Figure A.3.10 Theoretical surface water sites based on ecosystem considerations

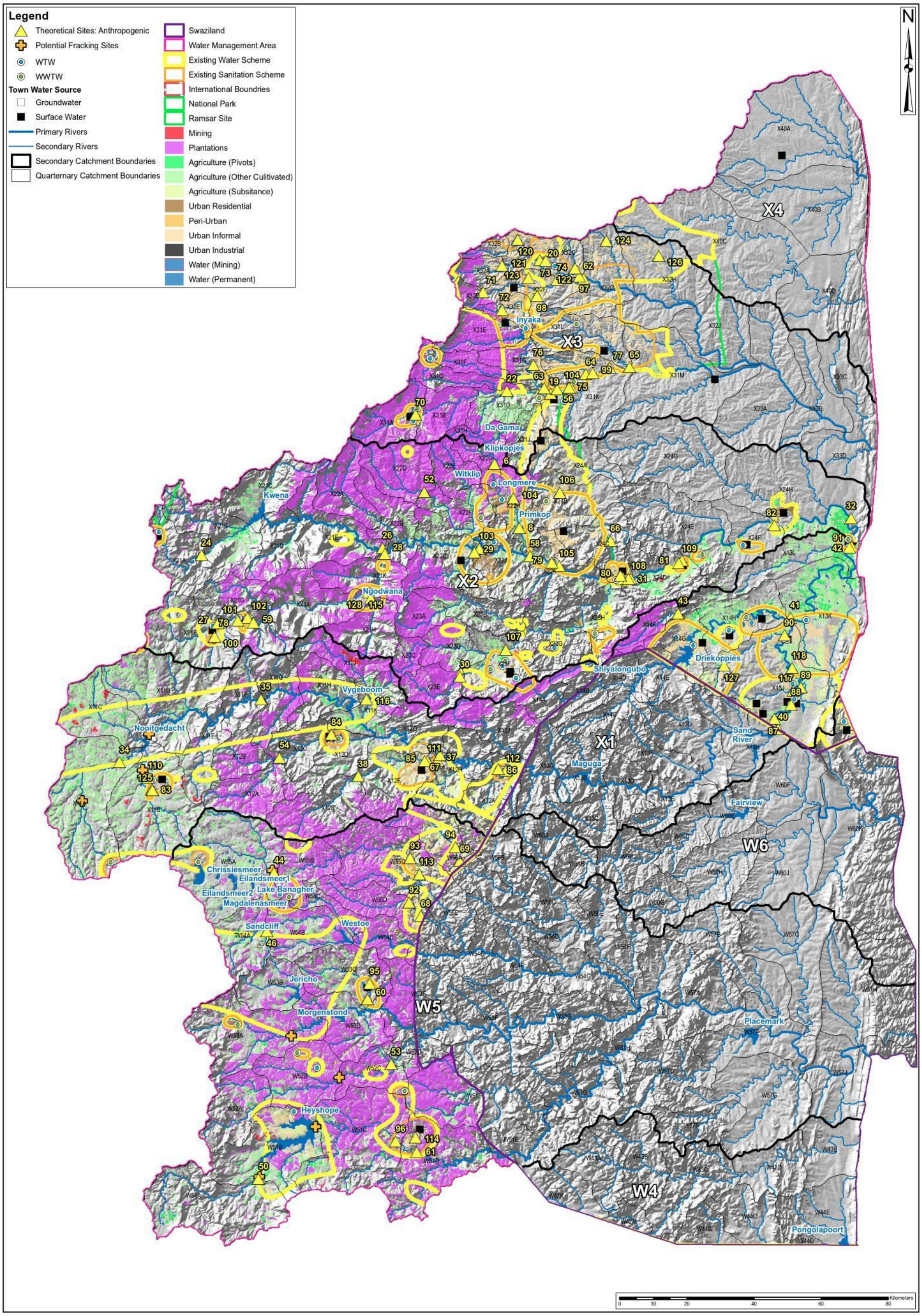


Figure A.3.11 Theoretical surface water sites based on anthropogenic considerations

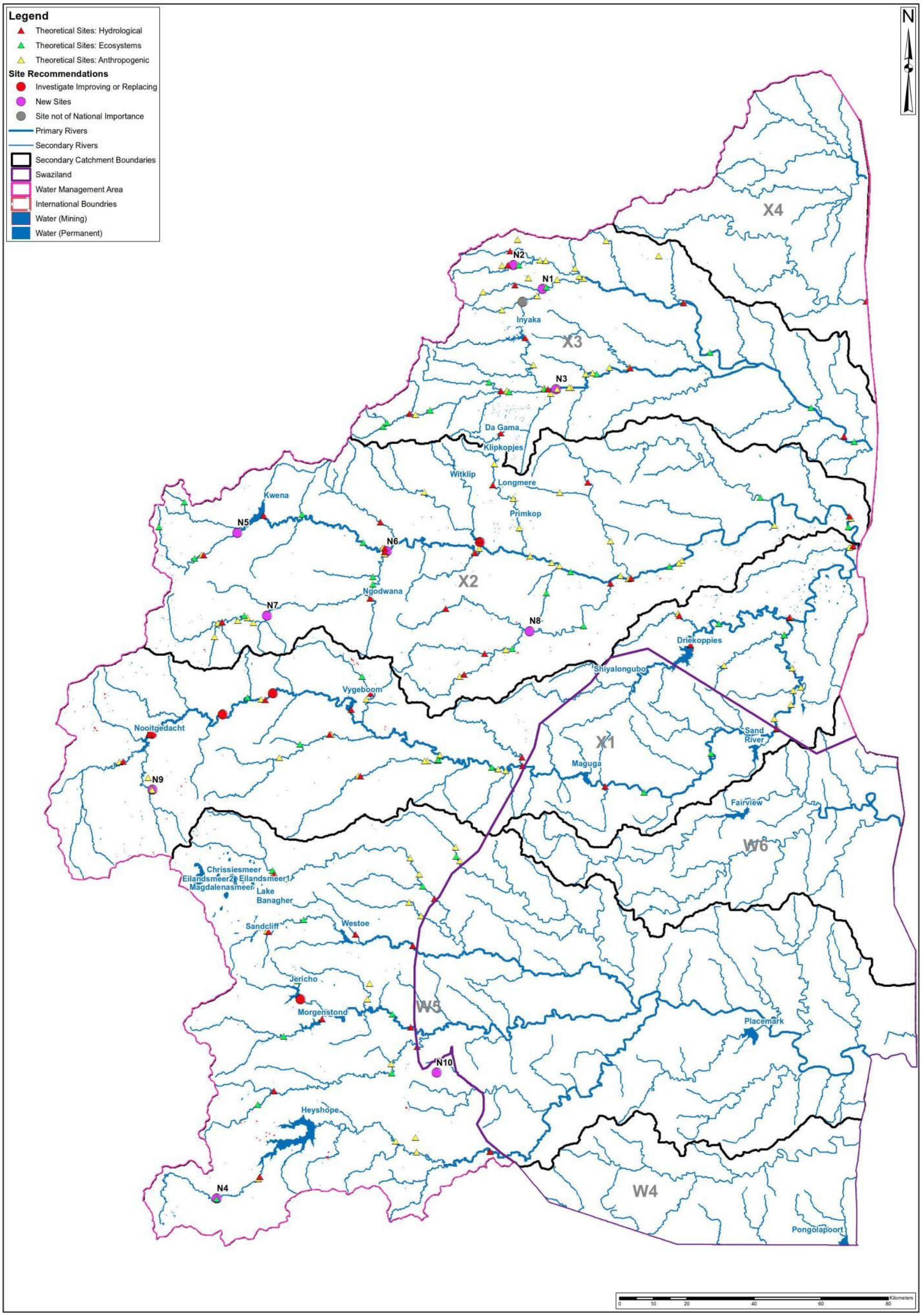


Figure A.3.12 All theoretical and actual surface water monitoring sites with recommended actions

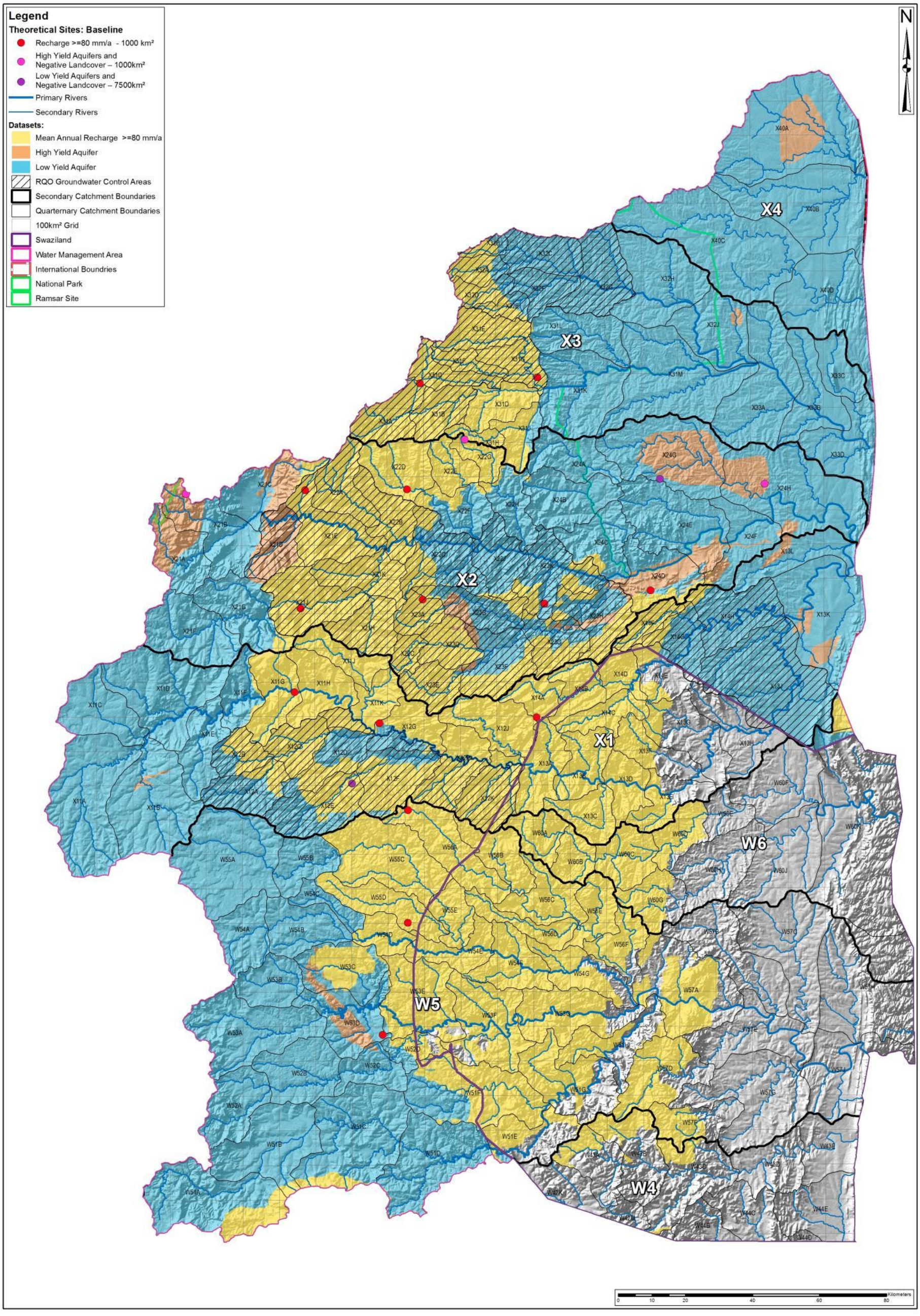


Figure A.3.5 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

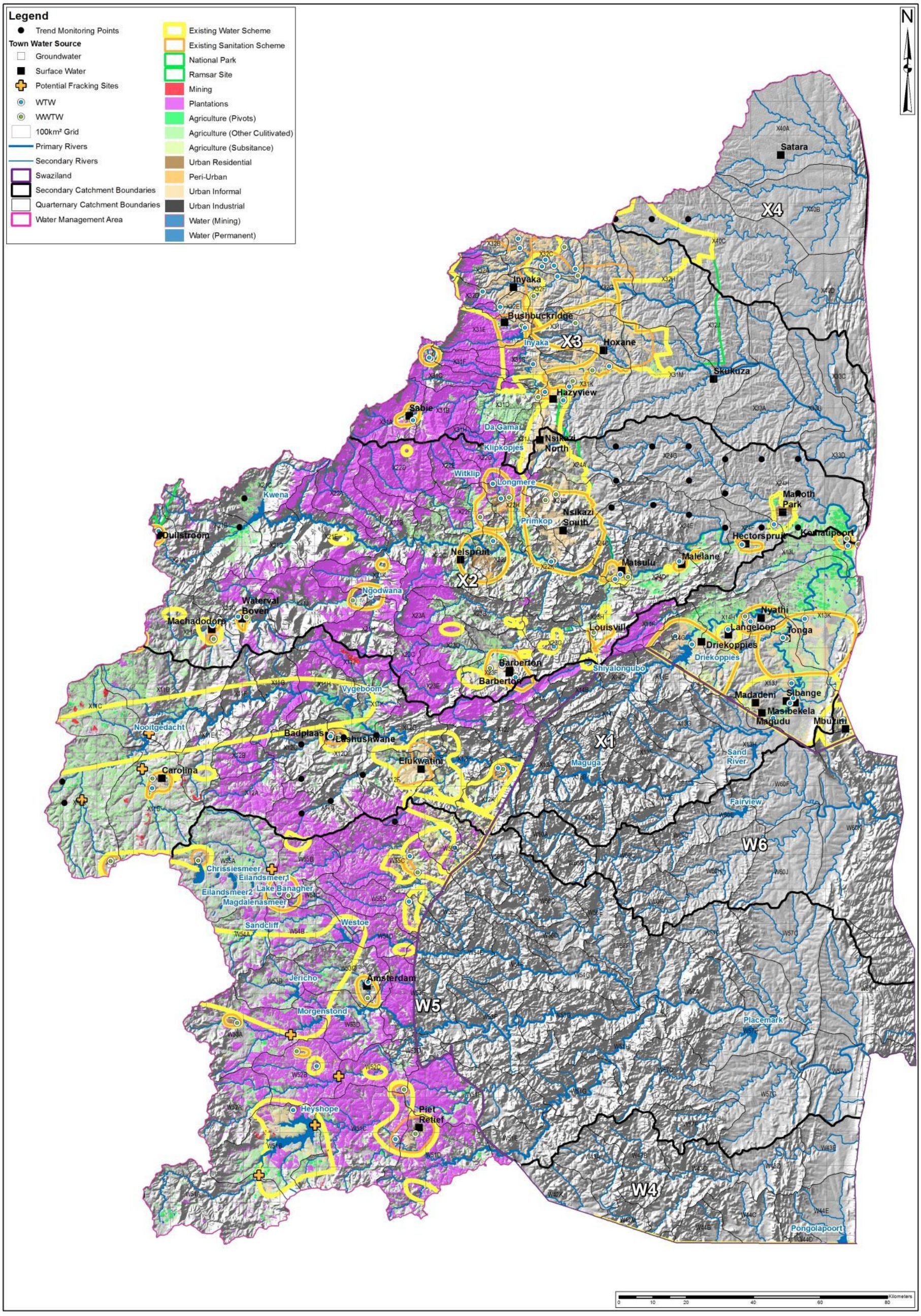


Figure A.3.6 Theoretical groundwater sites based on anthropogenic considerations (Trend)

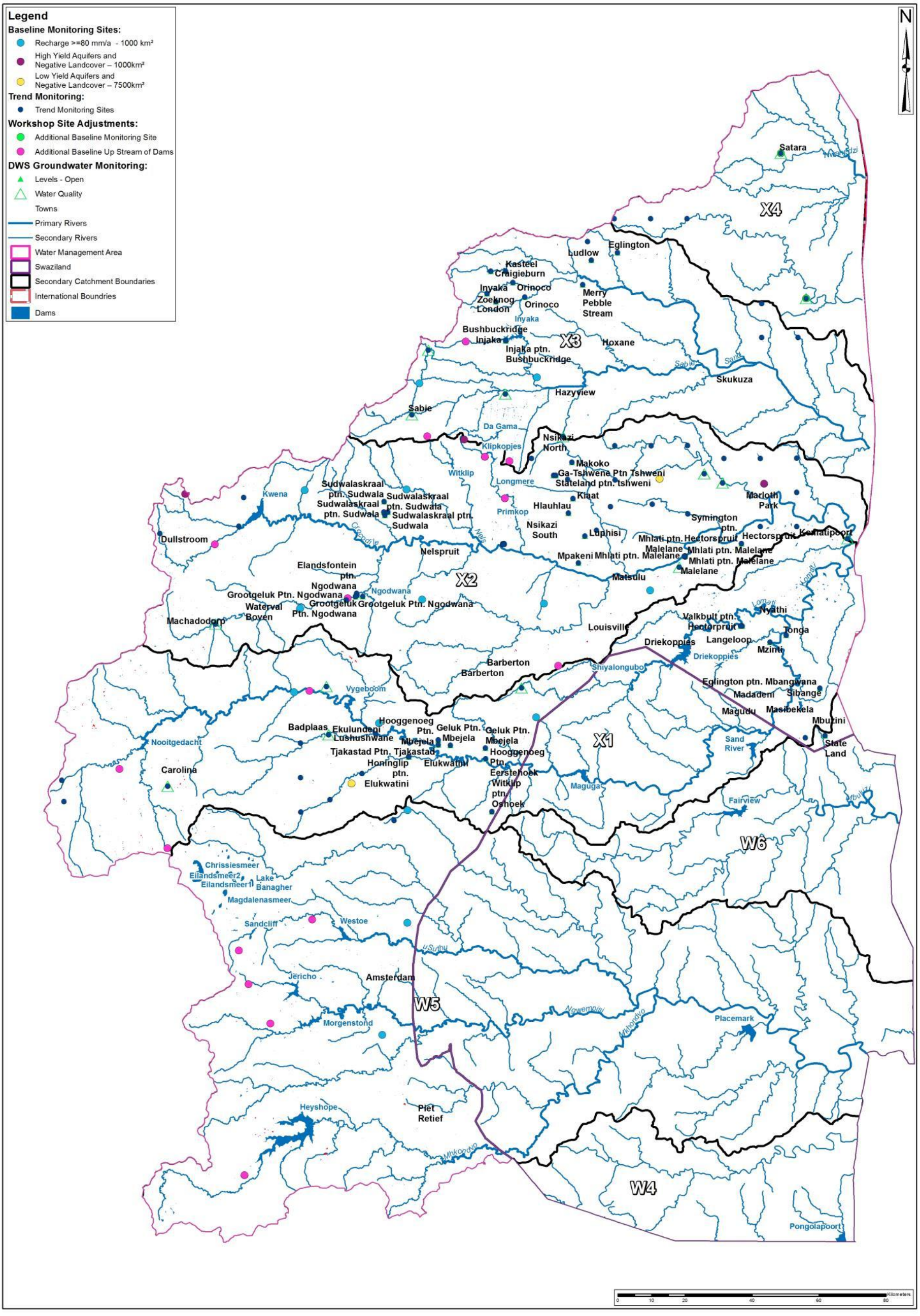


Figure A.3.7 Theoretical and exiting groundwater monitoring sites including additional recommended sites

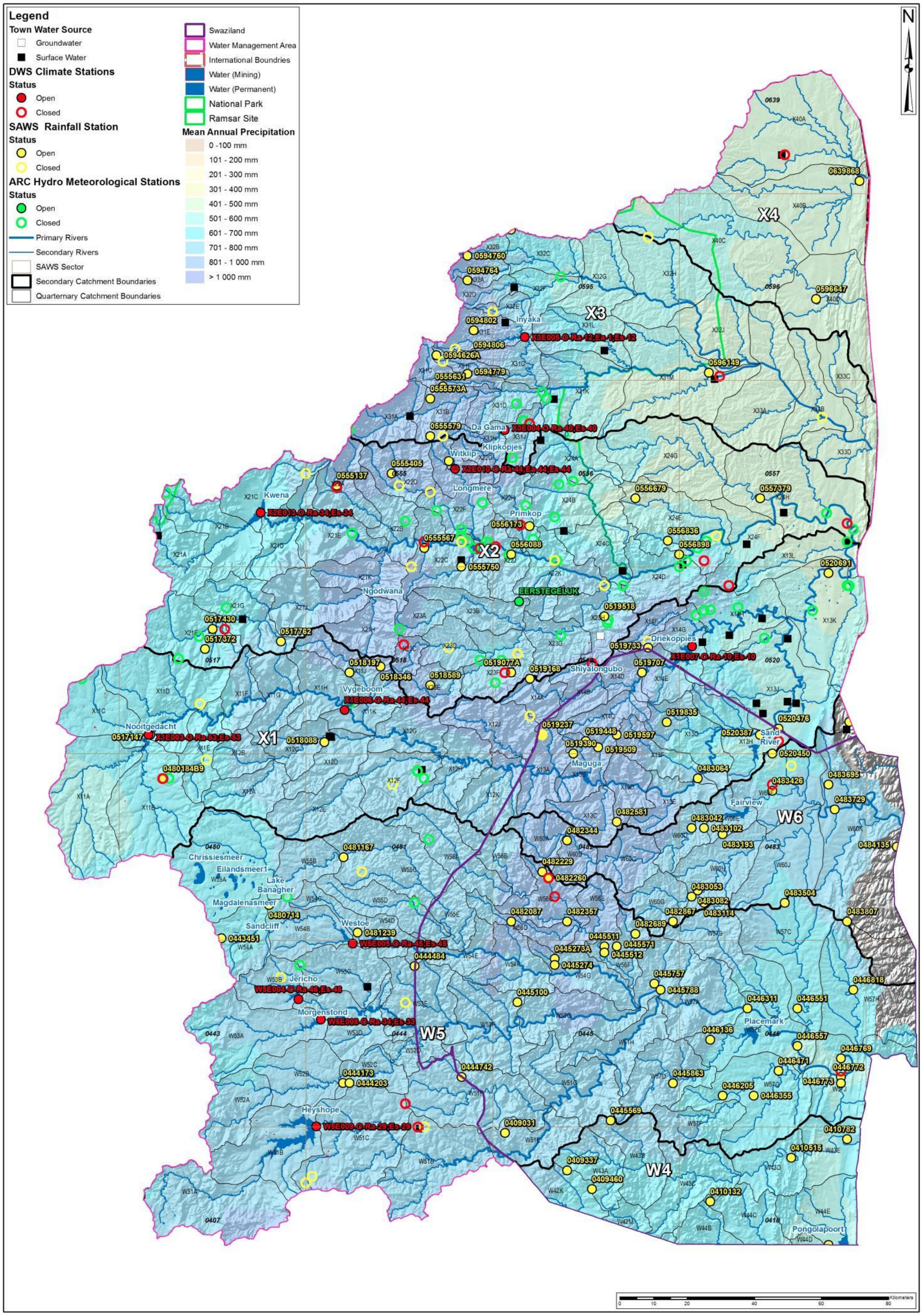


Figure A.3.8 Climatic information for the WMA

ANNEXURE 4

WMA 4: PONGOLA-uMZIMKULU

4. WMA 4: PONGOLA-UMZIMKULU

The Pongola-uMzimkulu WMA is located in KwaZulu-Natal. This is as the result of the amalgamation of the Thukela, Mvoti-Mzimkulu and half of the Usuthu catchments. This WMA is bounded by the Indian Ocean to the east, Mozambique, Swaziland and the Inkomati-Usuthu WMA to the North, Lesotho and the Vaal WMA to the west and the Mzimvubu-Tsitsikamma WMA to the south (DWS, 2013c).

The WMA covers an area of high season rainfall as well as heavy demands on water resources from the agricultural, mining and urban demand sectors. Certain rivers within the WMA are classified as international as their catchments are shared by Mozambique and Swaziland. The north of the WMA, formally the Usuthu to Mhlatuze WMA contains major rivers including the Pongola, Mhlatuze, Mkuze and Mfolozi rivers. The Pongola River rises near Wakkerstroom in KwaZulu-Natal and flows east descending steeply west of the Lebombo Mountains. The river is dammed at Jozini Dam in Mfolozi rivers. The Pongola River rises near Wakkerstroom in KwaZulu-Natal, and eventually joins the Maputu River in Mozambique. The Usuthu River starts in Mpumalanga, flows through Swaziland, re-enters South Africa and flows through Mozambique, finally emptying as the Maputo River into Maputo Bay (DWS, 2013c).

The Thukela River is the largest river in the country by volume and has a catchment area of approximately 29 000 km^2. The river has, as its major tributary, the Buffalo River and has smaller tributaries namely, the Bushmans, Mooi, Little Thukela, Klip, Sundays and Blood rivers. The main dams on the Thukela River are the Driel Barrage, Spioenkop and Woodstock dams. The Thukela is also part of a transfer scheme to feed the Vaal River system. Water from the Thukela and its tributaries are critical for both subsistence and commercial farming. Due to the mining activities which happen in the area, there are acid mine drainage issues and high pathogens within the water systems which pose health issues.

The Pongola-uMzimkulu WMA topography ranges from sea level to about 3 000 m. It has three distinct topographical types. The first is the coastland low lying region, which forms a narrow band in the south and widens towards the north. It typically has a thick subtropical thicket and some forest. The central region is known as the Natal midlands and can be described as a hilly plateau.

The WMA has relatively high rainfall compared to the rest of the country. The rainfall is uniformly spread across the WMA with the majority of rainfall occurring in summer with between 800 and 1 500 mm. Higher rainfall is experienced along the western part of the WMA on the windward side of the Drakensberg Mountains, while the lower end of the rainfall band is experienced in the rain shadow pockets (DWS, 2013c).

The water quality in the WMA is declining. This is especially true for the 400 000 km of river frontage exposed to various contaminants from industrial effluent to pathogens. In the developed areas, particularly the more densely populated towns, man-made interventions result in problems commonly associated with urban water use (DWS, 2013c).

A large part of the WMA is using water for rain fed agriculture and there is still potential to dam some of the rivers within the WMA and transfer water to other water stressed areas.

4.1 SITE REVIEWS

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

4.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Pongola-uMzimkulu WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. Error! Reference source not found. provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

According to Error! Reference source not found., there are 98 active river flow, 12 tidal and 36 reservoir monitoring sites in the Pongola-uMzimkulu WMA that was evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

The number of sites with water quality constituents being monitored in the Pongola-uMzimkulu WMA is provided in **Table** 1.3**4.2**.

Table 4.1 Number of surface water quantity monitoring sites per secondary catchment

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
T4	**0**	0	0	0	1	0	0	**1**
T5	**5**	0	0	0	5	1	1	**7**
U1	**5**	0	0	0	2	0	1	**3**
U2	**11**	0	0	2	17	4	0	**23**
U3	**2**	0	0	1	2	1	4	**8**
U4	**8**	0	0	0	2	1	1	**4**
U5	**0**	0	0	0	0	0	0	**0**
U6	**1**	0	0	0	2	1	0	**3**
U7	**8**	0	0	0	4	1	0	**5**
U8	**1**	0	0	0	5	1	0	**6**
V1	**15**	3	0	2	9	4	0	**18**
V2	**7**	0	0	0	7	2	0	**9**
V3	**9**	0	0	4	7	3	0	**14**
V4	**0**	0	0	2	0	0	0	**2**
V5	**0**	0	0	0	1	0	1	**2**
V6	**1**	0	0	0	4	0	0	**4**
V7	**6**	0	0	1	7	1	0	**9**
W1	**18**	2	0	1	7	5	0	**15**
W2	**6**	0	0	1	6	1	0	**8**
W3	**5**	0	0	1	4	1	1	**7**
W4	**3**	3	0	1	6	6	0	**16**
W7	**3**	0	0	0	0	3	3	**6**
Total	**114**	**8**	**0**	**16**	**98**	**36**	**12**	**170**

Table 4.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
T4	**0**	0	1	0	0	0	0	0	0	**1**
T5	**0**	0	5	0	0	0	0	0	0	**5**
U1	**0**	1	2	0	0	0	0	0	0	**3**
U2	**0**	4	7	0	0	5	0	8	0	**23**
U3	**0**	0	1	0	0	1	0	1	0	**3**
U4	**0**	1	1	0	0	0	0	0	0	**2**
U5	**0**	0	0	0	0	0	0	0	4	**4**
U6	**0**	1	2	0	0	1	0	4	0	**8**
U7	**0**	2	1	0	0	1	0	0	0	**4**
U8	**0**	1	3	0	0	2	0	1	0	**6**
V1	**0**	11	4	0	0	7	0	0	0	**19**
V2	**0**	8	2	0	0	2	0	0	0	**11**
V3	**0**	7	3	0	0	2	0	0	0	**10**
V4	**0**	0	0	0	0	0	0	0	0	**0**
V5	**0**	0	1	0	0	0	0	0	0	**1**
V6	**0**	2	3	0	0	0	0	0	0	**5**
V7	**1**	3	1	0	0	1	0	0	0	**5**
W1	**2**	6	2	0	0	0	0	8	0	**14**
W2	**4**	2	5	0	0	1	0	1	0	**9**
W3	**29**	5	3	0	0	1	0	4	0	**13**
W4	**1**	2	4	0	0	2	0	2	0	**8**
W7	**1**	2	0	0	0	0	0	0	0	**2**
Total	**38**	**58**	**51**	**0**	**0**	**26**	**0**	**29**	**4**	**156**

Notes:

(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

As can be seen from **Table** 1.3**4.2** the main water quality programmes in the WMA include chemical, eutrophication, microbial and estuarine monitoring. As stated earlier, the water quality parameters and frequencies will be reviewed during the strategy development and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

4.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 4.3**.

Table 4.3 Objectives and relative priorities assigned to existing river monitoring stations with no recommended actions

Site number	Description	Theoretical objective	Relative priority[#]
V1H058	Tugela River @ Driel	PME|Ir,Urb,HR,Base	11.0
V7H020	Boesmans River @ Wagendrift	PME|Wcomp,HR,Base	10.0
U8H004	Mtwalume River @ State Land	PME|WTW	9.5
U2H052	Mgeni River @ Inanda Loc.	PMC|Base,Div	9.0
U2H059	Mgeni River @ Inanda Location	PMC|Base,Div	9.0
V1H026	Tugela River @ Kleine Waterval	PMC|ExistResR,Ir	9.0
W1H032	Mhlatuze River @ Umhlatuze Valley	PEC|ExistResR,EstFFU, Base, Ir	9.0
W3H015	Hluhluwe River @ Valsbaai	PMC|PriorEstReq,Base	9.0
V2H002	Mooi River @ Mooi River	PEC|ExistResR,WTW,Urb	8.5
U2H055	Mgeni River @ Inanda Loc.	PMC|ExistResC	8.5
U3H001	Tongati River @ Riet Kuil	P|EcoImpSen,Rur,Urb,Ir,Mi	7.5
V1H031	Sand Spruit @ Kleine Waterval	PE|Ir,Urb,Rur	7.5
V1H038	Klip River @ Ladysmithdorpsgronde	PE|Base,HR, Urb	7.5
W1H018	Manzamnyama River @ The Ranche	PE|Base, PrioirEstReq, EcoImpSen	7.5
U2H058	Msunduze River @ Masons Mill	PE|Urb,Rur	7.0
U6H003	Mlazi River @ Umlaas	PE|Ir,Rur	7.0

Site number	Description	Theoretical objective	Relative priority[#]
W1H019	Siyaya River @ The Ranche	PE|PriorEstReq, EcoImpSen	7.0
W3H008	Mkuze River @ Doornhoek	PE|Base,PriorEstReq	7.0
T5H004	Mzimkulu River @ Fp 1609030	PC|HR,Base, ExitsResC	6.5
T5H012	Mzimkhulwana River @ Horseshoe	PC|Base,Ir,ExistResR	6.5
U2H011	Msunduze River @ Henley Dam	PE|Rur	6.5
U2H013	Mgeni River @ Petrus Stroom	PC|ExistResC,HR,Base	6.5
U2H041	Msunduze River @ Hamstead Park	PC|ExistResC,Rur,Urb	6.5
V6H004	Sondags River @ Kleinfontein	PC|HR,Base,ExistResR	6.5
W2H005	White Mfolozi River @ Overvloed	PC|Base,Ir,ExistResR	6.5
W2H006	Black Mfolozi River @ Native Res 12	PC|Base,ExistResR, EcoImpSen	6.5
W2H028	Black Mfolozi River @ Ekuhlengeni	PC|ExistResR, HR,Base	6.5
W2H032	Umfolozi River @ State Land	PC|ExistResR,Base, PriorEstReq	6.5
W4H006	Phongolo River @ M'Hlati	PC|ExistResR,Base,HR	6.5
W4H009	Phongolo River @ Ndumu Game Reserve	PE|Base,UPPA	6.5
W3H014	Mpate River @ Mpate Forest Res.	PE|PriorEstReq	6.5
T5H002	Bisi River @ Nooitgedacht	PC|ExistResR, Base	6.0
U2H006	Karkloof River @ Shafton	PC|HR,Base, ExistResC	6.0
U4H010	Kleinspruit	PC|Base,ExistResC	6.0
V2H004	Mooi River @ Doornkloof	PC|ExistResR,Base	6.0
V2H021	New station not on HYDSTRA	PC|ExistResR,BaselinePA	6.0
V5H002	Tugela River @ Mandini	PC|Base,ExistResR	6.0
V7H017	Boesmans River @ Drakensberg Loc 1	P|Base,Rur,EcoImpSen, BaselinePA	6.0
W1H009	Mhlatuze River @ Riverview	PC|ExistResR, Base	6.0
W1H028	Mhlatuze River @ Mhlatuze	PC|Base,ExistResR	6.0
T4H001	Mtamvuna River @ Gundrift	P|HR,Base, EcoImpSen	5.5
U7H001	Zwateni River @ Highlands	P|HR,Base,Ir	5.5
U7H007	Lovu River @ Beaulieu Estate	P|HR,Base,Ir	5.5
V2H007	Hlatikulu River @ Broadmoor	PC|ExistResR	5.5
V3H002	Buffels River @ Schurvepoort	P|HR,Base, EcoImpSen	5.5
V3H007	Ncandu River @ Rust	PC|ExistResR	5.5
W4H004	Bivane River @ Welgelegen	P|EcoImpSen,HR, Base	5.5
U2H005	Mgeni River @ Table Mountain	P|Base,HR	5.0
U2H007	Lions River@(Mpofana River) @ Weltevreden	P|HR,Base	5.0
U2H012	Sterk River @ Groothoek	P|HR,Base	5.0
U2H014	Mgeni River @ Albert Falls	P|Base,HR	5.0
U2H048	Mgeni River @ Midmar	P|HR,Base	5.0

Site number	Description	Theoretical objective	Relative priority[#]
U2H054	Mgeni River @ Inanda Mission Res	P|HR,Base	5.0
U2H061	Mpofana River	P|Base,HR	5.0
U4H002	Mvoti River @ Mistley	P|HR,Base	5.0
U8H003	Mpambanyoni River @ Umbeli Belli	P|EcoImpSen,Base	5.0
U8H005	Mzinto River	P|Base,Ir	5.0
U8H006	Mzimayi River	P|Urb,Ir	5.0
V1H010	Little Tugela River @ Winterton	P|HR,Base	5.0
V1H041	Mlambonja River @ kleinrivier	P|HR,Base	5.0
V2H005	Mooi River @ The Bend	P|HR,Base	5.0
V3H009	Horn River @ Ballengeich	P|HR,Base	5.0
V7H016	Ncibidwane River @ Drakensberg Loc 1	P|Base,Rur	5.0
W1H005	Mfulazane River @ Golden Reef	P|Base, Urb	5.0
W2H009	White Mfolozi River @ Doornhoek	P|Base,HR	5.0
W2H030	White Mfolozi River @ Klipfontein	P|HR,Base	5.0
W4H010	Phongolo River @ Lake View	P|Base, Rur	5.0
T5H005	Nkonzo River @ Dronkvlei	P|Base	4.5
U7H008	Nungwana River @ Umbumbulu	P|Base	4.5
U7H012	Nungwana River @ Umbumbulu	P|Base	4.5
V1H009	Bloukrans River @ Frere	P|Urb	4.5
V6H003	Wasbank River @ Kuikvlei	P|Base	4.5
V6H006	Sondags River @ Waterfall	P|Base	4.5
W1H004	Mlalazi River @ Eshowe	P|Base	4.5

[#] *Sites are listed in descending order based on relaitive priority*

4.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or needing to be upgraded. Reported in **Table 1.3** are the theoretical objectives that have been assigned to these existing river sites.

4.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 4.4** are all the proposed monitoring sites for the Pongola-uMzimkulu WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

Table 4.4 Proposed new river monitoring sites

Site number	Latitude	Longitude	Theoretical objective	Comment	Relative priority[#]
N6	-29.285	31.130	PEC|Base,ExistResC,Rur,Ir	There is currently no monitoring on the lower reach of the Mvoti River. This station would also be located downstream of a high runoff area.	9.0
N8	-28.240	29.750	PM|DDam	It is recommended that measurements be made at the dam.	7.5
N1	-31.024	30.164	PC|ExistResC,PriorEstReq, EcoImpSen,HR, Base	This station is located downstream of a high runoff area and upstream of a priority estuary.	7.5
N5	-30.074	30.647	PC|ExistResR, Base,HR,IR	New site required. Vandalism can be expected.	7.0
N13	-30.008	30.245	P|Base, Ir, F, Urb	New site to be investigated.	7.0
N16	-27.309	30.898	PC|HR, Base, ExistResR,EcoImpSen	Investigate new site in upper Pongola River.	7.0
N2	-30.060	29.789	PC|HR,Base, ExistResR	There is currently no monitoring taking place on the Ngwangwane River. This station would also be located downstream of a high runoff region.	6.5
N7	-28.761	29.659	PC|ExistResR,Base,HR	This station is located downstream of a high runoff area and would measure the contribution of the Little Tugela River upstream of the confluence with the Thukela River.	6.5
N15	-29.168	31.376	PC|ExistResR,WTW, Base	Region to investigate implementing measurement at the diversion weir.	6.5
N3	-30.612	30.234	PC|ExistResR, Base	Potential development of a diversion weir at this point.	6.0
N9	-28.757	30.429	PC|ExistResR, Base	Recommended as a replacement for V6H002.	6.0
N12	-28.736	29.821	PC|ExistResR, Base	Recommended as a replacement for V1H001, upstream of site.	6.0
N10	-28.052	30.375	PC|Base, ExistResR	Replacement for V3H010.	6.0
N11	-28.703	30.622	PC|Base, ExistResR	Important for measuring the Buffels River. Search for site upstream from the confluence with the Thukela River.	6.0
N14	-28.767	30.169	PC|ExistRes	Investigate new site on the lower Boesmans River.	5.5

[#] *Sites are listed in descending order based on relaitive priority*

4.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, coordinates, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 4.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Relative priority
V1H057	Tugela River @ Rhenosterfontein	PMEC|HR,Base,WComp, ExitResR	Permanent structure is required.	12.0
U3H005	Mdloti River @ Cotton Lands	PME|HR,Base, Urb	This station must be improved due to the dam being upgraded to a piano key.	10.5
T5H007	Mzimkulu River @ Bezweni	PEC|Urb,Ir,F,ExistResR	This is a relatively old monitoring point that is exhibiting accuracy problems. This must be investigated for improvements / replacement.	9.0
U1H009	Mkomazi River	PEC|ExistResC,MI	It is recommended that the measurements at this point be synchronized with the water quality measurements at U1H006.	8.0
U1H005	Mkomazi River @ Lot 93 1821	PC|ExistResC, HR, Base	It is recommended that this station be upgraded along with the proposed dam development in the vicinity.	6.5
V7H012	Little Boesmans Riv. @ Estcourt	P|HR,Base,Ur, MI	This monitoring point experiences lots of siltation and must be investigated for improvement or made redundant if a new site is developed to replace it at a different location..	6.0
V3H010	Buffels River @ Tayside	PC|Base, ExistResR	Important Thukela station, investigate site upstream (new station N10).	6.0
U6H002	Mlazi River @ Nooitgedacht	P|HR,Base, EcoImpSen	Some leaks were observed at this station and it is therefore recommended that repairs and upgrades be made at this station.	5.5

[#] *Sites are listed in descending order based on relative priority*

4.3.4 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Reported in **Table** 1.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 4.6 Monitoring sites that are not of national importance

Site Number	Latitude	Comments
U2H022	Msunduze River @ Inanda Loc	This is an operational station and is, from a water resources perspective, not of national importance.
U8H004	Mtwalume River @ State Land	This station measures abstractions made in the vicinity and is possibly not of national importance.

4.3.5 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, coordinates and comments that resulted in the site classification.

Table 4.7 Redundant river flow monitoring sites

Site number	Description	Comment
V2H006	Little Mooi River @ Dartington	There is already a station located on this stretch of the river and it is recommended that this station be made redundant.
U8H001	Fafa River @ Cowick	This station is exhibiting poor accuracy and it is therefore recommended that it be made redundant.
U2H057	Slang Spruit @ Pietermaritzburg	This station is located in the vicinity of other stations and it is recommended that this station be made redundant and its objectives be incorporated with nearby stations.
V6H002	Tugela River @ Tugela Ferry	This station is exhibiting poor accuracy in measuring low flows. It is therefore recommended that it be replaced by N9.
V1H001	Tugela River @ Tugela Drift	This station is exhibiting poor accuracy and it is therefore recommended that it be replaced with N12 at a location upstream from the location of the current station.

4.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must there for be monitored efficiently. In this area, however, there is one W-component proposed which is listed in **Table 4.8**.

Table 4.8 New and changes to W-components for dams

Site number	Latitude	Longitude	Theoretical objective	Comment	Relative priority[#]
U2H048	Mgeni River @ Midmar		PMC|HR,Base,ExistResC	Improve capacity of the weir.	9.5
N4	-30.312	30.592	PE|Wcomp,Rsupply	W-component constructed and other components need to be measured for U8R001.	7.0

4.5 ESTUARIES

The Pongola-uMzimkulu WMA has 18 estuaries that falls within the top 20% of Estuaries in the country according to a ranking system developed by the RQIS. This study (DWS, 2002) devised a method for prioritising South African estuaries on the basis of conservation importance, and presented the results of a ranking based on the collation of existing data for all South African estuaries. Estuaries are scored in terms of their size, type and biogeographical zone, habitats and biota (plants, invertebrates, fish and birds).The identified estuaries include:

Top 10% estuaries

- Richards Bay Estuary
- St Lucia Estuary

- Mpenjati Estuary
- Mlalazi Estuary
- Mtamvuna Estuary
- Mgeni Estuary
- Mfolozi Estuary
- Mhlanga Estuary

Top 20% estuaries

- Nonoti Estuary
- Kosi Estuary
- Mzimkulu Estuary
- Mhlatuze Estuary
- Msimbazi Estuary
- Intshambili Estuary
- Damba Estuary
- Mdlotane Estuary
- Zinkwazi Estuary
- Siyaya Estuary

The first eight estuaries fall under the top 10% of estuaries in the ranking systems and all, with the exception of the Richards Bay, Mlalazi and Mfolozi Estuary, have tidal sites. Only three of the eleven top 20% estuaries have upstream tidal sites, but it is not deemed important that tidal sites are installed here. River inflow measurements to the top 10% of the estuaries were prioritised during the river site analysis.

4.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.4.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

4.7 GROUNDWATER MONITORING

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring station points does not plot on top of mountains.
- Increase spatial density over groundwater control areas to 500 km^2 to set baseline monitoring points. This rule applies to all groundwater control areas throughout the country.

- Increase spatial density over Natal sandstones to 500 km^2 to generate additional baseline monitoring points.
- Set ZQMTEP1-N1|GO-V18-F24W and W7N0001 as baseline monitoring points.
- Set additional the Bongwana spring as additional baseline monitoring point. Coordinates to be provided by Dr Molla Demlie, University of KwaZulu-Natal.

- Convert the current monitoring points to trend monitoring station. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring stations that fall within the buffer.

T4N0001	V3N0017	W7N0007
T5N0001	V3N0005	ZQMMAE2-N0|GO-V18-F24W
ZQMCRC2-N2|GO-V18-F24W	V3N0016	W4N0012
ZQMMGS1-N2|GO-V18-F24W	V3N0020	W4N0007
U2N0506	V3N0002	W4N0011
U2N0500	V3N0003	W4N0017
U2N0503	V3N0015	ZQMMUG1-N32|GO-V38-F24W
U3N0003	ZQMHRT1-N30|GO-V38-F24W	W4N0013
U3N0001	V3N0014	W7N0002
U4N0001	W1N0510	W7N0006
V7N0505	W1N0513	ZQMSFR1-N29|GO-V38-F24W
V5N0001	W1N0503	W7N0003
V2N0001	W3N0014	ZQMSHE1-N0|GO-V18-F24W
V1N0001	W3N0015	W4N0014
V1N0002	W3N0001	ZQMKOS1-N29|GO-V38-F24W
V6N0003	W1N0500	W7N0004
V3N0072	ZQMNGM1-N26|GO-V38-F24W	
V3N0068	W2N0002	
V3N0035	W3N0007	
V3N0042	W3N0010	
V6N0006	ZQMMNG1-N27|GO-V38-F24W	
V3N0055	W3N0012	
V3N0045	W3N0006	
V3N0026	W3N0010	
V3N0065	W3N0011	
ZQMBRK1-N30|GO-V38-F24W	W7N0008	

APPENDIX A.4

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 4: PONGOLA-UMZIMKULU

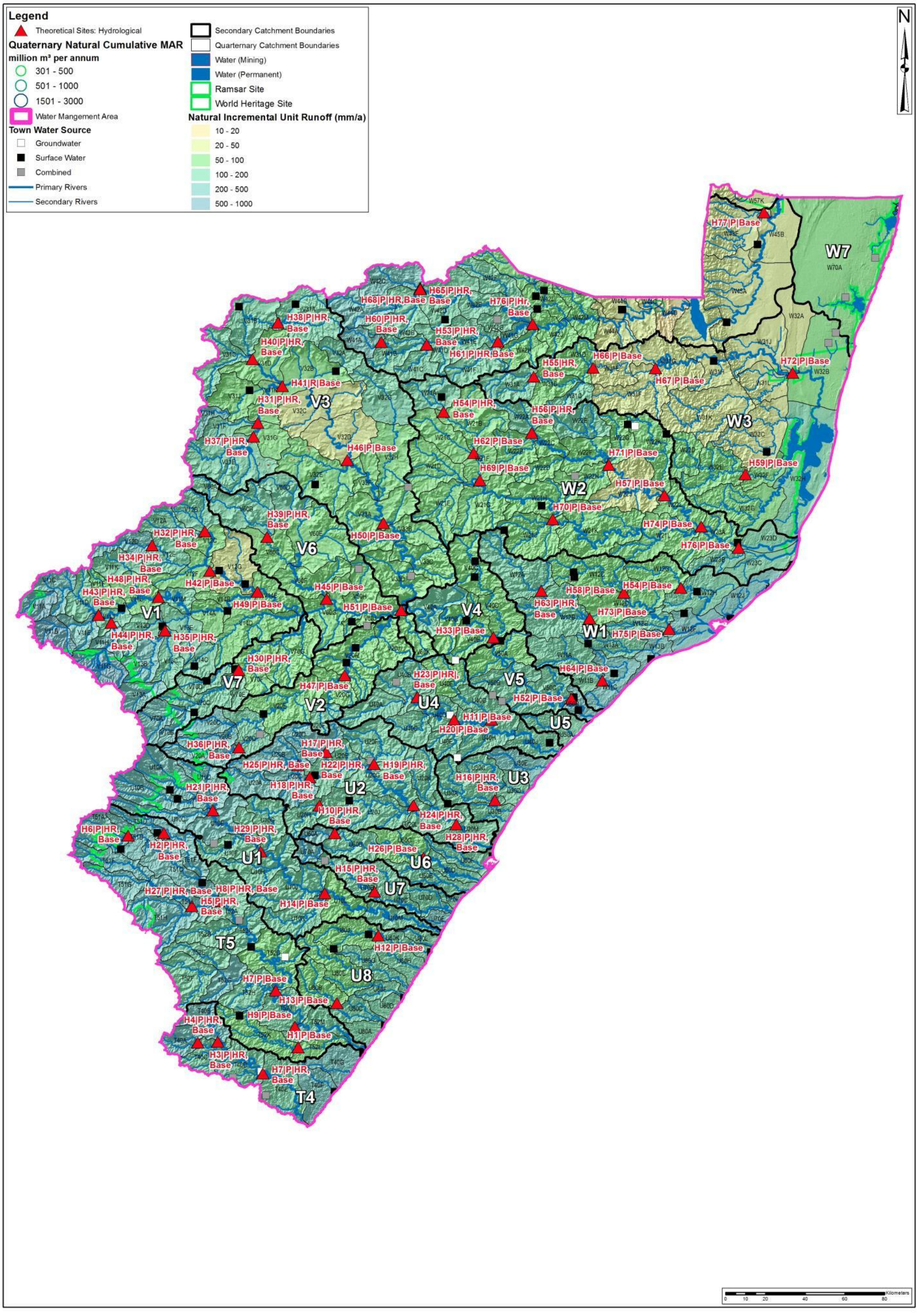


Figure A.4.13 Theoretical surface water sites based on hydrological (runoff) considerations

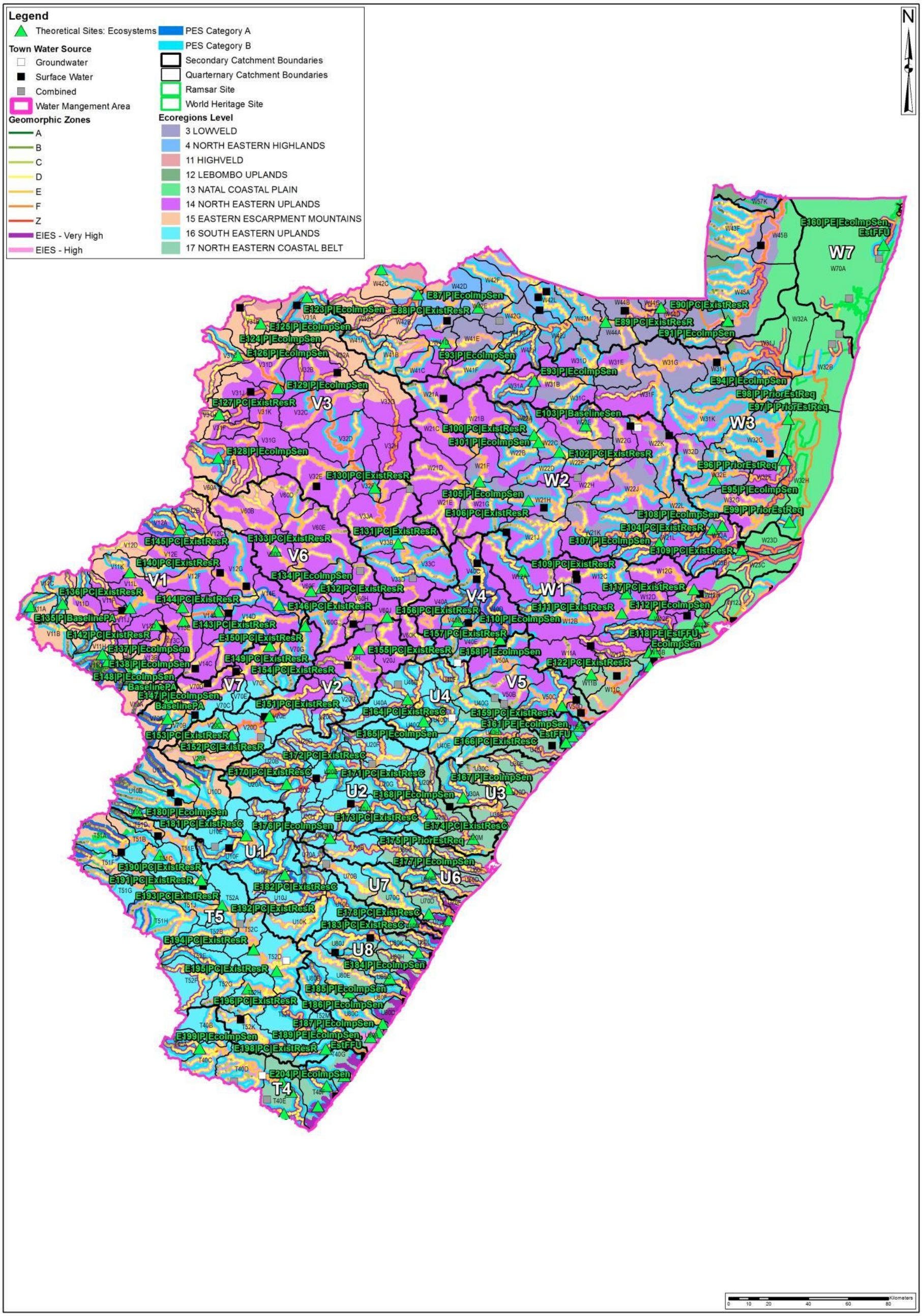


Figure A.4.14 Theoretical surface water sites based on ecosystem considerations

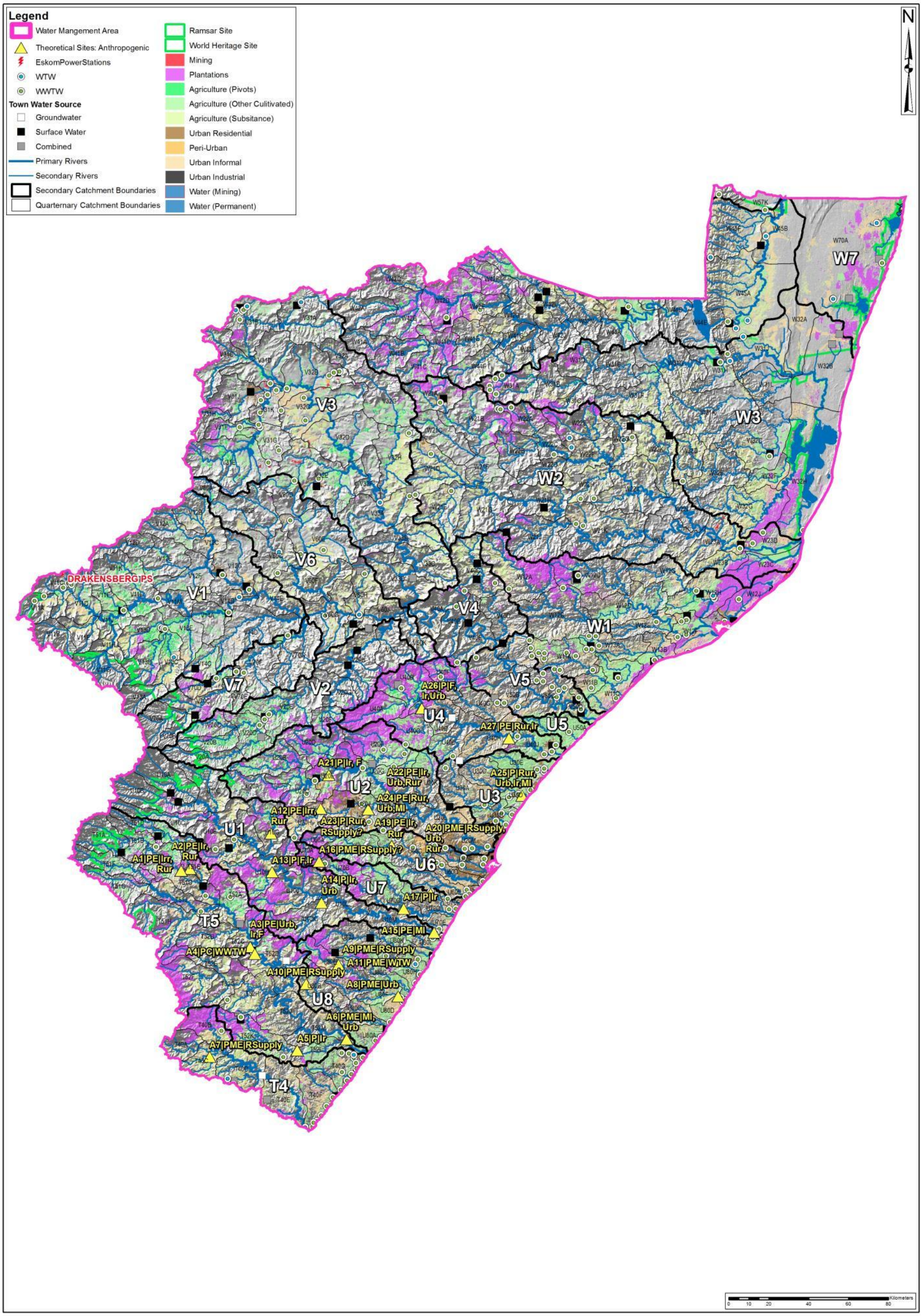


Figure A.4.15 Theoretical surface water sites based on anthropogenic considerations

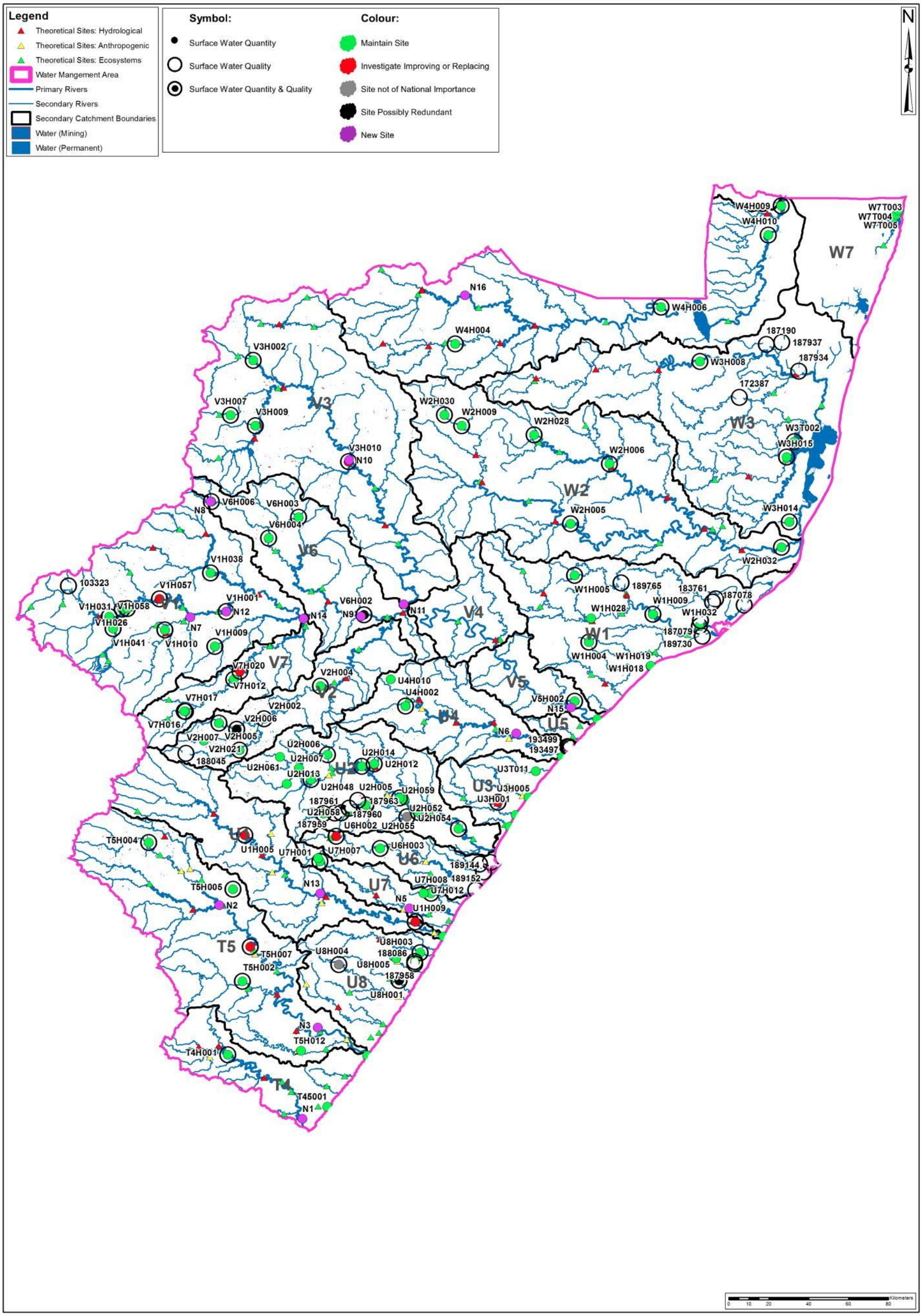


Figure A.4.16 All theoretical and actual surface water monitoring sites with recommended actions

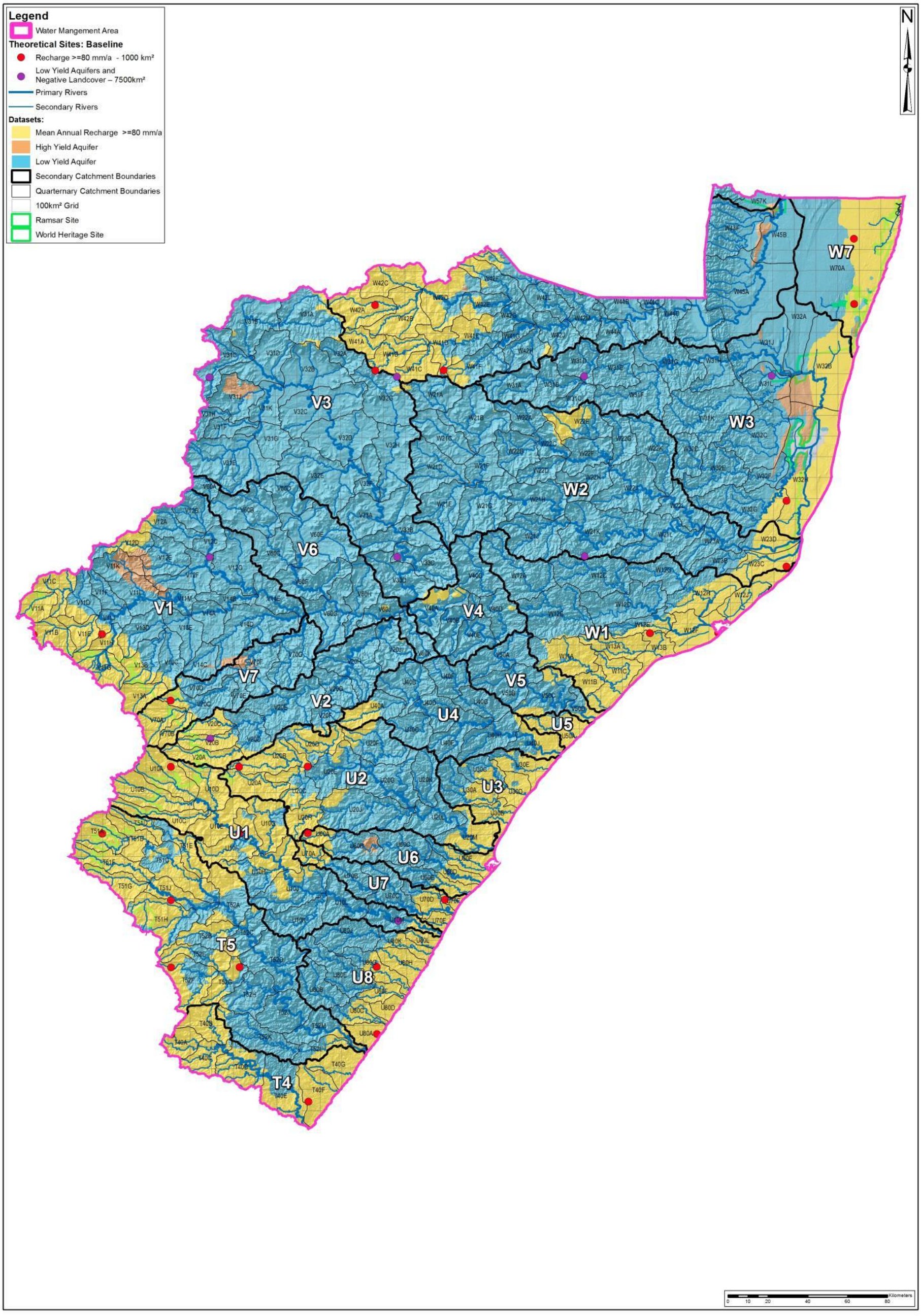


Figure A.4.5 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

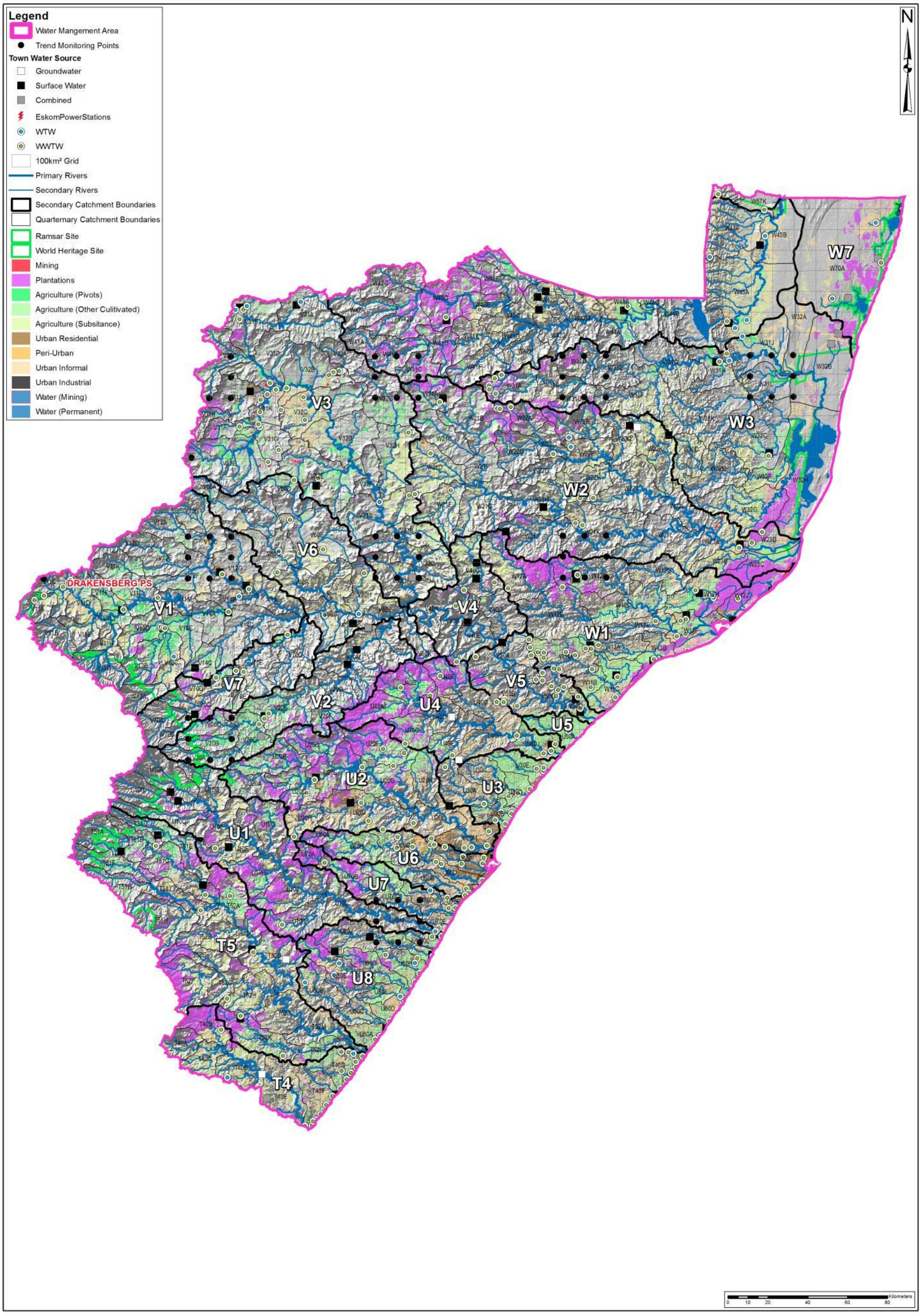


Figure A.4.6 Theoretical groundwater sites based on anthropogenic considerations (Trend)

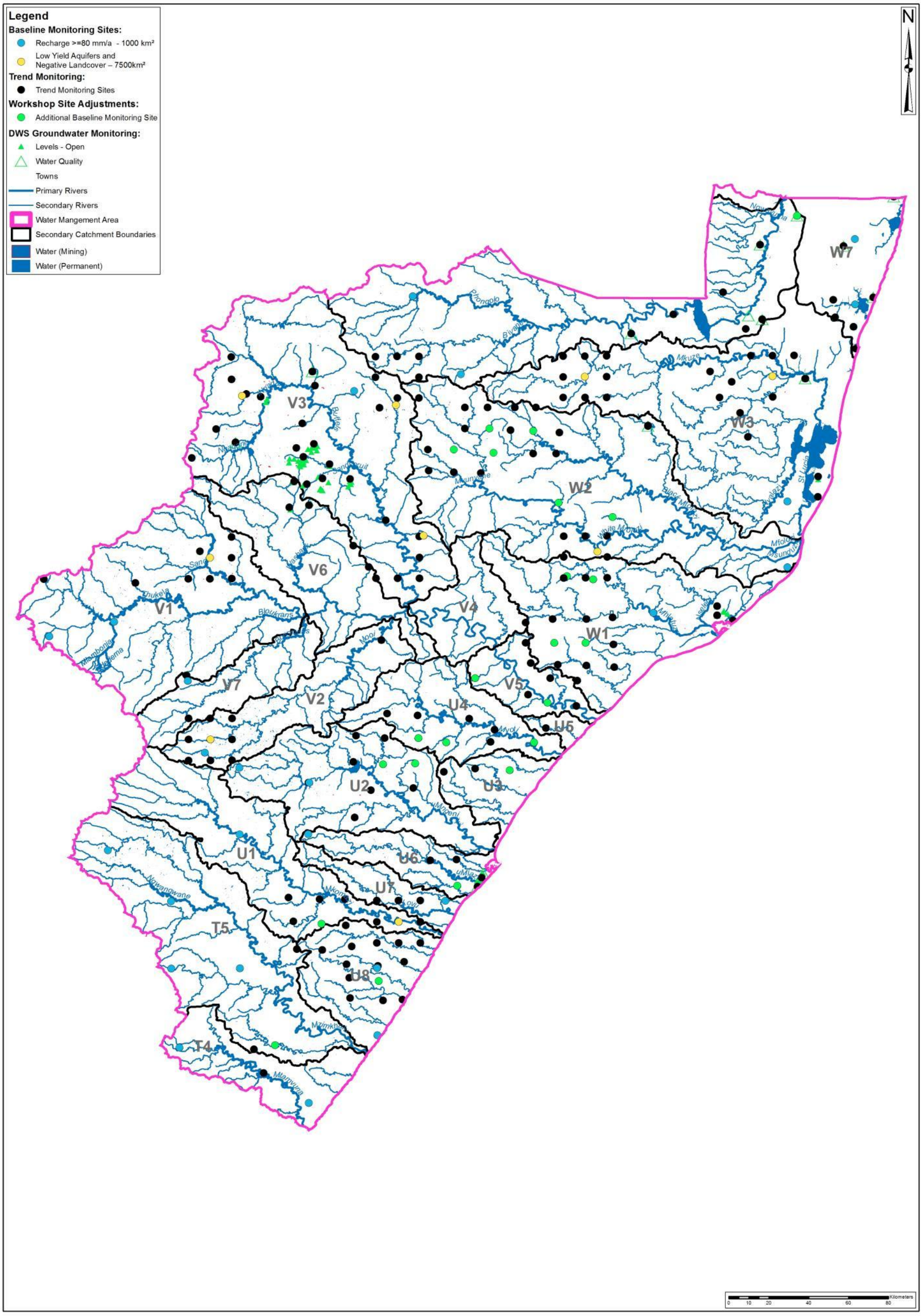


Figure A.4.7 Theoretical and exiting groundwater monitoring sites including additional recommended sites

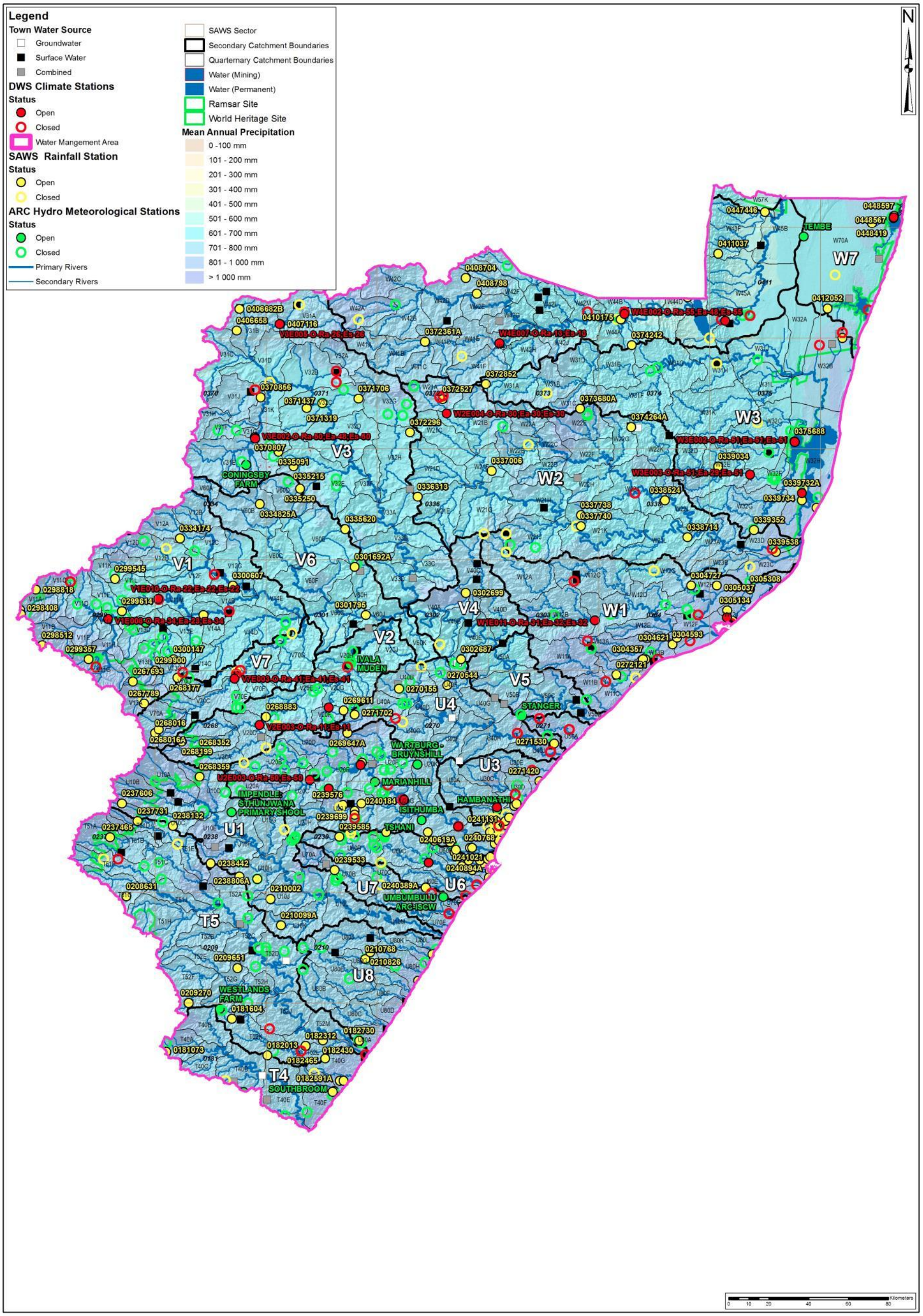


Figure A.4.8 Climatic information for the WMA

ANNEXURE 5

WMA 5: VAAL

5. WMA 5: VAAL

The Vaal Water Management Area (WMA) occupies the central north-east area of South Africa. It extends from Ermelo in KwaZulu-Natal, just west of Swaziland in the east, across to Kuruman in the Northern Cape to the west. To the Northwest, the WMA borders Botswana and the Limpopo and Olifants WMAs. To the south east it is bounded by Lesotho and to the south west by the Orange WMA (DWS, 2013d).

The Vaal WMA is split into three sub-catchments, namely the Upper, Middle and Lower Vaal. The Upper Vaal catchment has an area of 55 565 km^2. It is located towards the centre of the country extending over the Free State to the confluence of the Mooi and Vaal Rivers, the south east of Mpumalanga and the south west of Gauteng and its southern limit adjoins Lesotho. It consists of the Vaal, Klip, Wilge, Liebenbergsvlei and Mooi rivers and includes the Vaal, Grootdraai and Sterkfontein dams.

The Middle Vaal catchment has an area of 52 563 km^2. The area extends between the confluence of the Vaal and Rietspruit rivers down to the Bloemhof Dam and from Schoonspruit River in the north to the Vet River in the south including parts of the Free State and North West province. It consists of the Schoonspruit, Rhenoster, Vals and Vaal rivers and includes the Bloemhof Dam (DWS, 2013d).

The Lower Vaal catchments has an area of 132 000 km^2. It extends between the Bloemhof Dam and the confluence of the Vaal and Douglas rivers, the North West, Northern Cape and the south west of the Free State provinces, while its northern border adjoins with Botswana. It consists of the Harts River, which is the only significant tributary to the Vaal River (DWS, 2013d).

The Vaal River slopes gently from about 1800 m in the east at its origin to 1 450 m in the vicinity of the Vaal Barrage at Vereeniging. The area between the confluence of the Vaal and the Rietspruit rivers and the Bloemhof Dam is relatively flat with a maximum elevation of 2 200 m in the hilly upper reaches of the Vals River and a minimum elevation of about 1 250 m in vicinity of Bloemhof Dam. Pans and other enclosed drainage basins are features of the western parts. The area between Bloemhof Dam and the confluence of the Vaal and Orange rivers has no distinct topographic features with most of the terrain being relatively flat (DWS, 2013d).

The mean annual temperature ranges between 16°C in the west to 12°C in the east, with an average of about 15°C for the WMA as a whole. Maximum temperatures are experienced in January with minimum temperatures occurring in July. Seasonal rainfall is experienced in this WMA with high rainfall occurring between October and April. Peak rainfall occurs in the months of December and January. Rainfall within the WMA generally occurs as convective thunderstorms often accompanied by hail.

The mean annual precipitation (MAP) in the WMA deceases fairly uniformly in a westwards direction from the eastern escarpment regions across the central plateau area. The MAP decreases from about 800 mm in the Upper Vaal to 500 mm in the Middle Vaal and 100 mm in the Lower Vaal sub-catchments. This trend is, however, inversed when considering the potential annual evapotranspiration which increases in westward direction from 1 300 mm in the Upper Vaal to 2 800 mm in the Lower Vaal (DWS, 2013d).

The monitoring and control of the state of water quality is a key component of water resource management for this WMA. In order to ensure that the water quality is kept at an acceptable level, an integrated Water Quality Plan has been developed for the Vaal WMA, but is yet to be implemented. The likeliest cause of water quality problems in this region is the large industrial and urban developments that are located within the WMA. These, amongst other economic activities, must be taken into consideration in the development of a water quality and water resources monitoring plan (DWS, 2013d).

5.1 SITE REVIEWS

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

5.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Vaal WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. Error! Reference source not found. provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

According to Error! Reference source not found., there are 56 active river flow, 10 eye monitoring and 28 reservoir monitoring sites in the Vaal WMA that was evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

Table 5.1 Number of surface water quantity monitoring sites per secondary catchment

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
C1	**6**	1	2	4	12	3	0	**22**
C2	**86**	17	4	3	20	7	0	**51**
C3	**10**	0	0	1	4	4	0	**9**
C4	**6**	3	0	0	6	2	0	**11**
C6	**3**	0	0	0	5	0	0	**5**
C7	**12**	2	0	0	5	1	0	**8**
C8	**22**	0	0	0	16	6	0	**22**
C9	**9**	4	0	0	7	3	0	**14**
D41	**20**	0	4	1	2	2	0	**9**
D73A	**0**	0	0	0	0	0	0	**0**
Total	**174**	**27**	**10**	**9**	**77**	**28**	**0**	**151**

The number of sites with water quality constituents being monitored in the Vaal WMA is provided in **Table** 1.3**5.2**.

As can be seen from **Table** 1.3**5.2** the main water quality programmes in the WMA include chemical, wetland, eutrophication microbial and estuarine monitoring. As stated earlier, the water parameters and frequencies will be reviewed during the strategy development quality and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

Table 5.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
C1	**1**	5	12	1	0	9	1	1	0	**19**
C2	**7**	23	27	14	0	11	3	12	0	**71**
C3	**0**	5	3	0	0	3	0	1	0	**9**
C4	**0**	6	8	1	0	2	0	1	0	**15**
C6	**2**	4	3	0	0	0	0	0	0	**7**
C7	**0**	3	2	0	0	0	0	0	0	**5**
C8	**2**	18	7	0	0	5	0	1	0	**26**
C9	**0**	8	4	0	0	4	0	3	0	**15**
D41	**0**	8	2	0	0	0	0	2	0	**12**
D73A	**0**	0	0	0	0	0	0	0	0	**0**
Total	**12**	**80**	**68**	**16**	**0**	**34**	**4**	**21**	**0**	**179**

Notes:

(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

5.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 5.4**.

5.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or needing to be upgraded. Reported in **Table 1.3** are the theoretical objectives that have been assigned to these existing river sites.

Table 5.3 Objectives and relative priorities assigned to existing river monitoring stations with no recommended actions

Site number	Description	Theoretical objective	Relative priority[#]
D4H014	Molopo-Eye @ Mallepoos-Eye	PMEC|Base,HR,ExistResR,Rur	12.0
D4H030	Compensation Water From Pipeline @ Mallepoos-Eye	PMEC|Base,HR,ExistResR,Rur	12.0
C2H140	Vaal River @ Woodlands	PME|Base,Rur,MI,Ir	11.0
C2H061	Vaal River @ Klipplaatdrift	PME|Base,IR,WTW	10.5
C8H003	Cornelis River @ Warden	PEC|Base,Urb,WTW,Rur,Ir,WWTW,ExistResC	10.5
D4H007	Manyeding-Eye @ Manyeding Loc.	PME|Base,HR,Rur	10.5
C2H011	Gerhardminnebron-Eye @ Gerhardminnebron	PME|Base,GW	10.0
C2H064	Skoon Spruit @ Eye Of Schoonspruit	PME|Base,GW	10.0
C2H094	Turffontein-Eye-@Under @ Turffontein	PME|Base,GW	10.0
C2H279	GerhardMinnebron - Eye (Pool)	PME|Base,GW	10.0
C1H044	Leeu Spruit at Welbedacht	PMC|WWTW,Rur,Esk,EcoImpSen	9.5
C4H004	Vet River @ Fizantkraal	PEC|ExistResC,Base,MI,Ir,WTW	9.5
C6H009	Vals River @ Lindley	PEC|Base,IR,Urb,Rur,WTW	9.5
C8H001	Wilge River @ Frankfort	PEC|Base,Urb,Ir,Rur,WWTW	9.5
C9H010	Vaal River @ Gamagara	PM|WTW,UR,Rur,Ir,Base	9.5
C8H026	Liebenbergsvlei@River @ Frederiksdal	PM|Base,Ir,Urb,Rur	9.0
C8H030	Wilge River @ Slabberts	PM|Base,Ir,Urb	8.5
C8H005	Elands River @ Elands River Drift	PC|HR,Base,IR,WWTW,Rur,Urb	8.0
C8H037	Liebenbergsvlei @ Reward	PM|Base,Ir	8.0
C2H137	Klip River @ Zwartkopjes	PC|WWTW,Urb,Rur,MI,Ir	7.5
C1H015	Klip River@At Steel Bridge @ Sterkfontein	PC|HR,Base,ExistingResC,Ir	7.0
C1H027	Tweefontein Spruit @ Tweefontein	PC|HR,Base,ExistingResC,Ir	7.0
C3H016	Harts River @ Lloyds	PC|ExistResC,Base,Ir	6.5
D4H013	Molopo River @ Rietvallei	PC|Base,ExistResR,MI	6.5
C8H027	Wilge River @ Ballingtomp	P|Base,Ir,EcoImpSen	5.5
D4H037	Molopo River@Lotlamoreng Dam @ Mmabatho	P|Base,Urb,Rur	5.5
C7H019	Renoster River at Verheugd	P|Base,IR,EcoImpSen	5.0

[#] *Sites are listed in descending order based on relative priority*

5.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in

New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 1.4** are all the proposed monitoring sites for the Limpopo WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

5.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, site descriptions, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 1.4 are all the proposed monitoring sites for the Vaal WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

Table 5.4 Proposed new river monitoring sites

Site number	Lat	Long	Theoretical objective	Comment	Relative priority#
N5	.26.37	27.74	PME|Base,MI,Ir,Urb	Minewater decanting. Urgent monitoring required.	11.0
N4	.26.44	28.45	PEC|Base,ExistResC,Urb,Rur,Ir,MI,WWTW	New stations required urgently between Heidelberg and Nigel.	10.5
N22	.28.31	29.13	PMC|HR,Base, WTW,ExistResC	Investigate measurement of all component or replacement of site more upstream.	10.0
N8	-26.68	26.58	PEC|Base,Ir, ExistResR,Urb	New monitoring site is required on the Schoonspruit River.	9.0
N12	-28.71	26.96	PM|Base,WTW,Urb,Rur	Measurement upstream from Erfnis Dam is required for low-flow estimates.	9.0
N24	-27.85	25.92	PC|Base,Urb,Rur,Ir,WWTW,WTW,ExistResR,MI	Investigate a new site for possible replacement of C4H004.	9.0
N16	-27.78	27.58	PE|Base,Ir,Urb,Rur,WTW	Require new station before Kroonstad for hydrological considerations. Will replace measurement at Kroonstad C6H007.	8.5
N15	-28.31	27.58	PC|Base,Ur,Rur,WTW, WWTW	Investigate a new site in the area.	7.5
N1	-27.55	29.59	P|Base,HR,EcoImpSen, Ir,Urb,Rur	New gauge required on the Klip River near Memel.	7.0
N3	-26.91	29.87	P|Base,HR,Urb,Rur,Ir,WTW	New gauge required on the Rietspruit River.	7.0
N13	-28.57	27.09	PC|Base, ExistResR,Urb,Rur	Investigate new site.	7.0
N19	-28.13	28.29	P|Base,Ir,Urb,Rur,WWTW	Investigate new site to get natural contribution from uppper catchments.	6.5
N14	-28.15	27.83	P|Base,WTW,Urb,Rur	Investigate new site.	6.0
N2	-27.21	29.44	P|Base,HR,Ir	New gauge required on the Sandspruit River near Memel. High runoff area and hydrologically important.	5.5
N10	-27.16	24.75	P|Base,Urb,Rur	Investigate at this site or more upstream to meassure Dry Harts River.	5.5
N18	-27.05	27.00	P|Base,Ir,WTW	Possible replacement site for C7H006.	5.5
N20	-27.96	28.39	P|Base, Ir	Should invetigate site for upper reaches of Liebenbergsvlei runoff. C8H037 could also be upgraded.	5.0

[#] *Sites are listed in descending order based on relative priority*

5.3.4 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, coordinates, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 5.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Relative priority
C8H028	Wilge River @ Bavaria	PMEC|ExistResC,Base,Ir,HR	Station being improved. Very Important for flood management at Vaal Dam.	12.0
C9H008	Vaal River @ Schoolplaats	PME|Base,Wcomp,Ir,Urb,Rur	Need one good station that would superceed C9H008, C9H003, C9H009, C9H026, C9H024. Somewhere between Vaalharts abst and Harts rivers confluence.	11.5
C1H004	Waterval River @ Branddrift	PEC|WWTW,MI,Ur,Rur,Ir,HR,Base,EcoImpSen	Crucial, possible downstream replacement.	11
C9H024	Vaal River @ Schmidtsdrif	PMC|Base,WWTW,Urb,Rur,Ir,ExistResC	Need one good station that would superceed C9H008, C9H003, C9H009, C9H026, C9H024. Somewhere between Vaalharts abst and Harts rivers confluence.	11.0
C2H234	Suikerbosrant River @ Badfontein	PME|Base,ExistResC, Ir	Flood monitoring station, but rating needs to be improved.	10.5
C2R007	Rietspruit @ Klipplaatdrift	PMC|Base, ExistResR,Ir,Urb,Rur	Investigate improvement to monitoring at this site.	10.5
D4H009	Great-Koning-Eye @ Kono Loc.	PME|Base,HR,Rur,Urb.WTW	Municipality abstracts upstream from eyes. Partial has been damaged. Need for reinitiating meassurement is high. Will have to meassure all components and surface component might be costly.	10.5
C2H071	Klip River @ Kookfontein	PEC|WWTW,Urb,Rur,Ir,MI,Base	Investigation improvement of the rating and instrumentation.	10.0
C1H012	Vaal River @ Nooitgedacht	PEC|Base,Ir,Rur,Urb,ExistResC	Crucial, needs additional equiptment.	9.5
C2H007	Vaal River @ Pilgrims Estate	PEC|Base,MI,Urb,Rur,ExistResC	Requires major upgrades.	9.5

Site number	Description	Theoretical objective	Comment	Relative priority
C4H016	Sand River @ Bloudrif	PEC|WWTW,Ur,Rur,Ir,MI	Investigate improvement at this site.	9.5
C9H003	Vaal River @ Riverton	PM|Base,Ir,Rur,Urb,WTW	Need one good station that would superceed C9H008, C9H003, C9H009, C9H026, C9H024. Somewhere between Vaalharts abstraction and Harts River confluence.	9.5
C1H007	Vaal River @ Goedgeluk	PEC|HR,Base,Ir,ExistResR	Rating to be improved. Important for floods.	9.0
C3H017	Harts River @ Tlapeng	PM|Base,Ir,Rur,Urb	Once the W-component at Taung Dam is constructed, this site will become redundant.	9.0
C3H007	Harts River @ Espagsdrif	PMC|Base, Rur	Important from an operational point of view. Once Spitskop Dam is improved this station might become redundant.	9.0
C3H003	Harts River @ Taung	PM|Base,Ir,Rur,Urb	Once the W-component at Taung Dam is constructed, this site will become redundant.	9.0
C1H006	Blesbok Spruit @ Rietvley	P|HR,Base,WTW, WWTW, Urb, Rur,MI	Crucial, need upgrading.	8.5
C8H020	Liebenbergsvlei@River @ Roodekraal	PM|WTW,Ir,Base	This station is influenced by the Lesotho Highlands Transfers. Only accurate for low flows and there is abstraction. Investigate meassuring abstraction.	8.5
C9H026	Vaal River @ Sydney-on-Vaal	PE|WTW,UR,Rur,Ir,Base	Need one good station that would superceed C9H008, C9H003, C9H009, C9H026, C9H024. Somewhere between Vaalharts abstraction and Harts River confluence.	8.5
C2H085	Mooi River @ Hoogekraal	PC|WWTW,Urb,Rur,IR,MI,Base	Needs to be replaced with a gauge that is not sub-merged by the Vaal RIver.	8.0
C9H009	Vaal River @ De Hoop 65	PE|Base,Ir,Urb,Rur	Need one good station that would superceed C9H008, C9H003, C9H009, C9H026, C9H024. Somewhere between Vaalharts abstraction and Harts confluence.	8.0
C1H002	Klip River @ Sterkfontein	PC|HR,Base,ExistingResC,Ir	This site required serious upgrading or replacement.	7
C1H008	Waterval River @ Elandslaagte	P|Base,Ir,MI,Ur,Rur,EcoImpSen	Only for flood warning.Improve and investigate possibility to measure low flows.	7.0
C2H004	Suikerbosrant River @ Uitvlugt	PC|Base,Ir,Urb,ExistResC	Under Rurluence of the Vaal, needs complete replacement with a site more upstream	7.0

Site number	Description	Theoretical objective	Comment	Relative priority
C2H005	Riet Spruit @ Kaalplaats	P|Base,WWTW,Urb,Rur,MI,WTW	Mostly return flows and of an operational importance. Replace station with a station more upstream .	7.0
C6H001	Vals River @ Roodewal	PC|Base,ExistResR,Urb,Rur	Serious upgrade or new structure required in area, between current and Reserve site. Possibly replace with upgrading of C6H006.	7.0
C6H006	Vals River @ Tweefontein	PC|Base,ExistResR,Urb,Rur	Investigate upgrading of site in conjunction with C6H001.	7.0
C8H023	Meul River @ The Willows	P|HR,Base,Ir,EcoImpSen	Replacement of site is required for low flow meassurement.	6.0
C4H017	Doring River @ Mond Van Doorn River	P|Base,Ir,MI	Investigate improvement at this site.	5.5
C7H003	Heuning Spruit @ Dankbaar	P|Base,Ir,EcoImpSen	Requires improvement / replacement.	5.5
C7H006	Renoster River @ Arriesrust	P|Base,Ir,WTW	Need new replacement site (Possibly at N18).	5.5
C4H015	Vet River @ Vaalkoppies	P|IR,Base	Improve this site to measure low-flows.	5.0
C8H012	Vaalbank Spruit @ Voorspoed	P|Base,IR	Investigate improvement to this site. Important for hydrological considerations.	5.0

[#] *Sites are listed in descending order based on relative priority*

5.3.5 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Reported in **Table** 1.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 5.6 Monitoring sites that are not of national importance

Site Number	Description	Comments
C1R003	Willem Brummer dam on a (unnamed) spruit at Spitskop	-
C1R004	Douglas dam on a (unnamed) spruit at Spitskop	-
C2H069	Mooirivierloop @ Blaauwbank	This station is in close vicinity with other stations and is from a

Site Number	Description	Comments
		national water resources perspective, not of national importance.
C2H136	Riet Spruit @ Waterval	Rand Water site, too small and can't be upgraded.
C2H139	Koekemoer Spruit @ Buffelsfontein	This station has a very small upstream catchment and is, from a water resources perspective, not of national importance.
C2H148	Blesbok Spruit @ Nigel	This station has a very small upstream catchment and is, from a water resources perspective, not of national importance.
C2H272	Vaal at Bankfontein (Lethabo)	This station is located downstream of a reservoir monitoring station (C1R001) and is thus from a water resources perspective, not of national importance.
C2H274	Vierfontein Spruit at Groenfontein	This station was constructed as part of a licensing agreement and is thus, from a water resources perspective, not of national importance.
C2R006	Swartleegte River @ Elandskuil	-
C2R011	Nigel Dam	Not of national importants, possibly redundant.
C6H002	Vals River @ Grootdraai	Not of national importantce, but required from a water quality point of view.
C7H001	Renoster River @ Junction	
C7H020	Rhenoster River at Doorndraai	Not of national water resources importance.

5.3.6 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, coordinates and comments that resulted in the site classification.

Table 5.7 Redundant river flow monitoring sites

Site number	Description	Comment
C1H005	Leeu Spruit @ Welbedacht	This station is located upstream of a reservoir monitoring station and is possibly redundant as measurements can be made by station number C1R002.
C1H017	Vaal River @ Villiers	This station is located upstream of a reservoir monitoring station and is possibly redundant as measurements can be made by station number C1R001.
C1H045	Human Spruit (Witbank)	This station was established for use in a water quality project and is from a national water resources perspective, redundant.
C1H046	Human Spruit (Witbank)	This station was established for use in a water quality project and is from a national water resources perspective, redundant.
C2H001	Mooi River @ Witrand	This station is in close vicinity with other stations and is from a national water resources perspective, possibly redundant.
C2H018	Vaal River @ De Vaal	-
C2H177	Blesbok Spruit @ Welgedacht	Closed due to high vandelism.
C6H007	Vals River @ Kroonstad	-
C8H013	Vaalbank Spruit-West @ Vaalbank 327	Closed.

5.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must therefore be monitored efficiently. Listed in **Table 5.8** are all the required W-components as well as changes and potential improvements to existing reservoir monitoring within the WMA.

5.5 ESTUARIES

There are no estuary / tidal stations in this WMA.

5.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.5.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

Table 5.8 New and changes to W-components for dams as well as changes to existing reservoir monitoring

Site number	Lat	Long	Theoretical objective	Comment	Relative priority
C9H021	Vaal River @ Port Arlingto		PMEC|Base,ExistResC,Urb,Rur,Wcomp,WTW	Scheduled for imporvemnts as part of dam rehab. Will required completely new meassurements.	13.0
N17	-27.26	27.67	PME|Base,Ir,Urb,Rur	W-component required for Koppies Dam.	11.0
N21	-28.59	28.94	PME|Base,HR,Urb,Rur	W-component required for Metsi Matso Dam to establish balance.	11.0
N9	-27.53	24.86	PMC|Base,Ir,Urb,Rur, WWTW	Taung Dam being improved. Urgently needs a W-component.	10.5
C8H038	Namahadi River @ Namahadi River@Fi		PME|Base,Urb,Rur	Investigate the improvement or replacement of W-component.	10.5
C8R004	Liebenbergvlei @ Saulspoort		PME|Base,Urb,Rur	Improve measurements at Saulspoort Dam.	10.5
N6	-26.26	27.16	PMC|Base,Ir,ExistResC,Gw	Klerkskraal Dam requires a W-component. Have groundwater upstream and a classification site downstream of the dam.	10.0
C3R001	Harts River @ Rietput (Wentzel Dam)		PMC|Base,Urb,Ir,Rur	Monitoring at this reservoir requires urgent upgrading.	10.0
N23	-27.2	25.3	PMC|Base,Urb,Ir,Rur	W-component is required for Wentzel Dam.	10.0
N11	-28.1	24.5	PMC|Base,Ir,Rur	Spitskop Dam requires a W-component.	9.5
C3R002	Harts River @ Spitskop		PMC|Base,Ir,Rur	Measurement at Spitskop Dam needs to be improved.	9.5

Notes:

(#) Sites are listed in descending order based on relative priority

(*) Proposed coordinates are reported for the new station recommendations only. Station descriptions, as per DWS, database are used for all existing stations

5.7 GROUNDWATER MONITORING

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring station points does not plot on top of mountains.
- Increase spatial density over groundwater control areas to 500 km^2 to set baseline monitoring points. This rule applies to all groundwater control areas throughout the country.
- Set all springs as baseline monitoring points.
- Set the following as additional baseline monitoring stations

C2N1126	D4N2304	ZQMKUR1	D7N0579
C2N1151	D4N2310	D4N1881	-
ZQMDSD2	ZQMMLO2	D4N2382	-
C3N0072	ZQMPNR5	D4N2383	-
C3N0065	D4N2489	D4N2466	-
ZQMBSO1	ZQMGRU2	D4N2463	-
C9N0616	ZQMSTL1	D4N2462	-
C9N0544	D7N0835	ZQMKNR1	-
ZQMDAN1	D7N0536	ZQMKLH5	-
C9N0549	D7N0537	ZQMSEV1	-
D4N1666	D7N0538	D4N2537	-
ZQMMCR2	D7N0533	D4N1878	-
ZQMGYA2	D7N0525	D4N1540	-

- Convert the current monitoring points to trend monitoring station. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring stations that fall within the buffer.

ZQMMGZ1	C2N1179	C2N0252	C2N0308	C2N0788
ZQMSEC1	C2N0320	C2N0283	C2N0362	C2N0885
C2N1021	C2N0023	C2N0322	C2N1097	C2N0813
C2N1020	C2N0347	C2N0365	C2N1098	C2N0814
ZQMBOO2	C2N0022	C2N0327	C2N0509	C2N0788
C2N1037	C2N0301	C2N0610	C2N0625	C2N0866
C2N1129	C2N0243	C2N0534	C2N0370	C2N0865
C2N1024	C2N1002	C2N0615	C2N0747	C2N0790

C2N1130	C2N0228	C2N0606	C2N0850	C2N0867
C2N1026	C2N0226	C2N0604	C2N0370	C2N0868
C2N1025	C2N0180	C2N1018	C2N0836	C2N0812
ZQMBOO1	C2N0082	C2N0662	C2N0833	C2N0864
C2N1036	C2N1027	C2N1019	C2N0822	C2N0791
C2N1023	C2N1028	C2N0596	C2N0821	C2N0868
C2N1131	C2N1033	C2N0332	C2N0820	C2N0869
C2N1132	ZQMVDP3	C2N0596	C2N0778	C2N0864
C2N0890	C2N1030	C2N0597	C2N0780	C2N0862
C2N0893	C2N1032	C2N0685	C2N0775	C2N0860
C2N1191	C2N0190	C2N0998	C2N0769	C2N0897
C2N1192	C2N0017	C2N0331	C2N1176	C2N1004
C2N1177	C2N0594	C2N0371	C2N1175	C2N1005
C2N1178	C2N0001	C2N0619	C2N1174	C2N0900
C2N1184	C2N0198	C2N0622	C2N1173	C2N0899
C2N1188	C2N0204	C2N0621	C2N1172	C2N0120
C2N1181	C2N0012	C2N0004	C2N0781	C2N0915
C2N1181	C2N0011	ZQMZUU1	C2N0782	C2N0917
C2N0903	C2N1140	C2N1156	C3N0021	C3N0075
C2N0923	C2N1141	C2N1170	ZQMLTG2	C3N0082
C2N0003	ZQMVFD3	C2N1165	C3N0651	ZQMVRY2
C2N0104	ZQMVFD2	C2N1158	C3N0649	ZQMVRY3
C2N0002	ZQMVFD1	C2N1161	C3N0509	C3N0078
C2N0878	C2N1133	C2N1169	ZQMSHF1	C3N0063
C2N0879	C2N1124	C2N1168	ZQMSHF2	C3N0663
C2N0880	C2N1124	C2N1164	C3N0107	C3N0633
C2N0877	C2N1110	C2N1167	C3N0650	C3N0064
C2N0881	C2N1134	C3N0549	C3N0662	C3N0073
C2N0882	C2N1137	C3N0550	C3N0661	C3N0060
C2N0873	C2N1135	C3N0552	C3N0559	C3N0061
C2N1150	C2N1134	C3N0038	C3N0560	C3N0062
C2N1119	C2N1136	C3N0036	C3N0623	C3N0079
C2N1146	C2N1115	C3N0544	C3N0624	C3N0067
C2N1147	ZQMPMF2	C3N0553	C3N0655	C3N0070

C2N1149	C2N1193	C3N0036	C3N0656	C3N0069
C2N1148	C2N1194	C3N0038	C3N0664	C3N0511
C2N1146	C2N1171	C3N0652	ZQMDVE1	C3N0081
C2N1120	C2N1159	C3N0563	C3N0657	C3N0512
C2N1121	C2N1160	C3N0653	C3N0500	C3N0058
C2N1145	C2N1195	C3N0028	C3N0508	C3N0054
C2N1144	C2N1155	C3N0030	ZQMLOU1	C3N0055
ZQMEDE3	C2N1166	C3N0004	C3N0099	ZQMKME2
C2N1143	C2N1157	C3N0525	C3N0098	ZQMSRE1
C2N1142	C2N1154	C3N0035	C3N0097	ZQMSZE1
ZQMTAU2	C9N0613	D4N2286	D4N0124	D4N2291
C3N0555	C9N0615	D4N2287	D4N0855	D4N2289
ZQMPRM2	ZQMBHF1	D4N2288	D4N0852	D4N2005
C3N0556	D4N2488	D4N2305	D4N0075	ZQMPLS1
C3N0527	D4N2519	D4N2309	D4N0829	D4N1653
C3N0530	D4N1665	D4N2299	D4N0114	D4N1655
ZQMJKD1	D4N1663	D4N2301	D4N0665	D4N1652
ZQMTAU1	ZQMTSC1	D4N2300	D4N0115	D4N0120
ZQMTAU3	D4N2520	D4N1534	D4N0117	D4N0088
C3N0665	D4N1467	D4N0113	D4N0102	D4N1651
ZQMULC1	D4N1669	D4N0108	D4N0826	D4N1650
ZQMULC2	D4N2505	D4N0039	D4N0823	D4N0839
ZQMBFT1	ZQMPNR3	D4N0688	D4N0824	D4N0840
ZQMMQD3	D4N2296	D4N0140	D4N0825	D4N0838
ZQMMQD2	D4N2344	D4N0145	D4N0694	D4N0095
ZQMAGP3	D4N1703	D4N0687	ZQMMLO1	D4N0092
ZQMEDE2	D4N1702	D4N0148	D4N2302	D4N0094
ZQMBTM1	D4N2491	D4N0147	D4N2325	D4N1667
ZQMWAR1	ZQMVOR1	D4N2496	D4N2326	D4N0095
ZQMAGP2	D4N1705	D4N0141	D4N2322	D4N1664
ZQMAGP1	ZQMPFR1	ZQMLTG1	D4N2317	D4N1890
C5N0622	D4N1701	D4N0139	D4N2317	D4N1889
C9N0571	D4N1699	D4N0017	D4N2295	D4N1654
C9N0559	D4N2312	D4N0833	D4N2327	D4N2499

C9N0558	ZQMTSC2	D4N0128	D4N2316	D4N2506
ZQMBSF1	D4N2315	D4N0834	D4N2290	D4N2498
ZQMPLS2	D4N1874	D4N1539	D4N1568	D7N0692
ZQMKLH1	D4N1872	D4N1550	D4N1560	D7N0697
ZQMMCR1	D4N1873	D4N1549	D4N2467	D7N0689
ZQMKRA1	D4N1875	D4N1555	D4N1863	D7N0567
D4N2199	D4N2378	D4N1556	D4N1544	D7N0570
D4N2557	D4N1876	D4N1862	D4N1545	D7N0614
D4N2540	D4N1792	D4N2384	D4N2470	D7N0578
D4N2539	D4N1877	D4N0543	D4N2469	D7N0602
D4N2186	D4N1865	D4N2386	D4N2548	D7N0588
D4N2187	D4N1866	D4N2385	D4N2377	D7N0562
ZQMGYA3	ZQMKME1	ZQMKLH4	D4N2387	D7N0561
ZQMGYA1	D4N1888	D4N2370	D7N0556	D7N0587
D4N1676	D4N2556	D4N2369	D7N0557	D7N0647
D4N1956	D4N1867	D4N2375	D7N0558	D7N0653
D4N1998	D4N1868	D4N2374	D7N0559	D7N0658
D4N2009	D4N1794	D4N2372	D7N0560	D7N0660
D4N1671	D4N1779	D4N1574	D7N0605	D7N0568
D4N1938	D4N1580	D4N2549	D7N0591	D7N0569
D4N1672	D4N1581	D4N2371	D7N0540	D7N0709
D4N1968	D4N1583	D4N2373	D7N0539	D7N0650
D4N1939	D4N1886	D4N2459	D7N0553	D7N0649
ZQMVZL1	D4N1885	D4N2027	D7N0534	D7N0644
ZQMKMF1	D4N1777	ZQMSIS1	D7N0528	D7N0638
D4N1860	D4N1585	D4N1524	D7N0531	D7N0575
ZQMNTS1	D4N1533	D4N1214	D7N0530	D7N0728
D4N2545	D4N1882	D4N1861	D7N0834	D7N0574
D4N2544	D4N1884	D4N0629	D7N0833	D7N0718
D4N2542	D4N1883	D4N0630	D7N0832	D7N0716
D4N2543	D4N1894	D4N1572	D7N0527	D7N0712
D4N1869	D4N2458	D4N1573	D7N0526	D7N0711
D4N1797	D4N2381	D4N0706	D7N0704	D7N0573
D4N1789	D4N2380	D4N0561	D7N0675	-

ZQMDED1	D4N2457	D4N1567	D7N0671	-
D4N2558	D4N2461	D4N1571	D7N0672	-
D4N1799	D4N2460	D4N1564	D7N0673	-
D4N1791	D4N2464	D4N1616	D7N0667	-
D4N1870	D4N2465	D4N1562	D7N0571	-
D4N1871	D4N1553	D4N1614	D7N0670	-
D4N1793	ZQMKUR2	D4N1566	D7N0572	-

APPENDIX A.5

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 5: VAAL

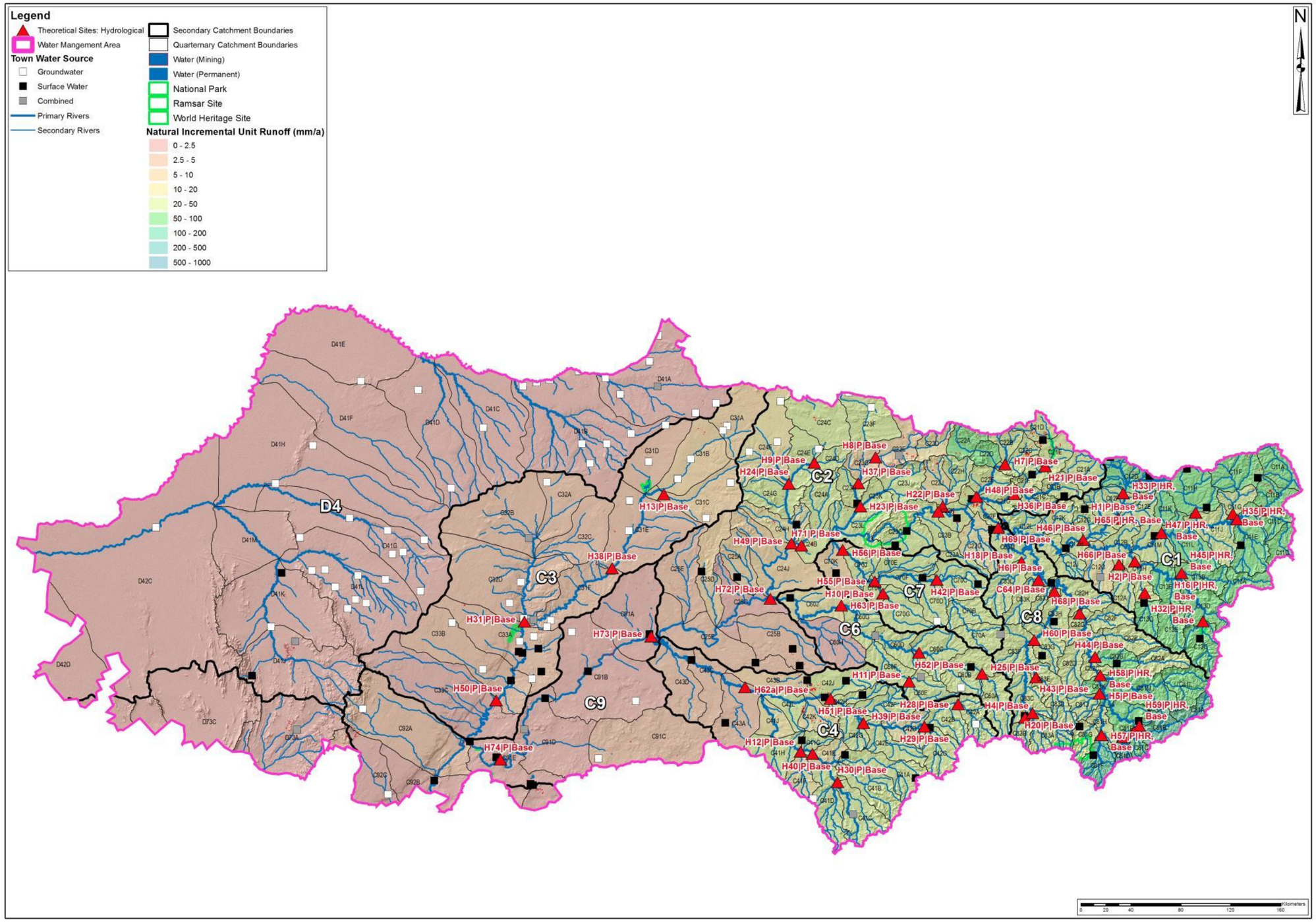


Figure A.5.17 Theoretical surface water sites based on hydrological (runoff) considerations

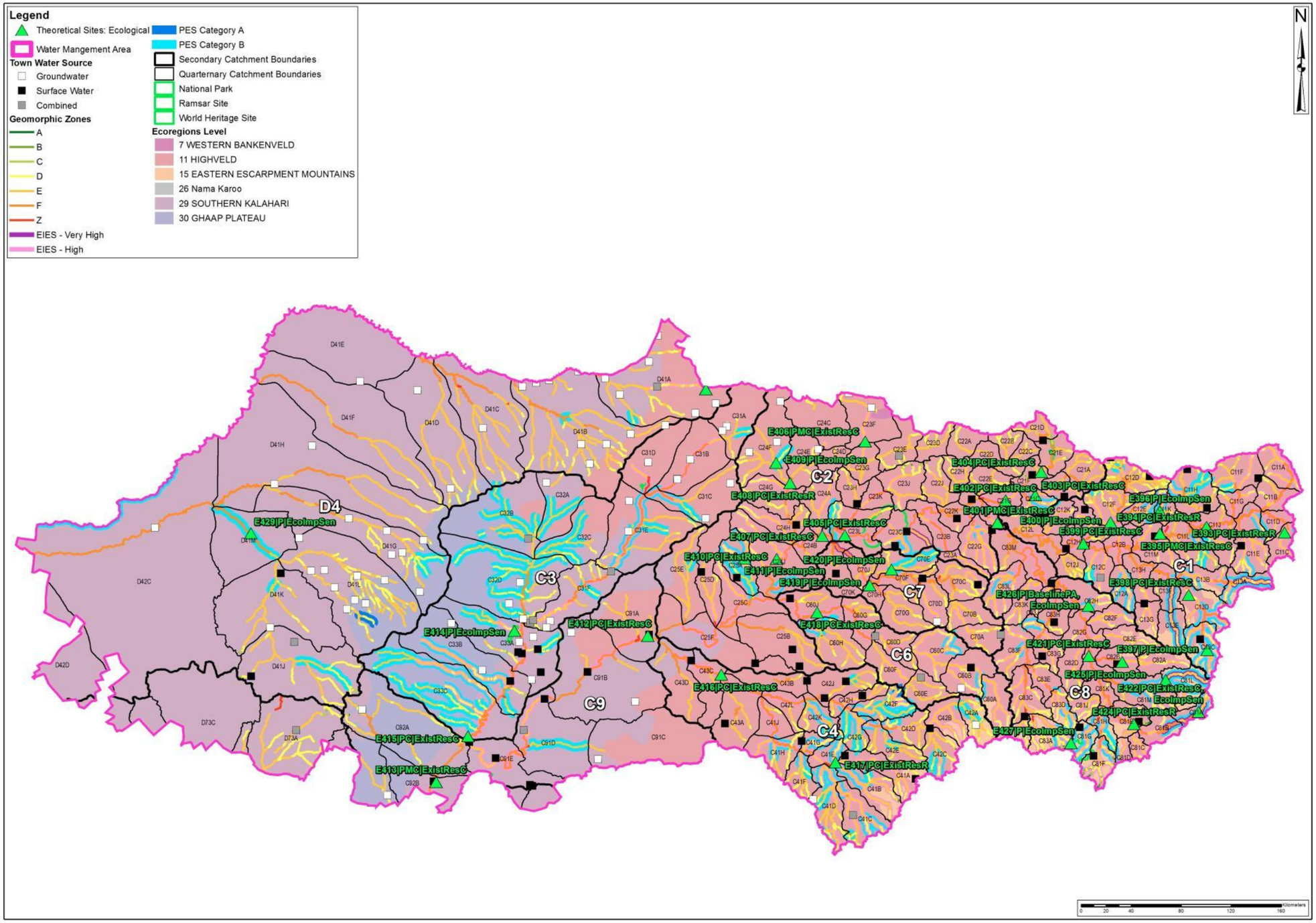


Figure A.5.18 Theoretical surface water sites based on ecosystem considerations

Figure A.5.19 Theoretical surface water sites based on anthropogenic considerations

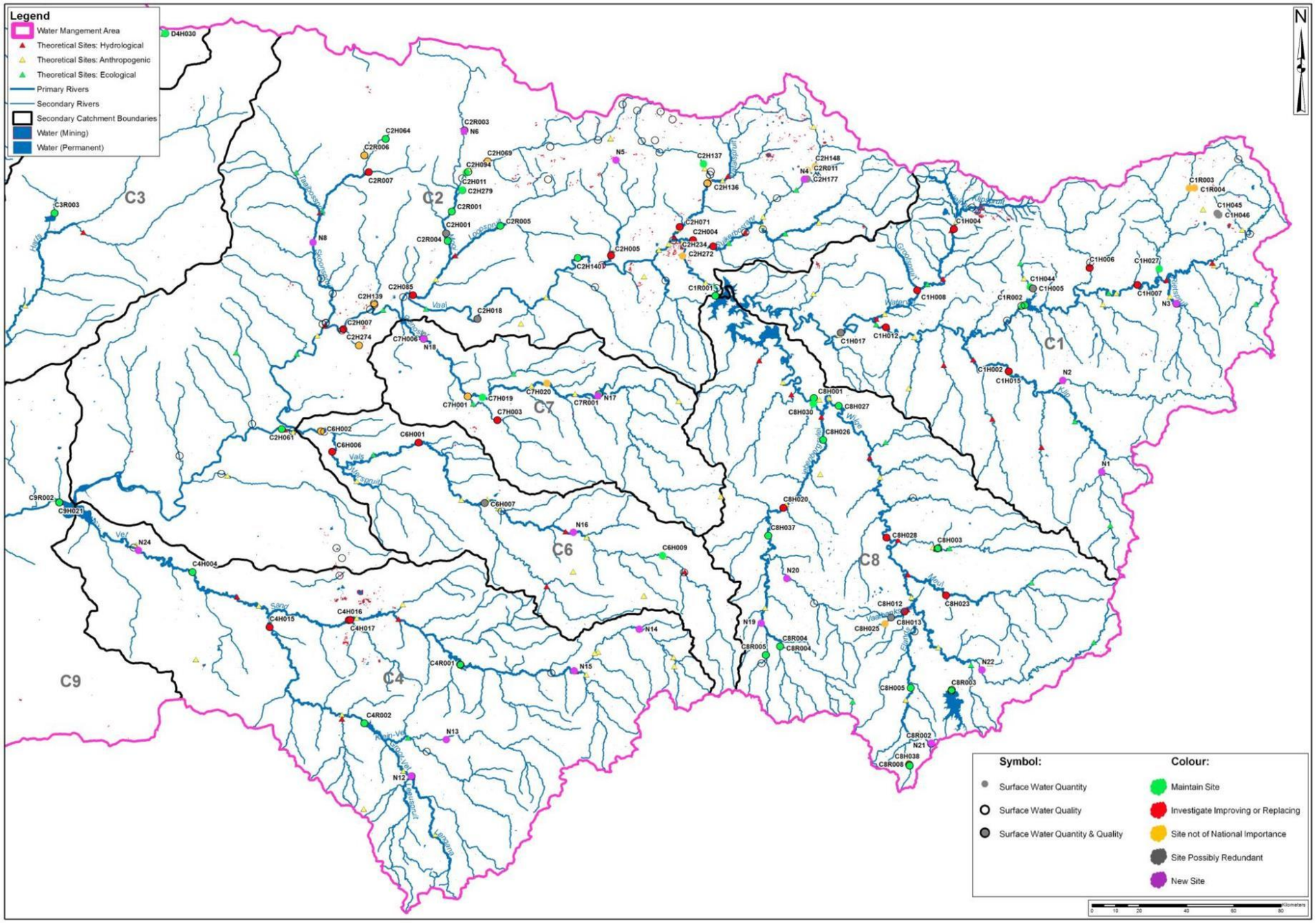


Figure A.5.20 All theoretical and actual surface water monitoring sites with recommended actions – C1, C2, C4, C6, C7 & C8

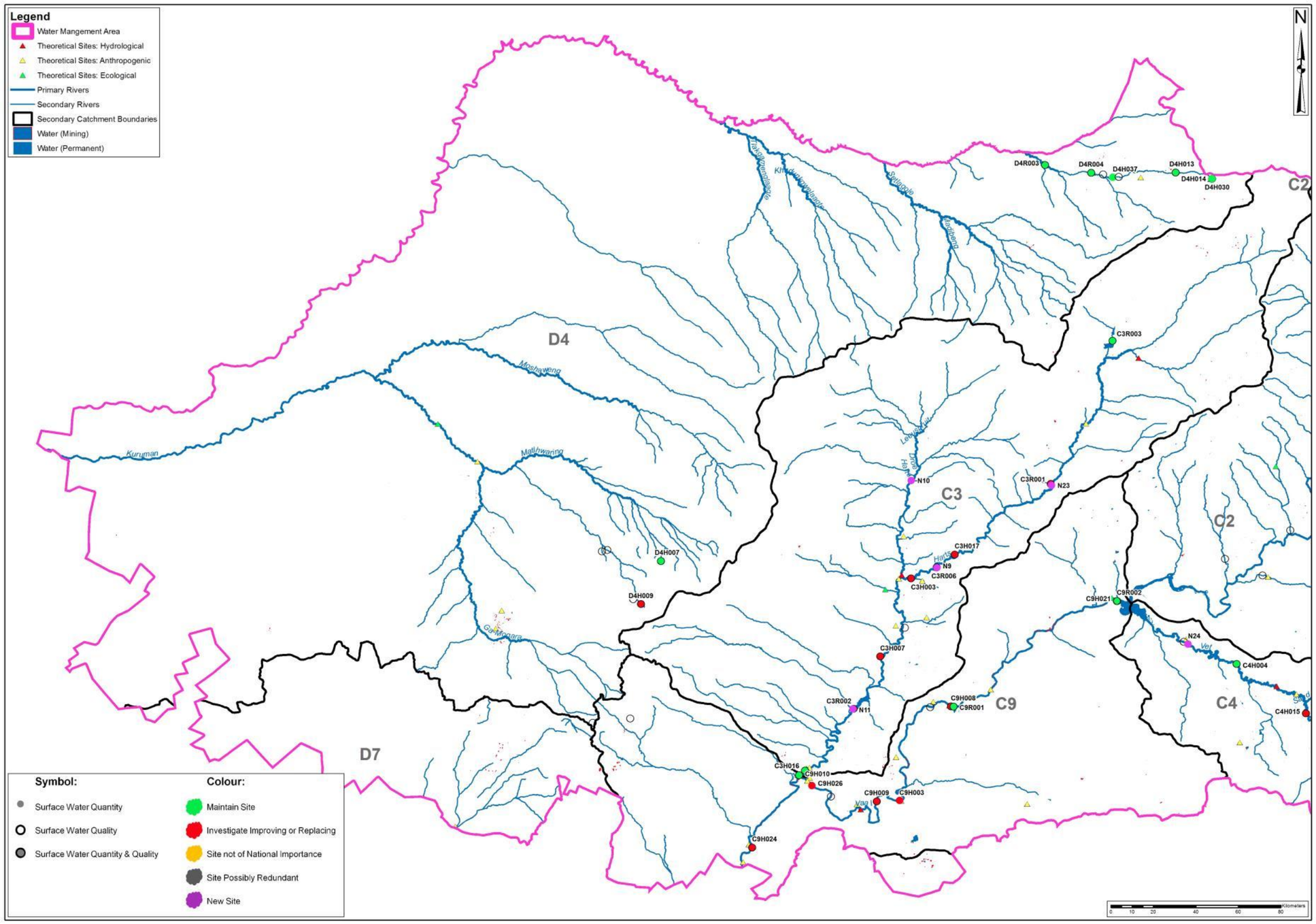


Figure A.5.21 All theoretical and actual surface water monitoring sites with recommended actions – C2, C3, C4, C9, D4, D7

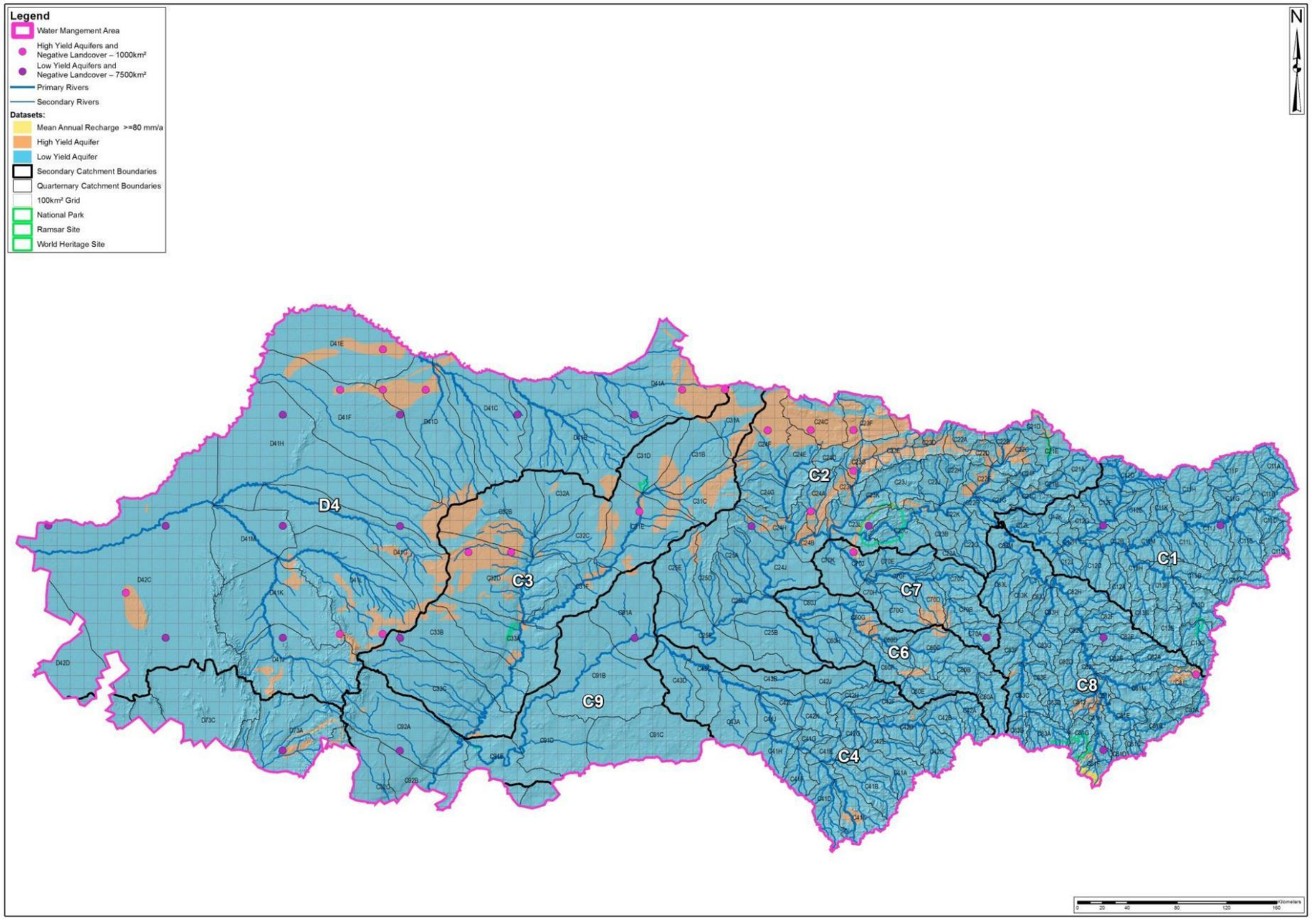


Figure A.5.22 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

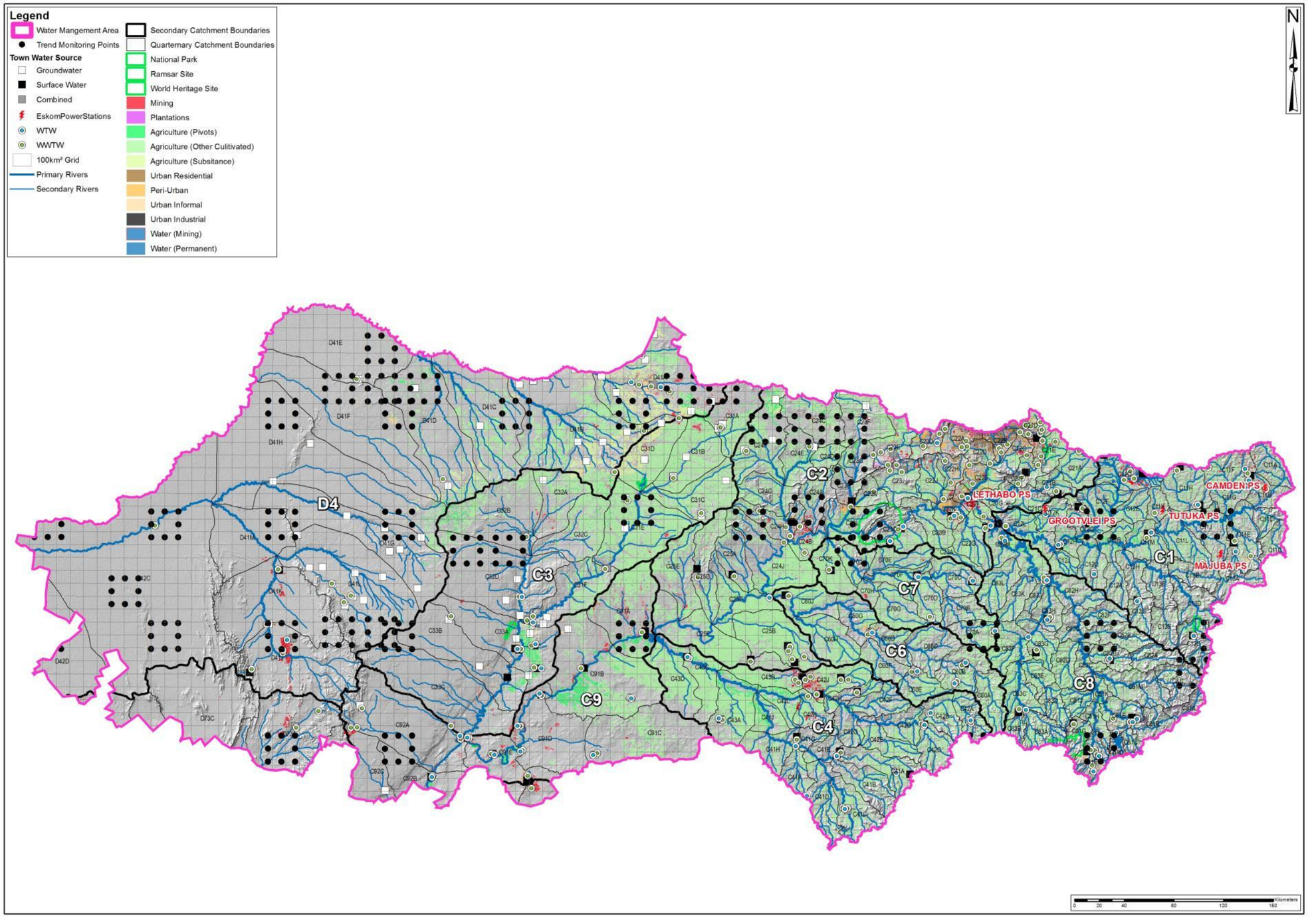


Figure A.5.23 Theoretical groundwater sites based on anthropogenic considerations (Trend)

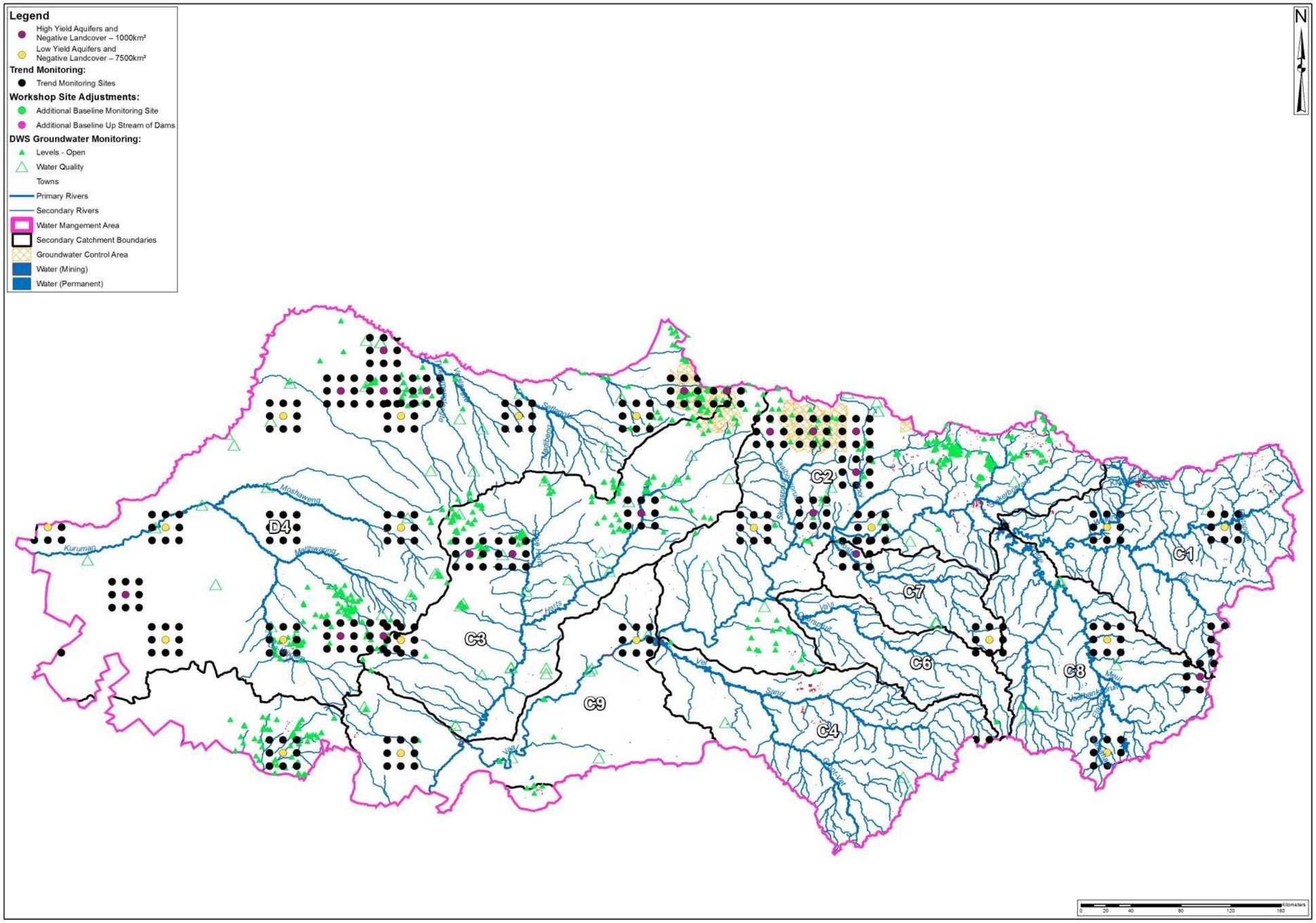


Figure A.5.24 Theoretical and exiting groundwater monitoring sites including additional recommended sites

Figure A.5.25 Climatic information for the WMA

ANNEXURE 6

WMA 6: ORANGE

6. WMA 6: ORANGE

The Orange Water Management Area (WMA) is made up of the Upper and Lower Orange sub-catchments. The Orange River, rising in the Drakensberg Mountains in Lesotho, is the longest river in South Africa and flows in a westward direction into the Atlantic Ocean at Alexander Bay. The Orange River forms the border of several South African provinces as well as the international border between South Africa and Namibia (DWS, 2015b).

The eastern part of the WMA (Upper Orange catchment) is covered, mainly, in savannah grassland with the geology consisting largely of sedimentary rocks of the Karoo Supergroup. Specific characteristics with regards to climate, rainfall and state of water resources are, in this reports, discussed for the Upper and Lower Orange catchments in **Section 1.1.1a)** and **0** respectively.

a) Upper Orange catchment

The Upper Orange catchment is mainly in the Free State Province and spreads over the Eastern Cape and Northern Cape provinces. This WMA borders Lesotho to the east, the Vaal WMA to the north, the Lower Orange catchment to the west and the Mzimvubu-Tsitsikamma WMA to the south.

Included in this WMA is the Lesotho Highlands Water Project (LHWP), which as a results of international co-operation between South Africa and Lesotho, transfers water from the Lesotho Highland region to South Africa for use mainly in the Gauteng Province.

The WMA, located within a cool to moderate and semi-dry to dry region, is subjected to typical plateau weather with summer rains, cold winters and daily sunshine. Temperatures experienced in the eastern Free State Province range from snow covered mountains to peak temperatures in the lower thirty's (°Celsius) in summer. The southern part of the WMA is characterised by semi-desert which experienced hot, dry summer days and long, cold winter nights. The Free State's capital city, Bloemfontein, exhibits average temperatures of 23˚C and 8˚C for summer and winter respectively (DWS, 2015).

Rainfall patterns change drastically from the east to the west of the WMA. The east side of the WMA has experienced rainfall as high as 1 000 mm/a, while the western region only receives rainfall in the order of 200 mm/a. The biggest water contributor to the Upper Orange WMA is Lesotho, which experience rainfall between 600 mm and 1 500 mm/a (DWS, 2015).

b) Lower Orange catchment

The Lower Orange catchment covers the majority of the Northern Cape Province and includes small portions of the Western Cape. The WMA borders on Namibia, Botswana and the Vaal WMA to the north, the Upper Orange sub-catchment to the east, the Mzimvubu-Tsitsikamma, Berg-Olifants and Breede-Gouritz WMAs to the south and the Atlantic Ocean to the west.

This WMA, located within a harsh semi-desert to desert region, experiences minimum and maximum temperatures between 6˚C and 40˚C respectively (DWS, 2015).

Rainfall in the Lower Orange catchment ranges from a high of 400 mm/a on the eastern side to a low of only 20 mm/a on the western side of the WMA. The rainfall characteristics in this WMA exhibit prolonged droughts with the exception of scarce and highly intermittent runoff from local rivers and occasional inflows from the Fish River in Namibia (DWS, 2015).

The availability of water resources within this WMA is completely dependent on the flow from the upstream Upper Orange catchment. Groundwater resources, although limited, are key to the supply of many rural areas.

6.1 SITE REVIEWS

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

6.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Orange WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. Error! Reference source not found. provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

Table 6.1 Number of surface water quantity monitoring sites per secondary catchment

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
C5	**22**	8	0	2	12	5	0	**27**
D1	**14**	0	0	0	10	3	0	**13**
D2	**11**	4	0	1	7	4	0	**16**
D3	**18**	5	0	7	4	2	0	**18**
D42	**3**	0	0	0	0	0	0	**0**
D5	**15**	0	0	0	6	1	0	**7**
D6	**1**	1	0	0	0	2	0	**3**
D7	**7**	3	0	0	5	1	0	**9**
D8	**5**	1	0	0	6	0	0	**7**
F1	**0**	0	0	0	0	0	0	**0**
F2	**0**	0	0	0	0	0	0	**0**
F3	**0**	0	0	0	0	0	0	**0**
F4	**0**	0	0	0	0	0	0	**0**
F5	**0**	0	0	0	1	0	0	**1**
F60A	**0**	0	0	0	0	0	0	**0**
Total	**96**	**22**	**0**	**10**	**51**	**18**	**0**	**101**

According to Error! Reference source not found., there are 56 active river flow sites in the Orange WMA that was evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

The number of sites with water quality constituents being monitored in the Orange WMA is provided in **Table** 1.3**6.2**.

Table 6.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
C5	**0**	16	9	0	0	3	0	7	0	**32**
D1	**0**	1	6	0	0	0	0	0	0	**7**
D2	**0**	6	5	0	0	2	0	1	0	**12**
D3	**0**	4	4	0	0	3	0	0	0	**8**
D42	**0**	0	0	0	0	0	0	0	0	**0**
D5	**0**	3	3	0	6	0	0	0	0	**12**
D6	**0**	2	0	0	0	0	0	0	0	**2**
D7	**0**	3	5	0	0	5	0	7	0	**16**
D8	**0**	1	4	0	0	4	0	0	0	**6**
F1	**0**	0	0	0	0	0	0	0	0	**0**
F2	**0**	0	0	0	0	0	0	0	0	**0**
F3	**0**	0	0	0	0	0	0	0	0	**0**
F4	**0**	0	0	0	0	0	0	0	0	**0**
F5	**0**	0	0	0	0	0	0	0	0	**0**
F60A	**0**	0	0	0	0	0	0	0	0	**0**
Total	**0**	**36**	**36**	**0**	**6**	**17**	**0**	**15**	**0**	**95**

Notes:

(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

As can be seen from **Table** 1.3**6.2** the main water quality programmes in the WMA include chemical, wetland, eutrophication microbial and estuarine monitoring. As stated earlier, the water parameters and frequencies will be reviewed during the strategy development quality and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

6.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 6.4**.

6.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or needing to be upgraded. Reported in **Table 1.3** are the theoretical objectives that have been assigned to these existing river sites.

Table 6.3 Objectives and relative priorities assigned to existing river monitoring stations with no recommended actions

Site number	Description	Theoretical objective	Relative priority[#]
C9R003	Vaal River @ St Claire	PMEC|ExistResR,Base,Urb,Ir,WTW	12.5
D1H009	Orange River @ Oranjedraai	PMEC|HR,Base,IntObl	11.5
D8H014	Orange River @ Blouputs	PMC|Base,IntObl,Ir,ExistResR,UpPA,EcoImpSen	11.0
D2H035	Caledon River @ Ficksburg	PMC|Base,HR,WTW,Urb,Rur	10.5
D1H033	Malibamatso River @ Paray	PMC|Base,HR,IntObl	9.5
D1H041	Senqu @ Polihali	PMC|Base,HR,IntObl	9.5
D1H035	Orange River @ Lesotho - Mantilane	PMC|Base,IntObl	9.0
D8H016	New Station: Sendelingsdrift	PMC|Base,PriorEstReq	9.0
C5H014	Riet River @ Klipdrift	PC|Base,WWTW,WTW,Ir,Rur,ExistResC,UpPA	8.5
C5H035	Modder River @ Tweeriviere	PC|Base,Ir,MI,WTW,WWTW,ExistResC	8.0
D7H012	Orange River @ Irene	PM|Base	7.5
D7H014	Orange River @ Kakamas South Neusberg	PC|Base,WTW,Urb,Rur,Base	7.5
D1H011	Kraai River @ Roodewal	PC|ExistResR,Base,Ir,HR	7.0
C5H003	Modder River @ Likatlong	P|Base,IR,Rur,MI,Urb	6.5
C5H054	Renoster Spruit @ Bishop's Glen	P|Base,Urb,Rur,Ir,MI	6.5
D7H008	Orange River @ Boegoeberg Dam Res.	PC|ExistResR,Ir	6.0
D3H015	Seekoei River @ De Eerstepoort	P|Base,EcoImpSen,Ir	5.5

Site number	Description	Theoretical objective	Relative priority[#]
C5H022	Kgabanyane River @ Bedford	P|Base,Baseline	5.0
C5H048	CONTACT REGION FOR CORRECT DATA: C5H057 influences data	P|Base,Ir	5.0
C5H056	Modder River @ Diepwater	P|Base,IR	5.0
D5H003	Fish River @ Hardeheuwel	P|Base,Ir	5.0
D5H011	Renoster River @ Bonekraal	P|Base,Ir	5.0
D5H016	Sak River @ Hol Pads Leegte	P|Base,Ir	5.0
D5H019	Sak River @ Tabaks Fontein	P|EcoImpSen,Base	5.0
F5H002	Kys River @ Leliefontein	P|Base,Rur	5.0

[#] *Sites are listed in descending order based on relative priority*

6.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in

New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 1.4** are all the proposed monitoring sites for the Limpopo WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

6.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, site descriptions, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 1.4 are all the proposed monitoring sites for the Orange WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

6.3.4 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Table 6-4 Proposed new river monitoring sites

Site number	Latitude	Longitude	Theoretical objective	Comment	Relative priority#
N19	-28.969	27.724	PMC|Base,HR,Ir,IntObl	New site identified. Negotiation for implementation underway. Crucial station.	10.0
N23	-29.531	27.269	PMC|Base,WTW,Ir,IntObl	Need new international station replacement for D2H022.	10.0
N18	-28.549	28.425	PC|HR,Base,ExistResR,BaselinePA,Urb,Rur	Require new gauge to measure transfer to Caledon River from the Ash River. Look for station from this point upstream.	8.0
N20	-29.101	27.572	P|Base,HR,Ir,Rur,Urb,WTW	Require new station, preferably downstream from confluence.	7.0
N22	-29.521	27.136	PC|Base,ExistResR,Rur,Urb	New site required on the Leeuspruit.	7.0
N25	-30.280	26.654	PC|Base,ExistResR,Ir,WTW	Require a new site on the lower Caledon River.	7.0
N5	-29.576	25.711	PC|Base,ExistResR,Ir	This is a replacement site for C5H012.	6.5
N10	-30.853	27.787	P|HR,Base,Rur,Ir,Urb	Require new site for measuring high runoff areas.	6.5
N11	-30.852	27.777	P|HR,Base,Rur,Ir,Urb	Require new site for measuring high runoff areas, possibly upstream from confluence.	6.5
N12	-30.976	27.228	P|HR,Base,Rur,Ir,Urb	Require new site for measuring high runoff areas. Investigate in conjunction with N13.	6.5
N13	-30.951	27.464	P|HR,Base,Rur,Ir,Urb	Require new site for measuring high runoff areas. Investigate in conjunction with N12.	6.5
N14	-30.995	27.057	P|Base,Rur,Ir,Urb	New site required.	6.0
N9	-30.532	27.266	P|HR,Base,Rur	Require new site to meassure high runoff areas.	5.5
N15	-30.649	26.466	P|Base,Rur,Ir	New site required.	5.5
N34	-29.671	17.596	P|Base,Rur,Ir	New station is required on the Buffels River.	5.5
N6	-29.704	25.600	P|Base, Ir	Investigate new site from hydrological considerations.	5.0
N26	-30.247	26.103	P|Base, Ir	Require new site. Anywhere on the Slykspruit (Important for hydrological considerations).	5.0
N30	-31.388	20.955	P|Base,Ir	Replacement site for D5H021.	5.0
N32	-30.606	23.307	P|Base,Ir	Require new site downstream of Smart Syndicate Dam.	5.0
N31	-29.528	21.223	P|Base	Possible replacement site for D5R001.	4.5
N33	-30.170	23.639	P|Base	New station is required in this area.	4.5
N35	-28.933	16.775	P|Base	New station is required on the Holgat River (investigate).	4.5

Site number	Latitude	Longitude	Theoretical objective	Comment	Relative priority#
N36	-30.381	17.506	P|Base	New station is required on the SpoegRiver (investigate).	4.5
N37	-30.093	17.449	P|Base	New station is required on the Swartlintjies River.	4.5
N38	-30.732	17.942	P|Base	New station is required on the Groen River.	4.5

Sites are listed in descending order based on relaitive priority

Reported in **Table 1.5** are the identified site numbers, coordinates, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 6.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Relative priority
D3H012	Orange River @ Dooren Kuilen	PMEC|Base,W-Comp,ExistResR,Esk,Ir,WTW	This river cross section has to be replaced with a W-component for Van Der Kloof Dam.	13.0
D7H002	Orange River @ Prieska	PMC|Base,Ir,Urb,Rur,WTW,MI	Operationally important. Investigate upgrading of the site to include low flows and to assess real losses.	12.0
D1H003	Orange River @ Aliwal-North	PME|HR,Base,Ir,Urb,MI	Required for hydropower planning. Should investigate improvement of low flow.	11.5
D7H005	Orange River @ Upington	PME|Base,Ir,Urb,Rur,MI	Monitoring problems. Access at Upington is a problem. Important for Upington. Important for operational purposes. Need to investigate the stage measuring equipment or relocate where access is not a problem.	11.5
D8H009	Orange Rivier @ Vioolsdrif	PMC|Base,ExistResR,UpPA,EcoImpSen,Ir,IntObl	Diversion for scheme, will be influenced by new dam. Uncertain if there would be a W-component of Vioolsdrifts - could possibly become redundant.	11.0
D3H013	Orange River @ Roodepoort	PME|Base,Ir,WTW	If W-component is constructed for Gariep then this station can become redundent.	10.5
D2H022	Caledon River @ Wilgerdraai	PMC|Base,WTW,Ir,IntObl	Should be replaced with station upstream from Leeuw River @ N23.	10
D2H039	Caledon River @ Caledonspoort	PMC|Base,HR,IntObl,Rur	International station required upstream from D2H039 to replace the site,	10.0
D3H008	Orange River @ Marksdrift	PMC|Base,Ir,ExistResR,MI	Structure needs to be lowered by 2 m.	10.0
D1H032	Senqunyane River @ Marakabei	PMC|HR,Base,IntObl	If W-component is constructed for Mohale Dam then this station can become redundant.	9.5

Site number	Description	Theoretical objective	Comment	Relative priority
D1H001	Wonderboom Spruit @ Diepkloof	PC|Base,Urb,Rur, WTW,WWTW	New design already done, should upgrade.	7.5
D1H006	Kornet Spruit @ Maghaleen	P|HR,Base,Ir,Rur, WTW,IntObl	Investigate replacement site.	7.0
D1H034	Kornet Spruit @ Maghaleen	P|HR,Base,Ir,Rur, WTW,IntObl	Investigate replacement site.	7.0
D2H012	Little Caledon River @ The Poplars	PC|Base,HR,IntObl, Ir	Replaced with station more upstream from current location.	7.0
C5H012	Riet River @ Kromdraai	P|Base,Ir,Urb,Rur	Site needs to be replaced with new site at N5 for ecological purposes.	6.0
D2H034	Meul Spruit @ Mpharane	P|HR,Base,Ir,Rur	Investigate replacement site more upstream, busy closing this station.	6.0
C5H053	Modder River @ Glen	P|Base,Ir,Rur	Department of Agriculture weir. Structurally not correct. Possibility of builing a small low flow gauge downstream. Measure water after offtake from Glen.	5.5
C5H007	Renoster Spruit @ Shannon Valley	P|Base,Rur	Vandilism is a big problem. Investigate point source meassurement and possibly make redundant or not of national importance.	5.0
D5H017	Renoster River @ Leeuwenkuil	P|Base,Ir	Need to be replace with structure higher upstream of this site, before abstraction.	5.0
D5H021	Sak River @ De Kruis	P|Base,Ir	Should be replaced with new site N30.	5.0

[#] *Sites are listed in descending order based on relaitive priority*

6.3.5 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Reported in **Table** 1.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 6.6 Monitoring sites that are not of national importance

Site Number	Description	Comments
D8H004	Orange River @ Onseepkans	
D8H008	Orange River @ Pella Mission	

6.3.6 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, coordinates and comments that resulted in the site classification.

Table 6.7 Redundant river flow monitoring sites

Site number	Description	Comment
D8H007	Orange River @ Korridor	

6.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must there for be monitored efficiently. In this area, however, there is one W-component proposed which is listed in

Table 1.7**8**.

6.5 ESTUARIES

There are no estuary / tidal stations in this WMA.

6.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.6.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

Table 6.8 New W-component for dams

Site number	Lat	Long	Theoretical objective	Comment	Relative priority[#]
N39	-29.5	28.1	PMEC|Base,HR,IntObl,Wcomp	New W-component structure is required. Current structure is too close to the wall.	12.0
N8	-30.6	27.4	PME|Base,HR,Rur,Ir,Wcomp	W-component is required for Jozanahoek Dam (Sterkfontein).	11.5
N27	-30.6	25.5	PME|Base,Esk,Ir,WTW,Urb	W-component required for Armenia Dam.	11.5
D1R002	Malibamatso River @ Katse		PMEC|Base,HR,IntObl	Needs access to the meteorological data at the dam to do a dam balance. Requires a W-component.	11.5
D1R003	Senqunyane River @ Mohale		PMEC|Base,HR,IntObl	Water levels measurements need to be improved at the dam. A joint dam balance for Katse and Mohale dams can be established.	11.5
N2	-29.3	26.6	PME|Base,Rur,Ir,W-Comp	W-component required for Rustfontein Dam.	11.0
N1	-29.5	25.2	PMC|Base,ExistResR,Ir,Wcomp	Possible replacement site for Kalkfontein Dam W-component C5H049. Better option would be to install a dedicated spillway which could be calibrated.	10.0
C5H039	Modder River @ Bultfontein		PMC|Base,ExistResR,Ir,WComp	New W-component is urgently required for Krugersdrift Dam. Current weir is too close to the dam wall.	10.0
C5H049	Riet River @ Philippia		PMC|Base,ExistResR,Ir,WComp	New W-component is required for Kalkfontein Dam. Proposed site at site N1.	10.0
D6R001	Dorp Spruit @ Victoria West		PM|Base,Rur,WTW,EcoImpSen	Measurement improvements should be investigated.	9.0
N21	-29.4	27.1	PM|Base,Ir,Wcomp	W-component required for Armenia Dam.	8.5
D5R001	Hartbees River @ Rooi Berg		PM|Base	Possibly redundant if river site can be located more upstream at N31.	7.5

Notes:

(#) Sites are listed in descending order based on relative priority

(*) Proposed coordinates are reported for the new station recommendations only. Station descriptions, as per DWS, database are used for all existing stations

6.7 GROUNDWATER MONITORING

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring station points does not plot on top of mountains.
- Increase spatial density over groundwater control areas to 500 km^2 to set baseline monitoring points. This rule applies to all groundwater control areas throughout the country.
- Increase spatial density over shale gas and SKA areas to 500 km^2.
- Set all springs as baseline monitoring points.
- Set the following as additional baseline monitoring stations:

ZQMZAS1	ZQMWIL1-	D7N0523-
ZQMALI1	D5N0599	D7N0733
ZQMPLP1	D6N0588	D7N0732
ZQMNSB1	ZQMSDG1	D7N0734
ZQMMTA1	D6N0067	D7N0736
D4N1936	D6N0526	D7N0735
ZQMMER2	D6N0527	D7N0731
D4N2330	D6N0528	D7N0730
D4N2331	D6N0529	D7N0729
ZQMMER1	D6N0531	D7N0555
ZQMWEL1	D6N0532	D7N0547
D4N2332	ZQMRCH1	ZQMNKP1
D4N1460	D6N0587	D7N0549
D4N1462	ZQMWSD1	D8N0012
D4N1935	D7N0742	D8N0011
ZQMWDR1	D7N0740	ZQMKHU1
ZQMRVM1	D7N0741	C9N0600
D4N1937	D7N0743	C9N0599
D5N0540	D7N0725	C9N0601
D5N0539	ZQMWIT4	C5N0624
D5N0586	D7N0524	C5N0628
D5N0603	D7N0739	F2N0001
D5N0607	D7N0524	F3N0507
D5N0600	D7N0739	ZQMBUF1
D5N0602	D7N0738	ZQMKOI1

D5N0601	D7N0737	ZQMKAM1

- Convert the current monitoring points to trend monitoring station. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring stations that fall within the buffer.

ZQMBUP2	D5N0591-	ZQMBUR1-	D6N0539-	D7N0501-
ZQMBUP1	D5N0597	D6N0501	D6N0540	D7N0552
ZQMBYS1	D5N0596	D6N0562	D6N0563	D7N0551
ZQMDDT2	ZQMLOX1	D6N0564	ZQMBUR2	D7N0548
ZQMDDT1	D5N0585	D6N0538	D6N0543	ZQMSWA1
D1N0011	ZQMDPS1	D6N0508	D6N0546	ZQMPOF1
ZQMCPT2	ZQMDPS2	D6N0500	D6N0647	ZQMBFT2
ZQMCCN1	ZQMFSG1	D6N0507	D6N0649	C9N0598
ZQMWEP1	D5N0598	D6N0063	D6N0650	ZQMFBD1
ZQMROW1	ZQMSUT1	D6N0066	ZQMRCH2	ZQMBLM1
ZQMHAN1	D5N0583	D6N0065	ZQMVWT1	ZQMJBL1
D3N0557	D5N0584	D6N0062	D7N0566	ZQMSZS1
ZQMNOU1	D6N0156	D6N0537	D7N0565	ZQMRDG1
ZQMTRN1	D6N0068	D6N0520	D7N0564	C5N0623
ZQMKRN1	D6N0597	D6N0521	D7N0563	C5N0643
ZQMKHT1	ZQMVSG1	ZQMBRI1	D7N0546	C5N0642
D5N0587	D6N0599	D6N0076	D7N0542	C5N0641
ZQMHPR1	D6N0598	D6N0069	D7N0543	C5N0639
ZQMVWV1	D6N0599	D6N0070	D7N0545	C5N0644
D5N0595	D6N0598	D6N0072	D7N0541	C5N0640
D5N0593	ZQMVSG2	D6N0071	ZQMPUT1	C5N0626
ZQMVWV2	D6N0648	D6N0073	D7N0837	C5N0627
D5N0592	D6N0595	D6N0074	D7N0836	C5N0625
D5N0605	D6N0643	D6N0551	D7N0839	ZQMSKF1
ZQMBRN2	D6N0530	D6N0550	D7N0838	ZQMLES1
D5N0590	D6N0061	ZQMDAR1	ZQMMDE1	F3N0509
ZQMKAM3-	ZQMDKN1	F5N0513	ZQMGAR3	-
F4N0004	F4N0005	ZQMGAR2	-	-

APPENDIX A.6

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 6: ORANGE

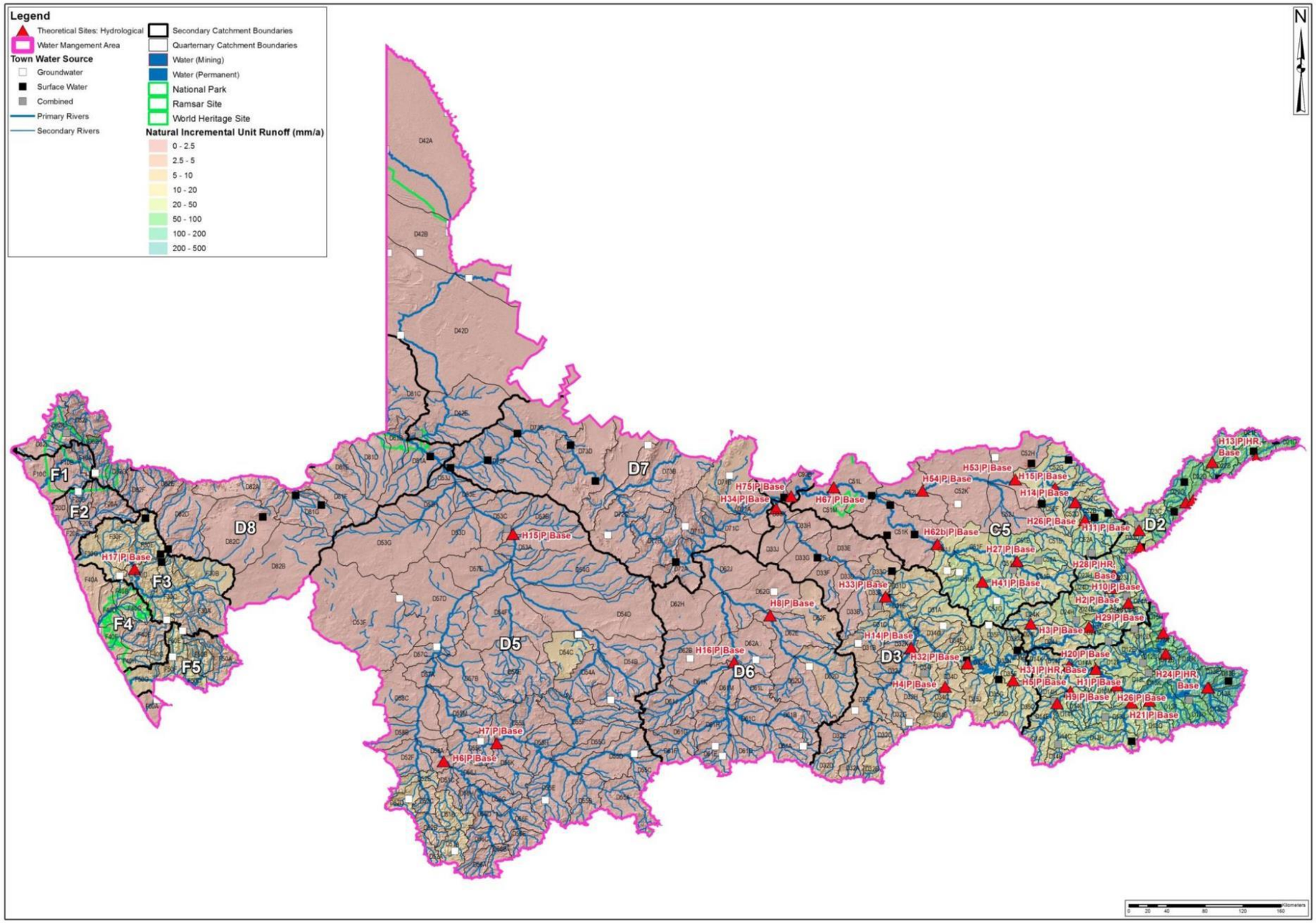


Figure A.6.26 Theoretical surface water sites based on hydrological (runoff) considerations

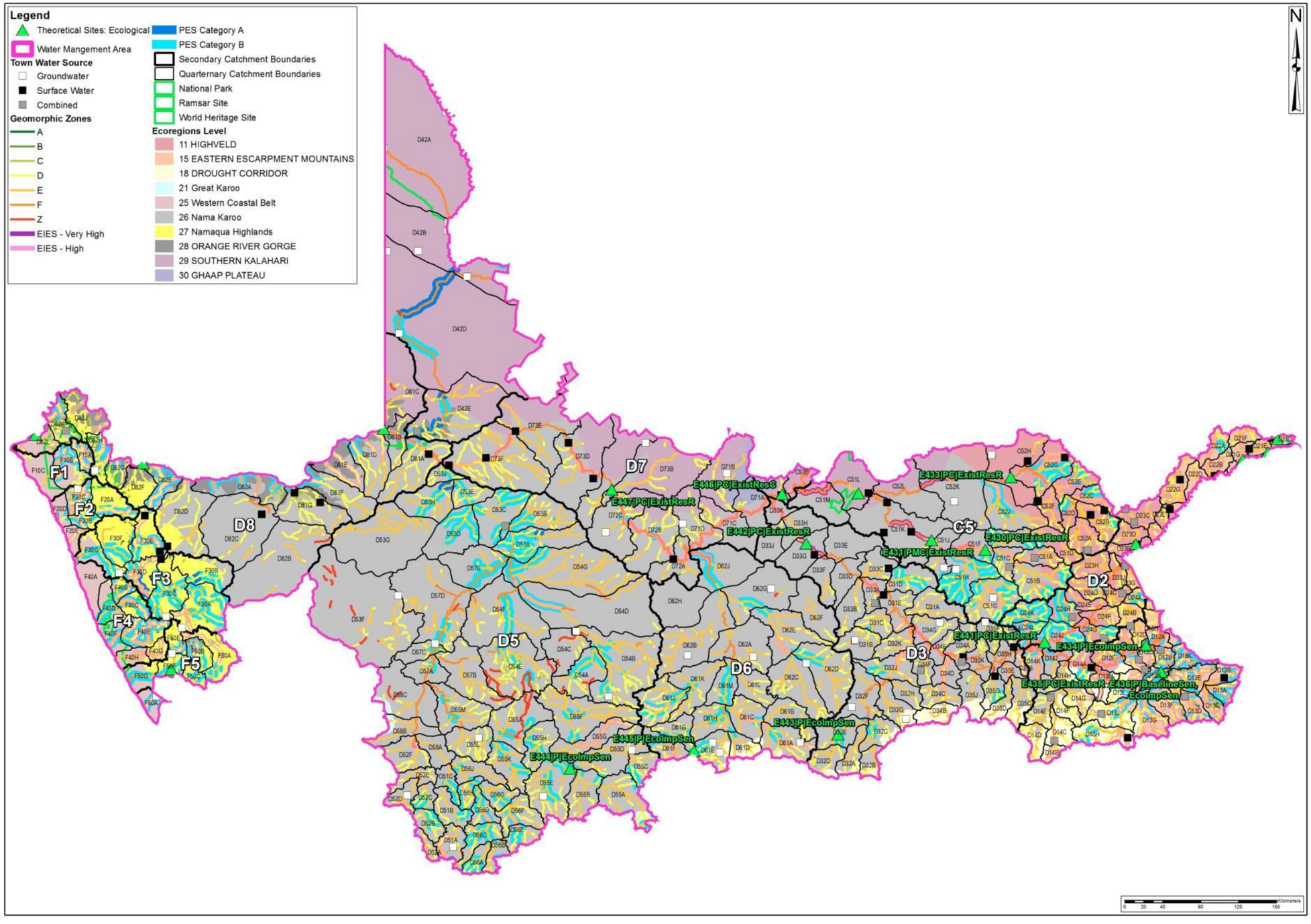


Figure A.6.27 Theoretical surface water sites based on ecosystem considerations

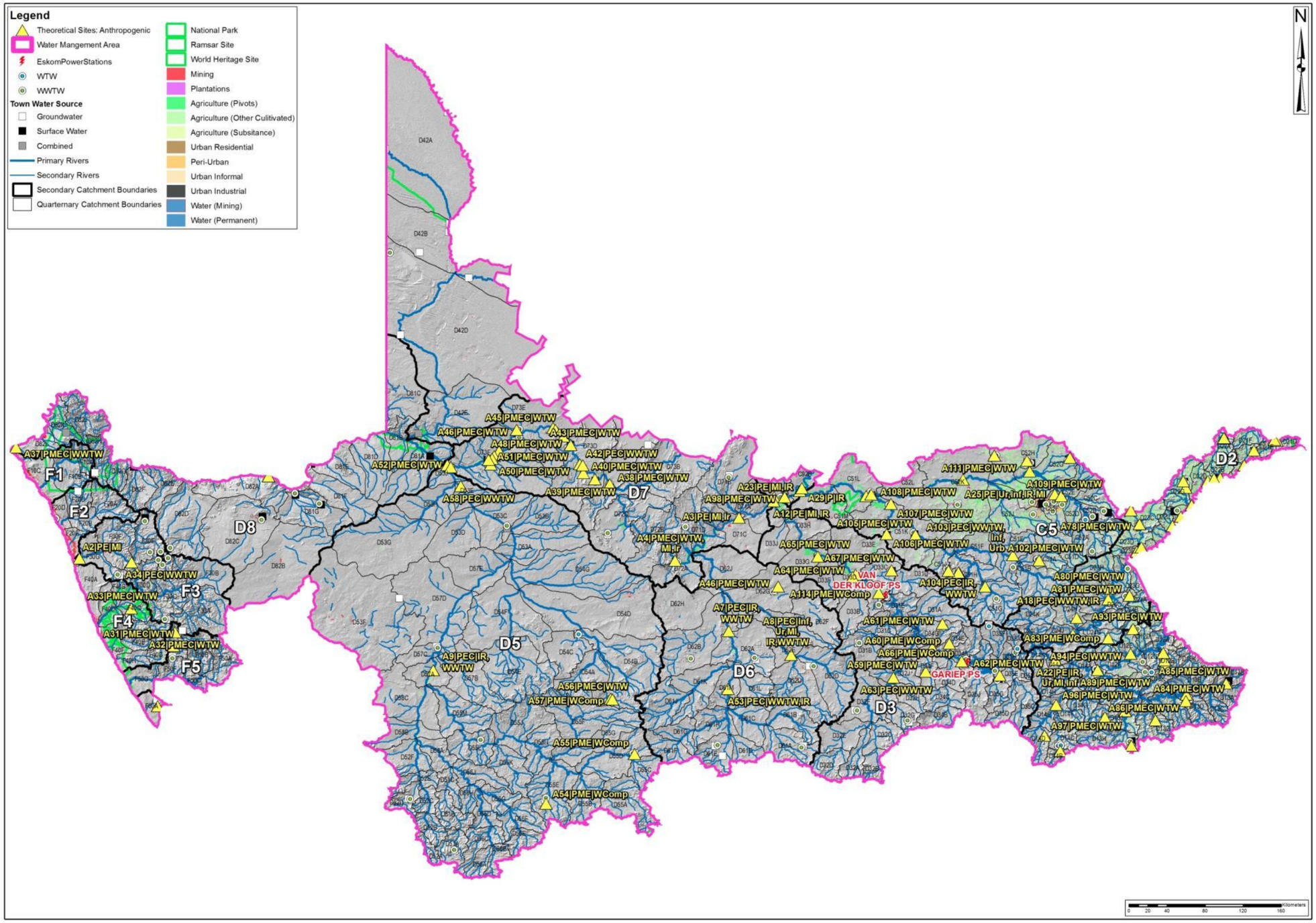


Figure A.6.28 Theoretical surface water sites based on anthropogenic considerations

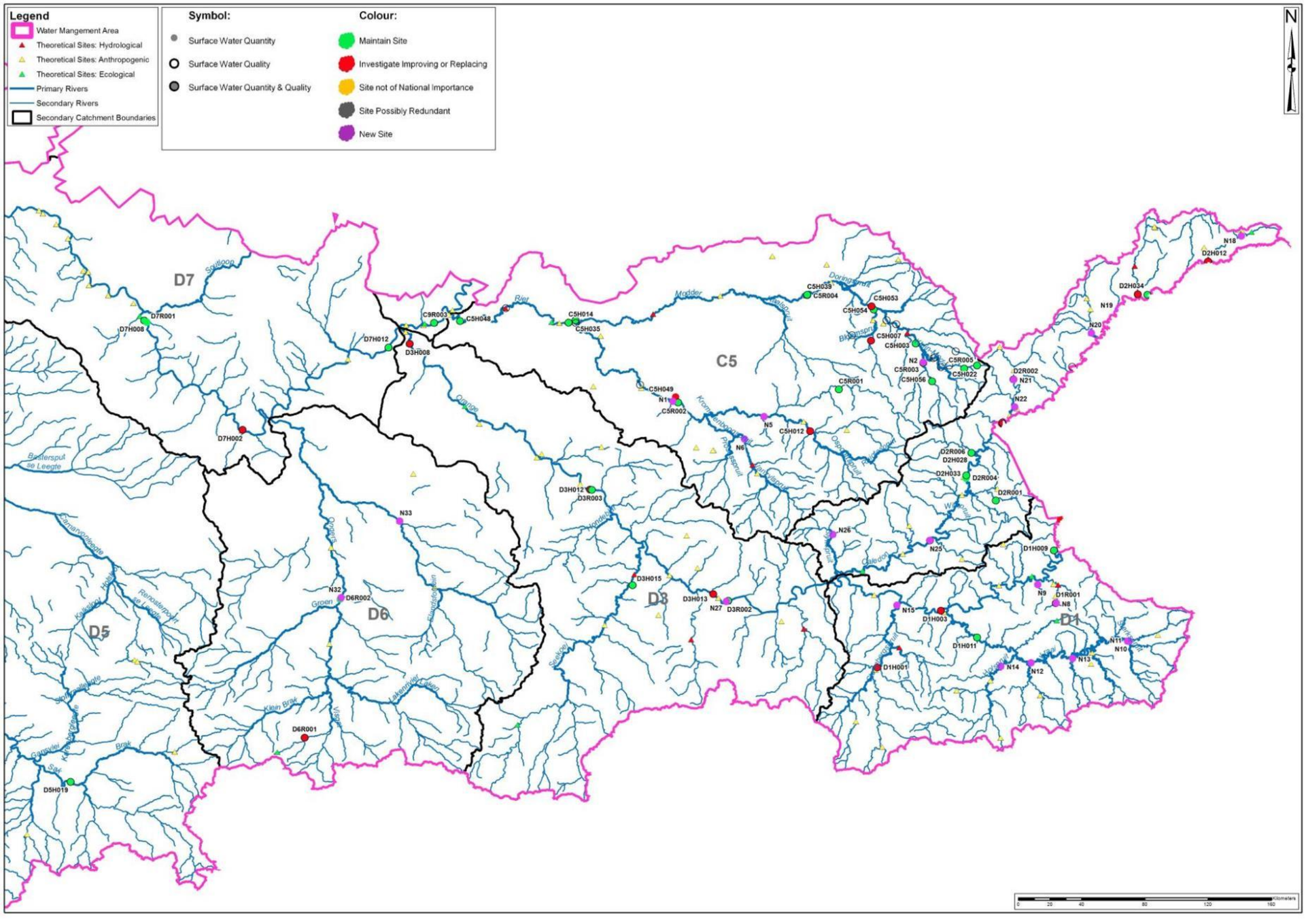


Figure A.6.29 All theoretical and actual surface water monitoring sites with recommended actions (Lower Orange sub-catchment)

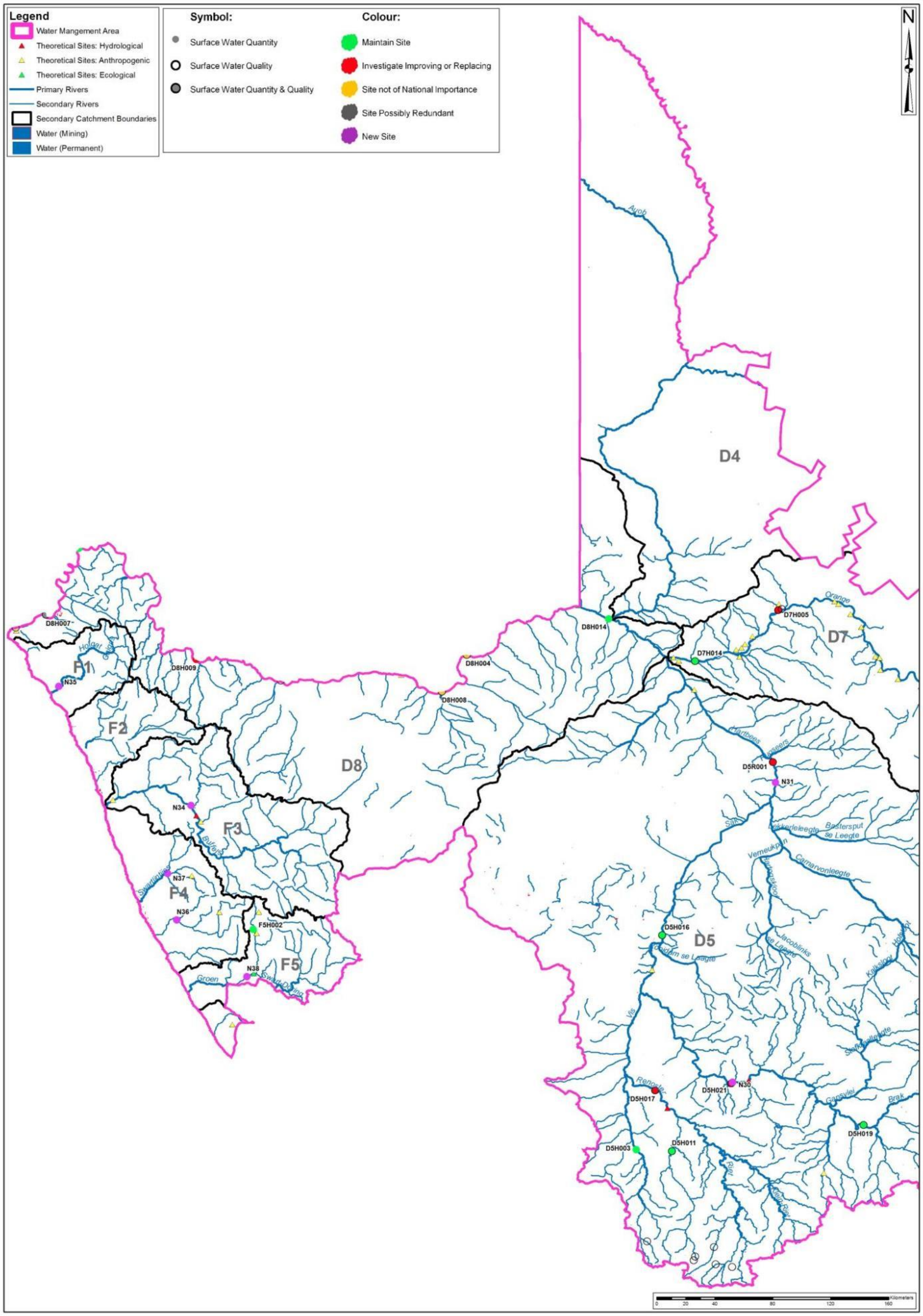


Figure A.6.30 All theoretical and actual surface water monitoring sites with recommended actions (Lower Orange sub-catchment)

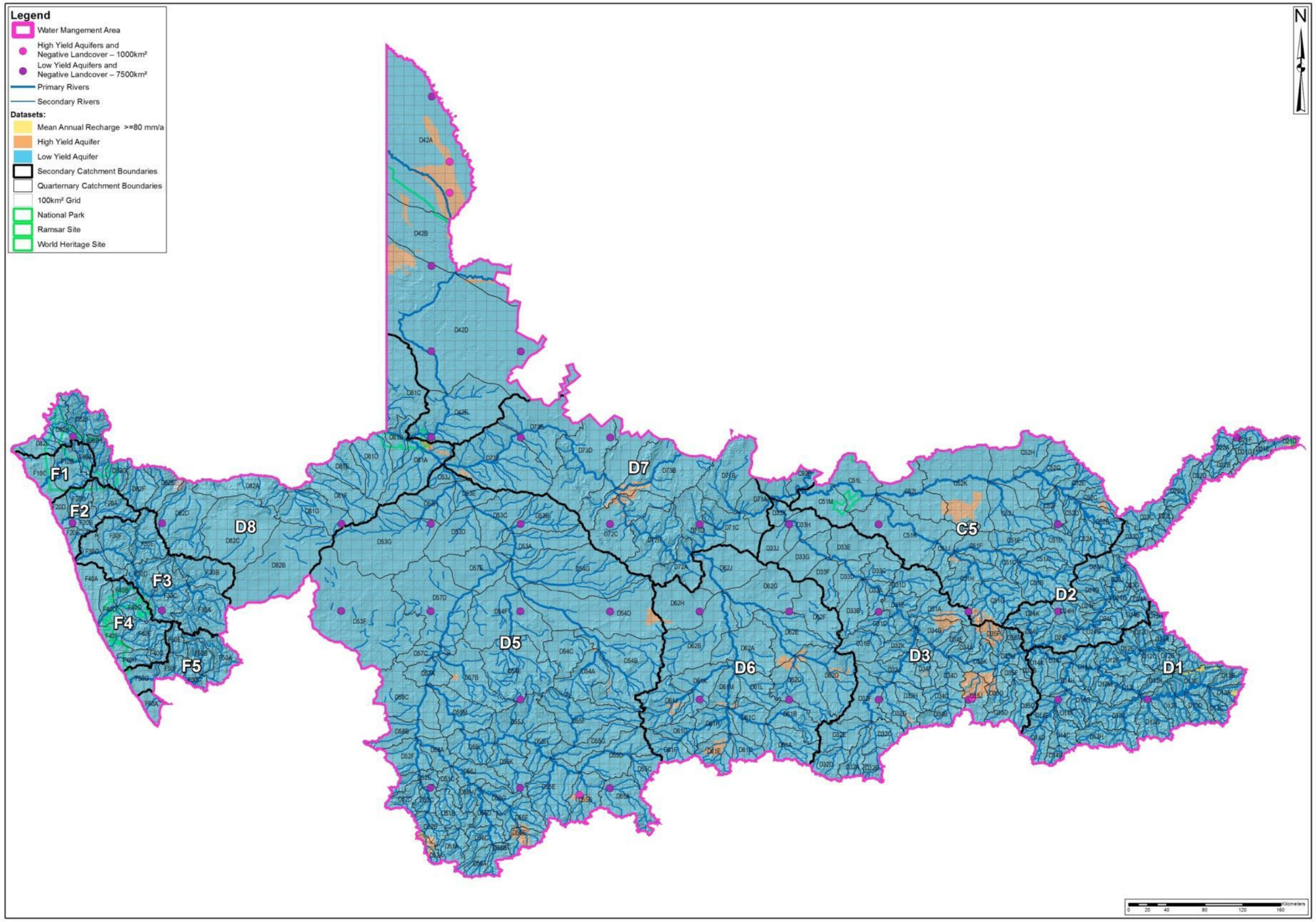


Figure A.6.31 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

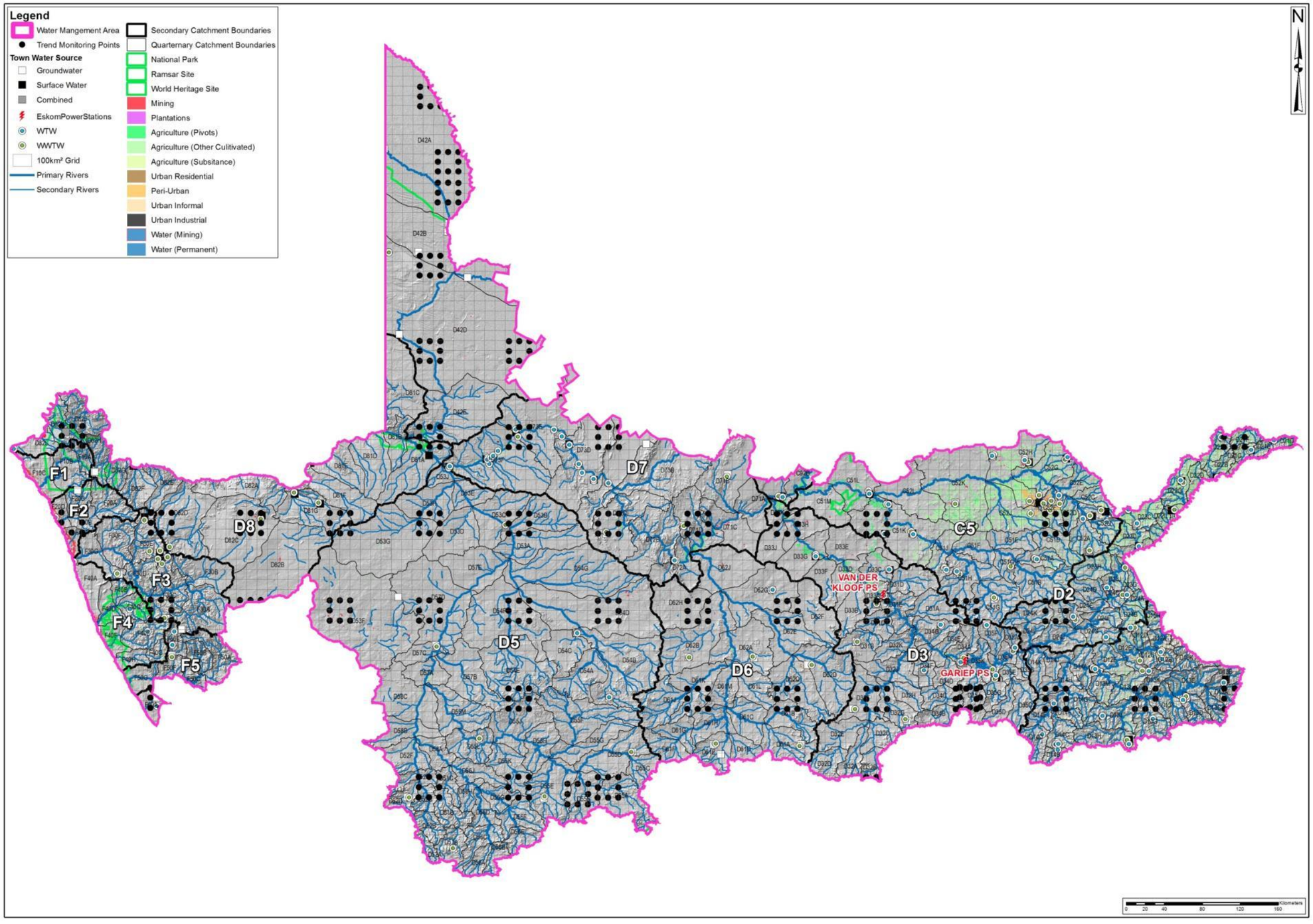


Figure A.6.32 Theoretical groundwater sites based on anthropogenic considerations (Trend)

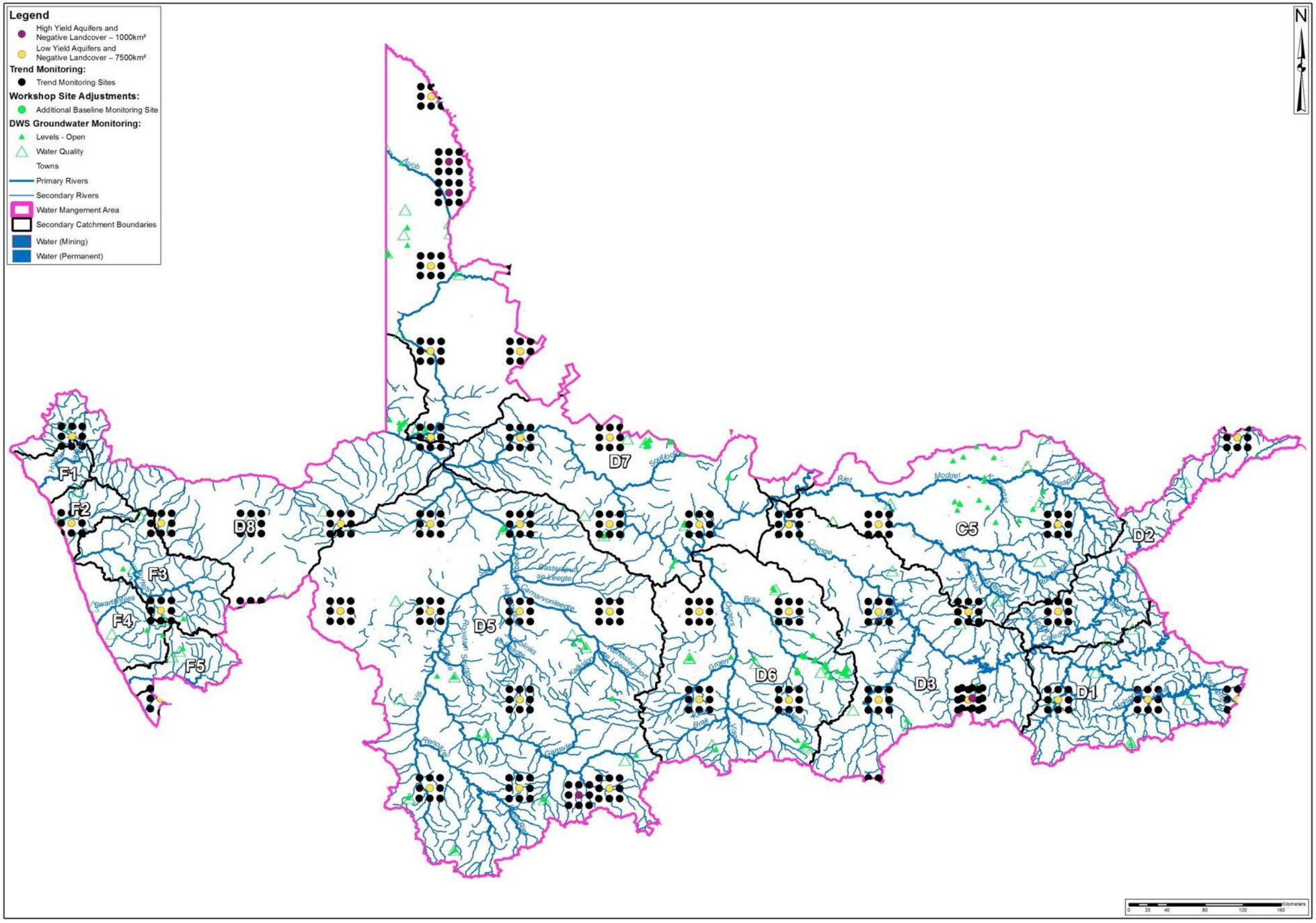


Figure A.6.33 Theoretical and exiting groundwater monitoring sites including additional recommended sites

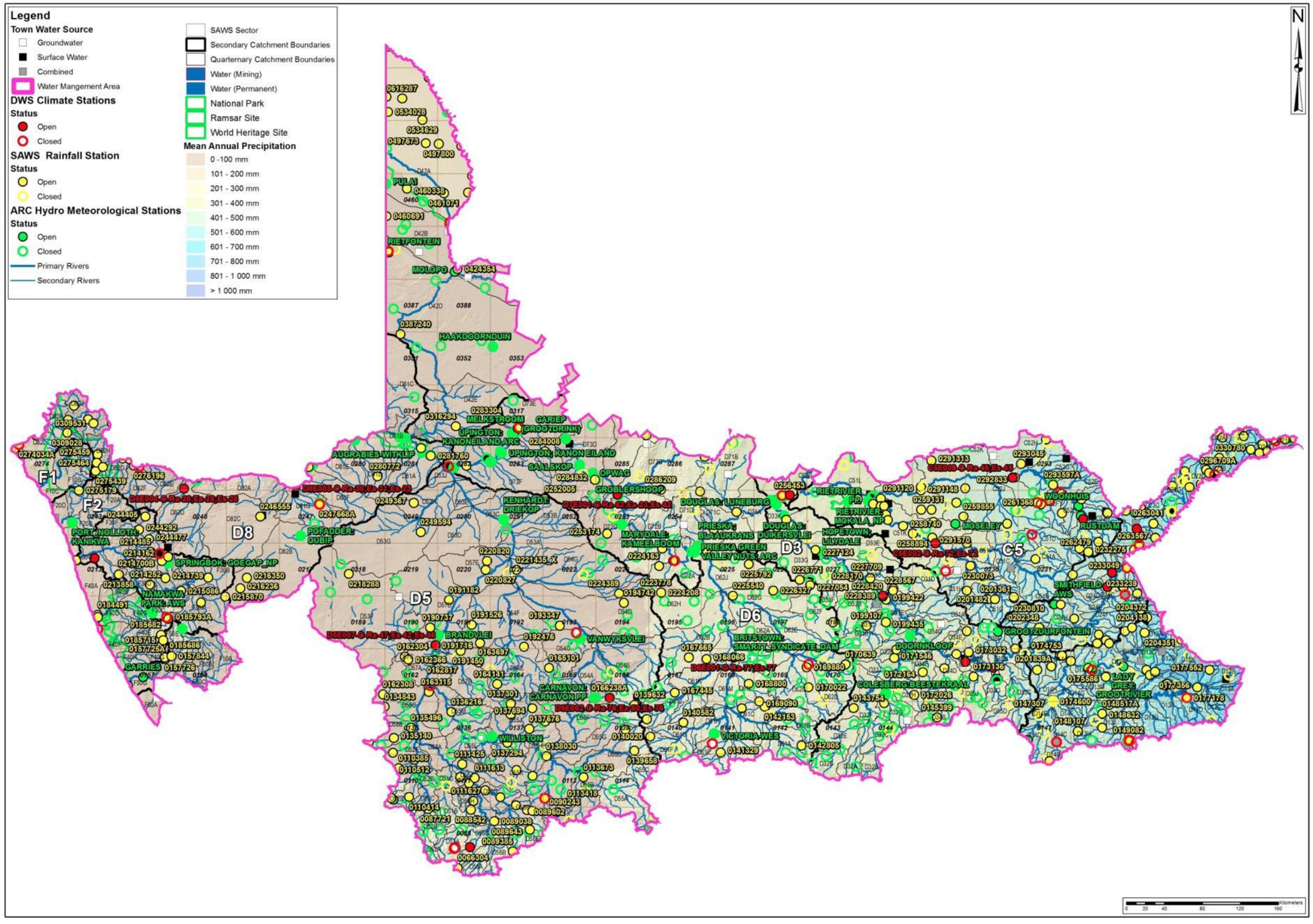


Figure A.6.34 Climatic information for the WMA

ANNEXURE 7

WMA 7: MZIMVUBU-TSITSIKAMMA

7. WMA 7: MZIMVUBU-TSITSIKAMMA

The Mzimvubu-Tsitsikamma WMA incorporates the former Mzimvubu to Kei and Fish to Tsitsikamma WMAs and covers the majority of the Eastern Cape and includes portions of the Western Cape, KwaZulu-Natal and the Northern Cape.

The Water Requirements for this WMA are described in terms of the Internal Strategic Perspective (ISP) areas described in the Department of Water and Sanitation study conducted approximately ten years ago.

Mzimvubu to Mbashane ISP area

There is relatively little development of water resources infrastructure in this region with the exception of Mthatha Dam on the Mthatha River. There is an irrigation transfer scheme between the Kei and Mbashe catchments. There are a number of small rivers in the Pondoland area that are in excellent condition for development, but have limited potential for development. The aforementioned ISP study indicated that this area has surplus water available and that it is without any further development of significant water resources infrastructure. The potential for this on the Mzimvubu is significant, but is dependent on further detailed feasibility assessments. The water quality in this area is generally good with the exception of the Mthatha River downstream of Mthatha (International, 2014).

Amatola to Kei ISP area

The main rivers within this area are the Buffalo, Keiskamma, Nahoon and the Great Kei. The main economic activities are manufacturing, agriculture, forestry and tourism. The area includes the major urban area of Buffalo City which includes King Williams Town, Bisho, East London and Mdantsane. There is significant infrastructure in this area consisting of a series of dams on a number of rivers to supply the Buffalo City area. There is also a water transfer scheme out of the ISP area from the Ncora Dam to the Mbashe catchment for use in the Ncora Irrigation scheme. The natural mean annual runoff in this area is 1 586 million m^3/a. The largest water user in the ISP area is irrigation use at 51% of the water requirements with urban use accounting for 43%. Groundwater use is relatively small in this area.

The Amatola catchment is highly developed and regulated, whereas there's limited development in Kei catchment. Rivers such as the Buffalo and Nahoon have poor water quality due to pollution from the surrounding urban areas. The water quality in the Kei River, although subjected to significant soil erosion is better than that of the Buffalo and Nahoon rivers (International, 2014).

Fish to Sundays ISP area

The most critical component of this system is the Orange-Fish-Sundays Water Supply System (WSS), which primarily supports irrigation in the Fish and Sundays catchments with additional transfers to the Nelson Mandela Bay area.

This is a water-scarce area in which the underlying geology results in additional water quality problems such as high salinity. The effects of the underlying geology are evident in many of the rivers in this area, including the Bushmans, Kariega, Kowie, Sundays and Fish, which have high salinity in their lower reaches

The main rivers in this area are the Great Fish, Sundays, Bushmans, Kowie and Kariega rivers. The main infrastructure consists of the Grassridge and Darlington Dams, together with various balancing dams, weirs and other infrastructure. The Lower Fish transfers water from the Orange River to Grahamstown and irrigators located along the Great Fish River. Groundwater is widely utilised in the drier parts of this ISP area (International, 2014).

Tsitsikamma to Coega ISP area

The Tsitsikamma to Coega ISP area includes, in addition to a portion of the Western Cape, the Nelson Mandela Bay Metro which dominates the economic activity of this area. The water supply to this area is from the Algoa water supply system which consists of a series of dams and is supplemented by water from the Orange-Fish transfer scheme.

Most of the inland area has a typically dry Karoo climate where rainfall can be as little as 100 to 150 mm/a, while some of the coastal areas to the west can reach 1 100 mm/a.

Some of the major infrastructure in the area include Churchill and Mpofu dams on the Kromme River, the Bergvlei Dam on the Groot River, the Kouga Dam on the Kouga River and the Groendal Dam on the Zwartkops River. Groundwater supply schemes are widely utilised in the hinterland areas of the Karoo.

Water quality varies dramatically with the water in the Tsitsikamma area generally being very good, and poor in the Seekoei River and the middle and lower reaches of the Zwartkops River.

Rainfall seasonality varies strongly across the different regions of the WMA. On the eastern side, in excess of 80% of rain occurs as thunderstorms during October to March. The peak rainfall months are December to February in the inland areas and November to March at the coast. The mean annual precipitation (MAP) ranges from in excess of 1 000 mm in the Wild Coast area, to less than 200 mm in the Karoo in the west.

The rainfall distribution on the western side of the WMA exhibits a more even distribution between summer and winter.

7.1 SITE REVIEWS

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

7.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Mzimvubu-Tsitsikamma WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. Error! Reference source not found. provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

Table 7.1 Number of surface water quantity monitoring sites per secondary catchment

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
K8	0	0	0	0	4	0	1	5
K9	1	0	0	4	2	2	4	12
L1	4	0	0	0	0	0	0	0
L2	3	0	0	0	0	0	0	0
L3	2	0	0	0	0	1	0	1
L4	0	0	0	0	0	0	0	0
L5	0	0	0	0	0	0	0	0
L6	1	0	0	0	1	0	0	1
L7	4	0	0	0	1	0	0	1
L8	3	1	0	1	3	2	0	7
L9	3	1	0	2	0	1	0	4
M1	5	0	0	3	2	1	0	6
M2	3	0	0	0	0	0	0	0
M3	0	0	0	0	0	0	0	0

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
N1	18	0	0	2	0	1	0	3
N2	6	0	0	0	2	0	0	2
N3	2	0	0	0	0	0	0	0
N4	8	3	0	1	2	1	0	7
P1	2	0	0	1	1	1	0	3
P2	0	0	0	0	0	0	0	0
P3	2	0	0	0	1	0	0	1
P4	0	0	0	0	1	0	1	2
Q1	15	4	0	1	4	1	0	10
Q2	1	0	0	0	1	0	0	1
Q3	4	0	0	0	1	0	0	1
Q4	10	3	0	0	1	1	0	5
Q5	4	1	0	0	1	0	0	2
Q6	3	0	0	0	1	0	0	1
Q7	4	0	0	0	1	0	0	1
Q8	5	2	0	0	4	1	0	7
Q9	16	1	0	1	8	1	0	11
R1	13	0	0	1	3	2	0	6
R2	14	1	0	2	10	3	0	16
R3	0	2	0	1	3	1	1	8
R4	0	0	0	0	0	0	0	0
R5	0	0	0	0	0	0	0	0
S1	0	0	0	0	1	1	0	2
S2	3	0	0	2	2	2	0	6
S3	7	0	0	0	5	2	0	7
S4	1	0	0	0	0	0	0	0
S5	1	0	0	0	2	1	0	3
S6	1	0	0	0	4	2	0	6

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
S7	0	1	0	2	2	2	1	8
T1	3	1	0	0	5	0	0	6
T2	6	0	0	1	2	1	0	4
T3	6	0	0	0	10	0	1	11
T7	0	0	0	0	1	0	2	3
T6	0	0	0	1	2	0	1	4
T8	0	0	0	0	0	0	0	0
T9	0	0	0	0	0	0	0	0
Total	**184**	**21**	**0**	**26**	**94**	**31**	**12**	**184**

According to **Error! Reference source not found.**, there are 94 active river flow, 12 tidal and 31 reservoir monitoring sites in the Mzimvubu-Tsitsikamma WMA that were evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

The number of sites with water quality constituents being monitored in the Mzimvubu-Tsitsikamma WMA is provided in **Table** 1.3**7.2**.

Table 7.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
K8	**1**	0	3	0	0	0	0	0	0	**3**
K9	**1**	3	1	0	0	0	0	0	0	**4**
L1	**0**	0	0	0	0	0	0	0	0	**0**
L2	**0**	0	0	0	0	0	0	0	0	**0**
L3	**0**	1	0	0	0	0	0	0	0	**1**
L4	**0**	0	0	0	0	0	0	0	0	**0**

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)[1]	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations[4]
L5	**0**	0	0	0	0	0	0	0	0	**0**
L6	**0**	0	1	0	0	0	0	0	0	**1**
L7	**0**	0	2	0	0	0	0	0	0	**2**
L8	**0**	4	2	0	0	0	0	0	0	**6**
L9	**0**	1	1	0	0	0	0	0	0	**2**
M1	**0**	2	1	0	0	0	0	0	0	**3**
M2	**0**	0	0	0	0	0	0	0	0	**0**
M3	**0**	0	0	0	0	0	0	0	0	**0**
N1	**0**	1	1	0	0	0	0	0	0	**2**
N2	**1**	3	1	0	0	0	0	0	0	**4**
N3	**0**	0	1	0	0	0	0	0	0	**1**
N4	**0**	4	1	0	0	0	0	0	0	**5**
P1	**1**	0	1	0	0	0	0	0	0	**1**
P2	**0**	0	0	0	0	0	0	0	0	**0**
P3	**0**	0	1	0	0	0	0	0	0	**1**
P4	**0**	0	1	0	0	0	0	0	0	**1**
Q1	**0**	1	4	0	0	0	0	0	0	**5**
Q2	**0**	0	1	0	0	0	0	0	0	**1**
Q3	**0**	0	1	0	0	0	0	0	0	**1**
Q4	**1**	1	1	0	0	0	0	0	0	**2**
Q5	**1**	1	0	0	0	0	0	0	0	**1**
Q6	**0**	0	1	0	0	0	0	0	0	**1**
Q7	**0**	0	2	0	0	0	0	0	0	**2**
Q8	**1**	5	1	0	0	0	0	0	0	**6**
Q9	**0**	7	4	0	0	0	0	0	0	**11**
R1	**0**	4	1	0	0	0	0	0	0	**5**
R2	**2**	12	1	0	0	5	0	3	0	**14**
R3	**1**	3	2	0	0	1	0	0	0	**5**
R4	**0**	0	0	0	0	0	0	0	0	**0**

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
R5	**0**	0	0	0	0	0	0	0	0	**0**
S1	**0**	1	1	0	0	0	0	0	0	**2**
S2	**0**	4	0	0	0	0	0	0	0	**4**
S3	**3**	5	2	0	0	0	0	0	0	**7**
S4	**0**	0	0	0	0	0	0	0	0	**0**
S5	**3**	2	1	0	0	1	0	1	0	**4**
S6	**1**	5	1	0	0	2	0	0	0	**6**
S7	**1**	1	2	0	0	0	0	2	0	**4**
T1	**0**	3	6	0	0	0	0	0	0	**9**
T2	**2**	2	2	0	0	1	0	3	0	**7**
T3	**2**	3	8	0	0	0	0	2	0	**13**
T7	**0**	0	1	0	0	0	0	0	0	**1**
T6	**2**	2	0	0	0	0	0	0	0	**2**
T8	**0**	0	0	0	0	0	0	0	0	**0**
T9	**1**	0	0	0	0	0	0	2	0	**2**
Total	**25**	**81**	**61**	**0**	**0**	**10**	**0**	**13**	**0**	**152**

Notes:

(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

As can be seen from Table 1.37.2 the main water quality programmes in the WMA include chemical, eutrophication and microbial monitoring. As stated earlier, the water quality parameters and frequencies will be reviewed during the strategy development and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

7.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 7.4**.

7.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or to be upgraded. Reported in **Table 1.3** are the theoretical objectives that have been assigned to these existing river sites. Please note that this list does not include W-components that are functioning adequately.

Table 7.3 Objectives and relative priorities assigned to existing river monitoring stations with no recommended actions

Site number	Description	Theoretical objective	Relative priority[#]
Q8H006	Little Fish River @ Wellington-Grove	PME|Div,Urb,Ir	10.5
Q8H008	Little Fish River @ Doorn Kraal	PME|Div,Urb,Ir	10.5
T3H009	Mooi River @ Maclear	PEC|HR,Base,Ur,F,ExistResR	9.5
R2H015	Yellowwoods River @ Fort Marray Uitspan	PM|Base,WWTW,Transf	8.5
S6H001	Kubusi River @ Stutterheim	PM|F,Ir,Urb	8.5
K8H001	Kruis River @ Farm 508	PC|HR,Base,ExistResR,BaselineUpPA	7.0
S3H006	Klaas Smits River @ Weltevreden	PC|Base,ExistResR,Rur,Ir	7.0
K8H005	Tsitsikama River @ Geelhoutboom	PC|Base,HR,ExistResR	6.5
K8H006	Groot River @ Rooiwal	PC|ExistResR, Base, HR	6.5
P4H001	Kowie River @ Bathurst	PC|Base,ExistResR, EstFFU	6.5
T2H008	Mtata River @ Umtata	P|HR,Base,Urb,Rur,MI	6.5
T3H005	Tina River @ Mahlungulu	PC|Base,ExistResR,Rur	6.5
T3H008	Mzimvubu River @ Kromdraai	PC|Ir,Base,ExistResR	6.5
T3H020	Mzimvubu River at Ntontela	PC|Base,Rur,ExistResR	6.5
T6H001	Mntafufu River @ Ntafufu Loc. 35	PC|ExistResR,Rur,PriorEstReq	6.5
T7H001	Mngazi River @ Mqwnyana Loc. 22	PC|Base,HR,ExistResR	6.5
K8H002	Elands River @ Kwaai Brand For. Res	P|HR,EcoImpSen,BaselineUpPA	6.0

Site number	Description	Theoretical objective	Relative priority[#]
L7H006	Groot River @ Grootrivierspoort	P|Base,EcoImpSen,Ir,Rur	6.0
Q3H005	Great-Fish River @ Rietfontyn	P|Base,Ir,Urb,Rur	6.0
Q9H002	Koonap River @ Adelaide	P|Base,Urb,Rur,Ir	6.0
Q9H019	Balfour River @ Grey Kirk	PC|ExistResR,Rur	6.0
S3H013	Swart Kei River @ Hotfire	PC|ExistResR,Base	6.0
S7H004	Great-Kei River @ Area 8\092092044Springs B	PC|ExistResR,Base	6.0
T1H013	Mbashe at Gxwali Bomvu	P|HR,Base,F,Rur	6.0
L8H001	Wabooms River @ Diepkloof	P|Base,Ir,BaselineUpPA	5.5
L8H002	Haarlem Spruit @ Welgelegen	P|HR,Base,Ir	5.5
L8H005	Kouga River @ Stuurmanskraal	P|HR,Base,EcoImpSen	5.5
P1H003	Boesmans River @ Donker Hoek	P|Base,Ir,Ur	5.5
P3H001	Kariega River @ Smithfield	P|Base, Ir,EcoImpSen	5.5
Q9H018	Great Fish River @ Matomela's Location	P|Base,Ir,Rur	5.5
R2H001	Buffalo River @ Pirie Main For.Res.	P|HR,Base,F	5.5
S1H004	White Kei River @ Cacadu	P|Base,Rur,Wcomp?	5.5
T1H014	Mbashe River at Rune	P|HR,Base,Rur	5.5
T2H010	Cicira River at Roode Heuvel	P|Base,Urb,Rur	5.5
T3H007	Mzimvubu River @ Ku-Makhola	P|Base,EcoImpSen,Rur	5.5
T6H004	Xura River @ Xura 27	PC|ExistResR	5.5
M1H004	Elands River @ Wintcanton	P|HR,Base	5.0
M1H012	Swartkops River @ Uitenhage	P|HR,Base	5.0
N4H001	Sondags River @ Korhaanspoort	P|Base, Ir	5.0
N4H005	Coerney River @ Selborne	P|Base,Ir	5.0
Q1H012	Teebus River @ Jan Blaauws Kop	P|Base,Ir	5.0
Q1H013	Little Brak River @ Zeeven Fontein	P|Base,Ir	5.0
Q2H002	Great-Fish River @ Zoutpansdrift	P|Base, Ir	5.0
Q3H004	Pauls River @ Coutzenburg	P|Base,Ir	5.0
Q4H013	Tarka River @ Bridge Farm	P|Base,Ir	5.0
Q5H007	Great Fish at Elandsdrift Dam	P|Base,Ir	5.0
Q6H003	Baviaans River @ Botmansgat	P|Base, EcoImpSen	5.0
Q7H005	Great Fish River @ Sout Vleij	P|Base,Ir	5.0
Q8H010	Little Fish River @ Grootvlakte	P|Base,Ir	5.0

Site number	Description	Theoretical objective	Relative priority[#]
Q9H012	Great Fish River @ Brandt Legte	P|Base,Ir	5.0
Q9H030	Koonap River @ Frisch Gewaagd	P|HR,Base	5.0
R3H001	Mgqakwebe River @ Msenge Ridge	P|Base,Ir	5.0
S5H002	Tsomo River @ Wyk Maduma	P|Base,Rur	5.0
S6H003	Toise River @ Forkroad	P|Base,Ir	5.0
T3H019	Kinira @ Mgungundlovu	P|Base,Rur	5.0
L6H001	Heuningklip River @ Campherspoort	P|Base	4.5
N2H007	Sondags River @ De Draay	P|Base	4.5
N2H008	Riet River @ Groene Leegte	P|Base	4.5

[#] *Sites are listed in descending order based on relative priority*

7.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in

New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 1.4** are all the proposed monitoring sites for the Limpopo WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

7.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, site descriptions, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 1.4 are all the proposed monitoring sites for the Mzimvubu-Tsitsikamma WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

7.3.4 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, coordinates, assigned theoretical objectives as well as problems associated with the monitoring site.

7.3.5 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Table 7.4 Proposed new river monitoring sites

Site number	Lat	Long	Theoretical objective	Comment	Relative priority[#]
N1	-30.196	29.115	PC|HR,ExistResR,Irr,F,Base	This site is located downstream of a high runoff region and will measure the contributions of the Nyongo and Mzimvubu rivers. It is also located close to a reserve study EWR site.	7.5
N18	-33.581	25.674	PE|EstFFU,Base, Ir	This site measures the entire Sondags River flow after irrigation use. Formalise current site or other sites up to the N2 crossing. Estuary under top 20% of estuaries.	7.5
N5	-31.311	29.86	PC|HR,Base,ExistResR, Rur	This site is located downstream of a high runoff region and will measure the contributions of the Msikaba and eMatheko rivers. Site needs to be investigated in the area.	7.0
N26	-31.169	28.67	PC|Base,HR,ExistResR, Rur	New dam site. Ensure all components of the dam to be measured.	7.0
N3	-30.63	28.481	PC|ExistResR,Base,Rur	This site is located downstream of a high runoff region and will measure the contributions of the Tinana and Thina rivers. It is also located close to a reserve study EWR site.	6.5
N6	-31.923	29.137	PC|Base,ExistResR,Rur	This site is located downstream of a high runoff region and will measure the contributions of the Mthatha and Ngqungqu rivers. It is also located close to a reserve study EWR site.	6.5
N25	-31.272	28.945	PC|Base, ExistResR	New dam site. All components of the dam to be measured to replace T3H006.	6.0
N4	-30.761	28.522	P|Base,Rur,F	There is currently no monitoring taking place in the Luzi river or any of its tributaries in this region.	5.5
N2	-31.107	29.399	P|Base,Rur,F	Recommended as a replacement for T3H017, before the confluence with the Mzimvubu River.	5.5
N8	-31.355	27.669	P|EcoImpSen,HR,Base	This site is located downstream of a high runoff region and will measure the contributions of the Tsomo and Cicira rivers. Closed site downstream could be investigated.	5.5
N10	-32.462	27.892	P|Base,F,Irr	Kubusi to be measured upstream of the confluence with the Groot-Kei River, due to limited good sites on lower Kei.	5.5
N19	-33.663	24.376	P|Base,Ir, EcoImpSen	There is currently no monitoring taking place on the Baviaanskloof River.	5.5
N22	-33.641	26.566	P|Hr, Base, EcoImpSen	No monitoring on lower Boesmans River which has higher runoff. New site required on Boesmans River upstream of this point.	5.5
N13	-33.03	27.098	P|Base, Rur	There is currently no monitoring taking place in the middle reach of the Keiskamma river or any of its	5.0

Site number	Lat	Long	Theoretical objective	Comment	Relative priority[#]
				tributaries. Difficulties of siltation and access will have to be considered.	
N9	-32.238	27.429	P|Base	There is currently no monitoring taking place in the Thomas River (Tributary of the Groot Kei). No measurement in S4.	4.5
N20	-33.99	24.923	P|Base	There is currently no monitoring taking place on the Kabeljous River. This station is also required to measure the inflow into the downstream estuary.	4.5

[#] *Sites are listed in descending order based on relaitive priority*

Table 7.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Relative priority
T1H015	Mbashe at Rara 34	PME|HR,Base,Rur,EstFFU	This is an operational station and the very last station on the Mbhase. Used for Eskom operations. Need to ensure that all components are measured. If not possible, look for site more downstream	11.0
R1H017	Keiskamma River @ Lower Mcqumeya	PME|Wcomp,ExistResR,Ir	Rocks are washed off by the spillway of Sandile Dam and block gauge	10.5
S2H006	Doorn River @ Indwe	PME|Wcomp,Rur	W-component needs upgrading or replacement	10.0
Q9H026	Kat River @ Weltevreden	PMC|Base, ExistResR,Rur	W-component for Katriver Dam (Q9R001). Requires upgrading	9.5
S7H001	Gcuwa River @ Butterworth	PM|Ur,Div,Rur	Site is to be upgraded.	8.5
Q9H029	Kat River @ Fort Beaufort	PC|Base,Ir,Ur,Rur,ExistResR	Investigate improvements or replacement.	7.5
R3H008	Nahoon River at Abbotsford	PC|ExistResR,Base, Urb,Rur	This monitoring station is scheduled for an upgrade	7.0
T1H001	Xuka River @ Caca 45	P|HR,Base,Rur,F,Eco ImpSen	This is a relatively old monitoring point that is experiencing siltation problems and must be investigated for improvements.	6.5
R1H014	Tyume River @ Kwa Khayaletu	P|HR,Base,F,Rur	Site requires upgrading, perennial spring upstream of site. If W-component is established for R1R003 this site could possibly be redundant	6.0
R2H005	Buffalo River @ King Williams Town	P|HR,Base,Urb,Rur	Due to the location of this site, there are safety issues associated with this station. Site needs replacement upstream to still include high runoff areas	6.0
T3H004	Mzintlava River @ Slang Fontein	P|Ur,Base,Rur,Ir	This is a relatively old monitoring point that is exhibiting accuracy problems for high flows. This must be investigated for improvements/replacement.	6.0

Site number	Description	Theoretical objective	Comment	Relative priority
T3H002	Kanira River @ Kanira Drift	P|EcoImpSen,Rur,Ir	To be replaced with new site 5km downstream	5.5
R1H015	Keiskamma River @ Farm 7	P|Base,Rur	Very last station on Keiskamma and requires upgrades or other station upstream (N13)	5.0
R2H006	Mgqakwebe River @ Msenge Ridge	P|HR,Base	The site is often outflanked and needs to be upgraded	5.0
R2H009	Ngqokweni River @ Sheshegu	P|Base,Rur	This is a relatively old monitoring point that is exhibiting accuracy problems. This must be investigated for improvements.	5.0
S3H004	Black-Kei River @ Cathcarts Gift	P|Base	This monitoring point experiences lots of siltation and must be investigated for improvement or made redundant if a new site is developed to replace it at a different location.	4.5

[#] *Sites are listed in descending order based on relaitive priority*

Reported in **Table** 1.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 7.6 Monitoring sites that are not of national importance

Site number	Description	Comments
R2H016	Zwelitsha Spruit @ Malakalaka	The upstream catchment for this station is relatively small and is currently only used for water quality measurements and is, from a water resources perspective, not of national importance.
T1H011	Qumanco at Damane	This station measures water releases for Eskom and is, from a water resources perspective, not of national importance.

7.3.6 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, coordinates and comments that resulted in the site classification.

Table 7.7 Redundant river flow monitoring sites

Site number	Description	Comment
Q9H017	Blinkwater River @ Blinkwater	Very small catchment
R2H008	Quencwe River @ Braunschweig	This station exhibits poor accuracy and it is recommended that it be made redundant
R2H010	Buffalo River @ 135 K.W.T.Q	It is recommended that this station be made redundant as it often gets flooded by the downstream dam
R2H027	Buffalo River @ Mhlabati	It is recommended that this station be made redundant if a W-component for R2R001 is constructed.
T3H006	Tsitsa River @ Xonkonxa	This is a relatively old structure that will be inundated and made redundant by the proposed dam in the vicinity.
T3H017	Mzintlava River @ Ludiwana	This station exhibits poor accuracy and it is recommended that it be replaced by N2

7.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must therefore be monitored efficiently. Listed in **Table 7.8** are all the required W-components as well as changes and potential improvements to existing reservoir monitoring within the WMA.

Table 7.8 New W-component for dams

Site number	Lat	Long	Theoretical objective	Comment	Relative priority
N23	-32.760	27.344	PMEC|Wcomp,HR,Base, ExistResR	Recommended that a WComp be constructed downstream of Rooikrans Dam. If W-Comp installed, R2H001 could become redundant	12.0
N7	-32.282	26.853	PME|RSupply,Wcomp, Base,HR	Recommended that a WComp be constructed downstream of Waterdown Dam, to replace S3H010	11.0
N15	-32.111	26.032	PME|Base,Ir,WComp	Recommended that a WComp be constructed downstream of Kommandodrif Dam.	10.5
N11	-32.149	28.101	PME|Wcomp,Rur	Recommended that a WComp be constructed downstream of Xilinxa Dam	10.0
N16	-32.242	24.528	PME|Base,WComp	Recommended that a WComp be constructed downstream of Nqweba Dam (Graaff-Reinet Dam)	10.0
N14	-32.970	27.488	PME|Wcomp,ExistResR	Recommended that a WComp be constructed downstream of Laing Dam	10.0
N21	-33.696	25.267	PME|Wcomp, HR	Recommended that a WComp be constructed downstream of Groendal Dam	10.0
N17	-33.216	25.146	PME|Base, WComp	Recommended that a WComp be constructed downstream of Darlington Dam	9.5
N24	-32.689	26.894	PM|WComp,Base	Recommended that a WComp be constructed downstream of Tyume River Dam (R1R003)	8.0

7.5 ESTUARIES

The Mzimvubu-Tsitsikamma WMA has four estuaries that falls within the top 20% of estuaries in the country according to a ranking system developed by the RQIS. This study (DWS, 2002) devised a method for prioritising South African estuaries on the basis of conservation importance, and presented the results of a ranking based on the collation of existing data for all South African estuaries. Estuaries are scored in terms of their size, type and biogeographical zone, habitats and biota (plants, invertebrates, fish and birds).The identified estuaries include:

- Kowie Estuary
- Mtanfufu Estuary.
- Sundays Estuary
- Mbashe Estuary

The first two estuaries fall under the top 10% of estuaries in the ranking systems and all have tidal stations. The latter two do not, but it is not deemed important that tidal stations are installed here. River inflow measurements to the top 10% of the estuaries were prioritised during the river site analysis.

7.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.7.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

7.7 GROUNDWATER MONITORING

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring station points does not plot on top of mountains.
- Increase spatial density over groundwater control areas to 500 km^2 to set baseline monitoring points. This rule applies to all groundwater control areas throughout the country.
- Set the following as additional baseline monitoring stations:

K9N0028	ZQMSSM2
K9N0028	S2N0001
L7N0013	ZQMTKA2
L7N0013	ZQMNOB1
Latitude: -33.482448° Longitude: 25.745407°	ZQMMND1

Latitude: -33.482448° Longitude: 25.745407°	P2N0005
Latitude: -33.975048° Longitude: 23.879041°	ZQMHDP1
Latitude: -33.975048° Longitude: 23.879041°	ZQMTSS1
P1N0502	ZQMTSS1
P1N0504	ZQMUTH1
Q1N0062	ZQMUTH1
Q1N0511	ZQMCRA1
Q1N0512	ZQMHDP1
Q1N0513	
Q4N0002	
ZQMABR1	
ZQMADO1	
ZQMADO1	
ZQMCBG2	

- Set grid to 500 km^2 over the town of Graaff-Reinet
- Convert the current monitoring points to trend monitoring station. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring stations that fall within the buffer.

ZQMSFB1	L1N0076	ZQMTSS2	N1N0505	Q1N0518
K9N0025	L1N0072	L1N0038	ZQMGRT3	Q1N0519
K9N0006	L1N0153	M3N0007	N1N0092	Q1N0517
K9N0017	L1N0070	ZQMMRA1	ZQMGRT2	Q1N0514
K9N0019	L1N0066	M3N0006	N1N0503	Q1N0042
K9N0020	L1N0065	M3N0005	N1N0506	Q1N0507
K9N0021	L1N0043	M3N0002	N1N0021	Q1N0508
K9N0024	L1N0005	M3N0003	ZQMGRT1	ZQMMDG1
K9N0011	L1N0145	M3N0004	N1N0022	Q1N0515
K9N0029	J2N0114	M3N0001	P4N0009	Q1N0050
K9N0030	L1N0134	M1N0034	P4N0008	Q1N0069
ZQMKWN1	L1N0054	M1N0003	P4N0003	S3N0013
ZQMSWN1	L1N0050	M1N0004	ZQMFRR1	ZQMSSM3
ZQMSTY1	L1N0051	M1N0038	Q7N0004	ZQMSSM1
L7N0014	L1N0056	M1N0010	ZQMSME1	S1N0001
L7N0011	L1N0151	ZQMKWD1	ZQMADL1	S3N0007

L7N0006	ZQMRSK1	M1N0008	ZQMSME1	S3N0016
L6N0003	J2N0111	N2N0500	ZQMCRA2	S3N0010
ZQMWHW1	ZQMRSK2	N1N0510	ZQMTAR2	S3N0008
ZQMKPT1	J2N0109	ZQMABD1	Q4N0003	ZQMQSN1
L4N0001	L1N0150	N1N0042	ZQMTAR3	S3N0001
L3N0001	L1N0146	N1N0046	Q4N0004	S3N0002
ZQMRTB4	L1N0030	N1N0031	ZQMHFR1	S3N0003
ZQMRTB3	L1N0027	N1N0037	Q1N0060	S3N0014
ZQMRTB2	ZQMURG1	ZQMGRT4	ZQMHFR2	ZQMKWE1
L1N0168	ZQMURG2	N1N0091	ZQMSTB1	ZQMKWE2
ZQMNWA1	ZQMSTH1	T3N0001	T2N0001	P2N0003
R3N0501	ZQMELT1	ZQMLAN1	ZQMYFM1	P2N0004
ZQMKMG1	T1N0001	ZQMLAN1	ZQMCPD1	ZQMBRM1
S7N0002	ZQMMAC1	T6N0001	P2N0002	P2N0001

APPENDIX A.7

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 7: MZIMVUBU-TSITSIKAMMA

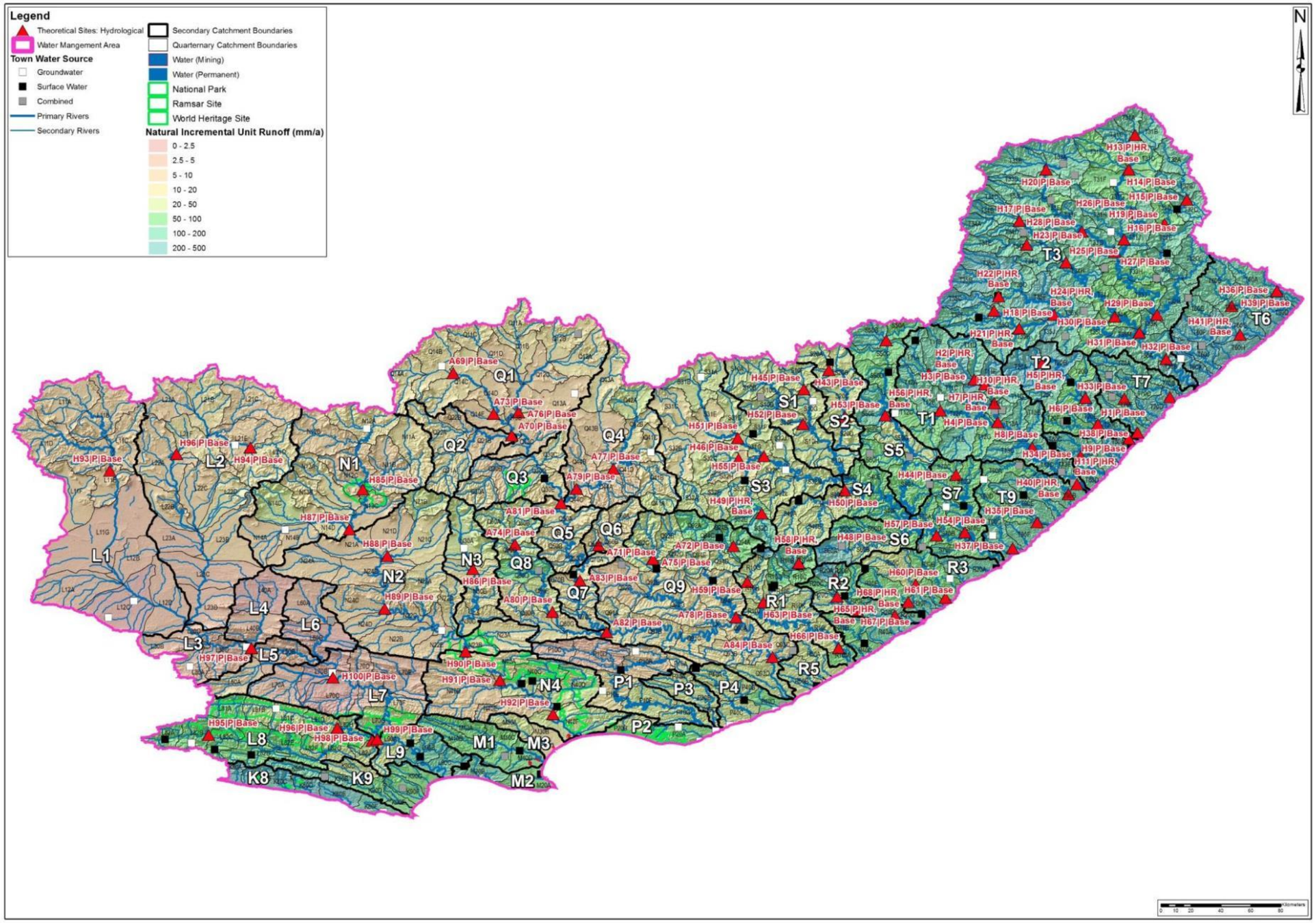


Figure A.7.35 Theoretical surface water sites based on hydrological (runoff) considerations

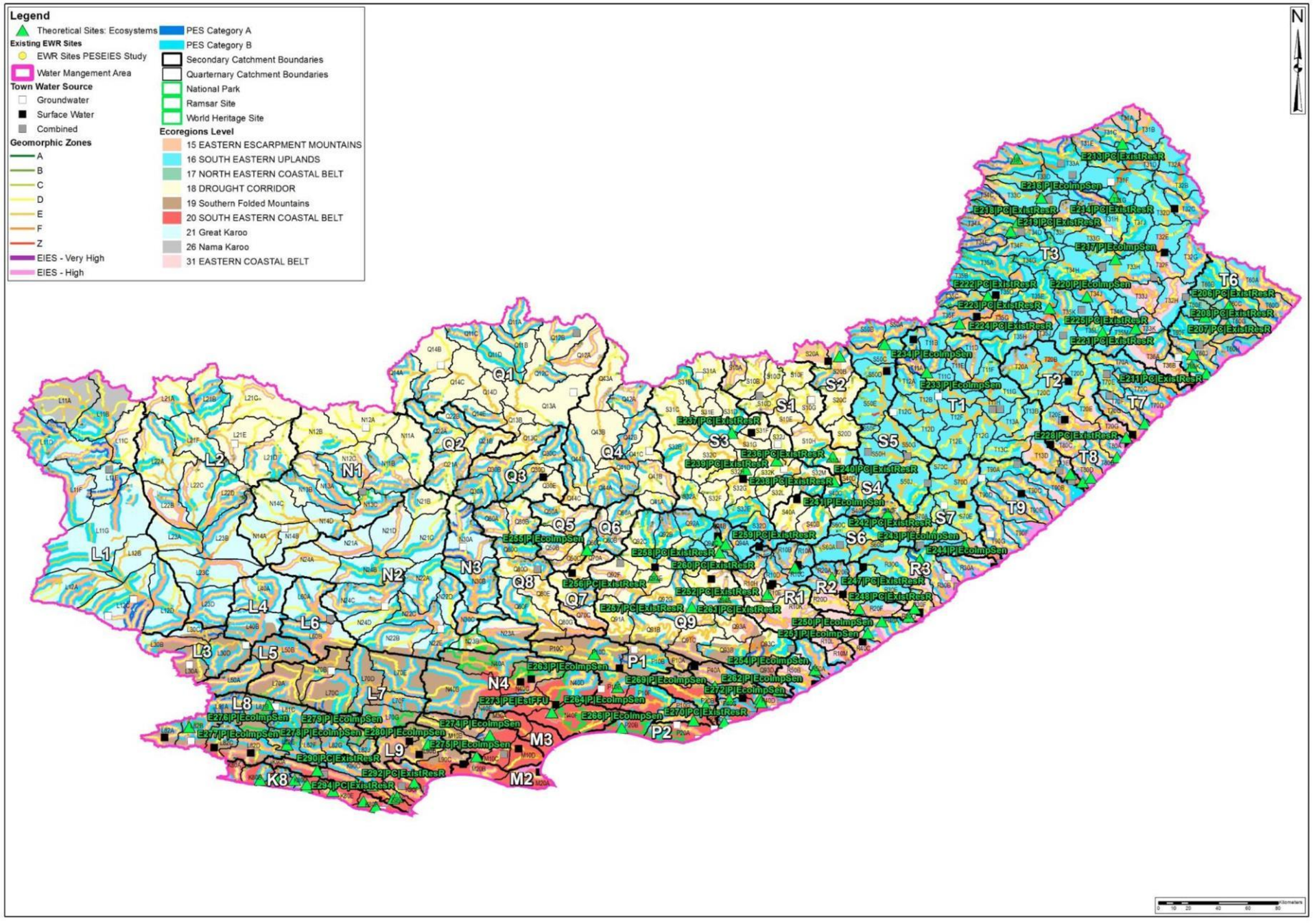


Figure A.7.36 Theoretical surface water sites based on ecosystem considerations

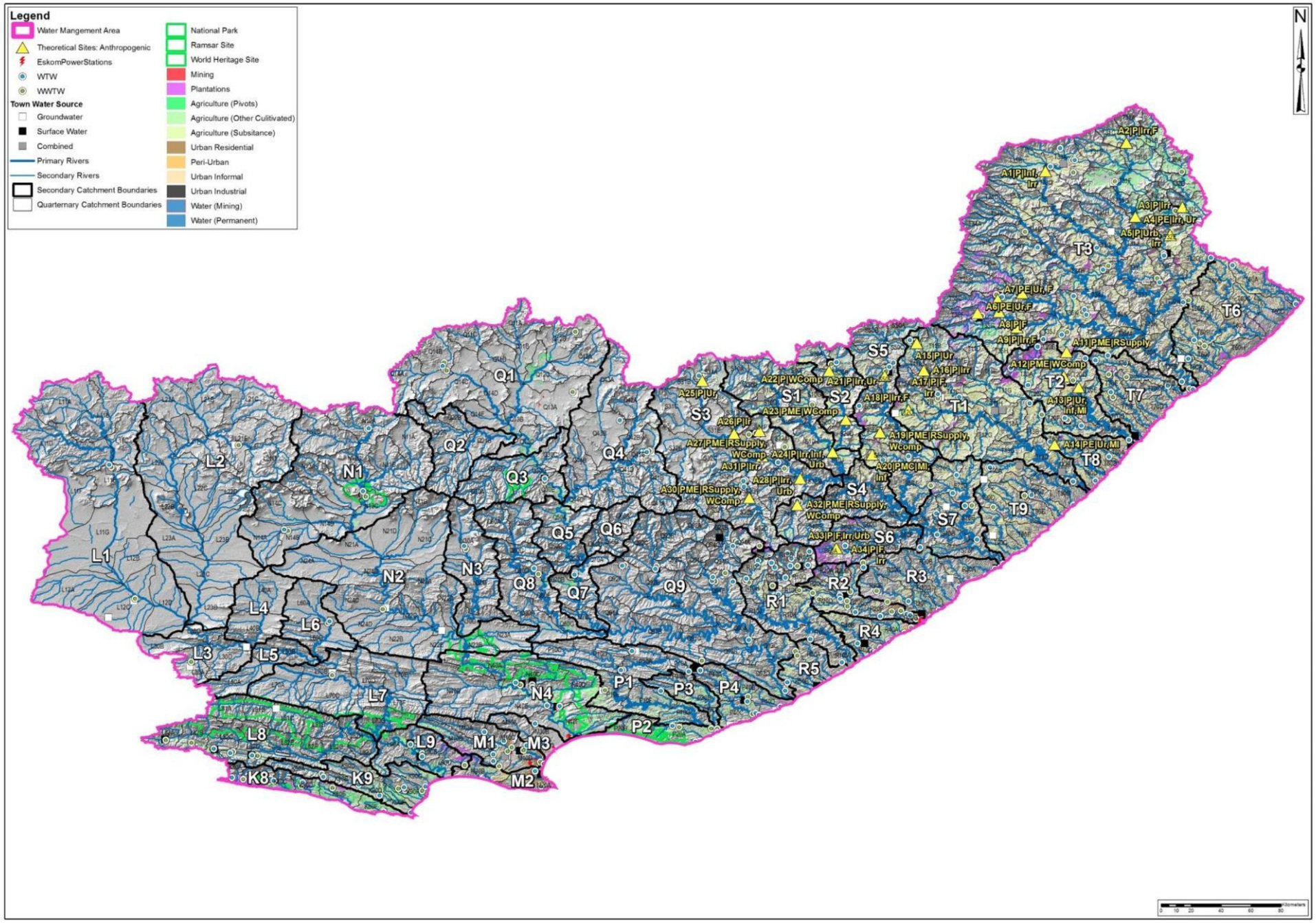


Figure A.7.37 Theoretical surface water sites based on anthropogenic considerations

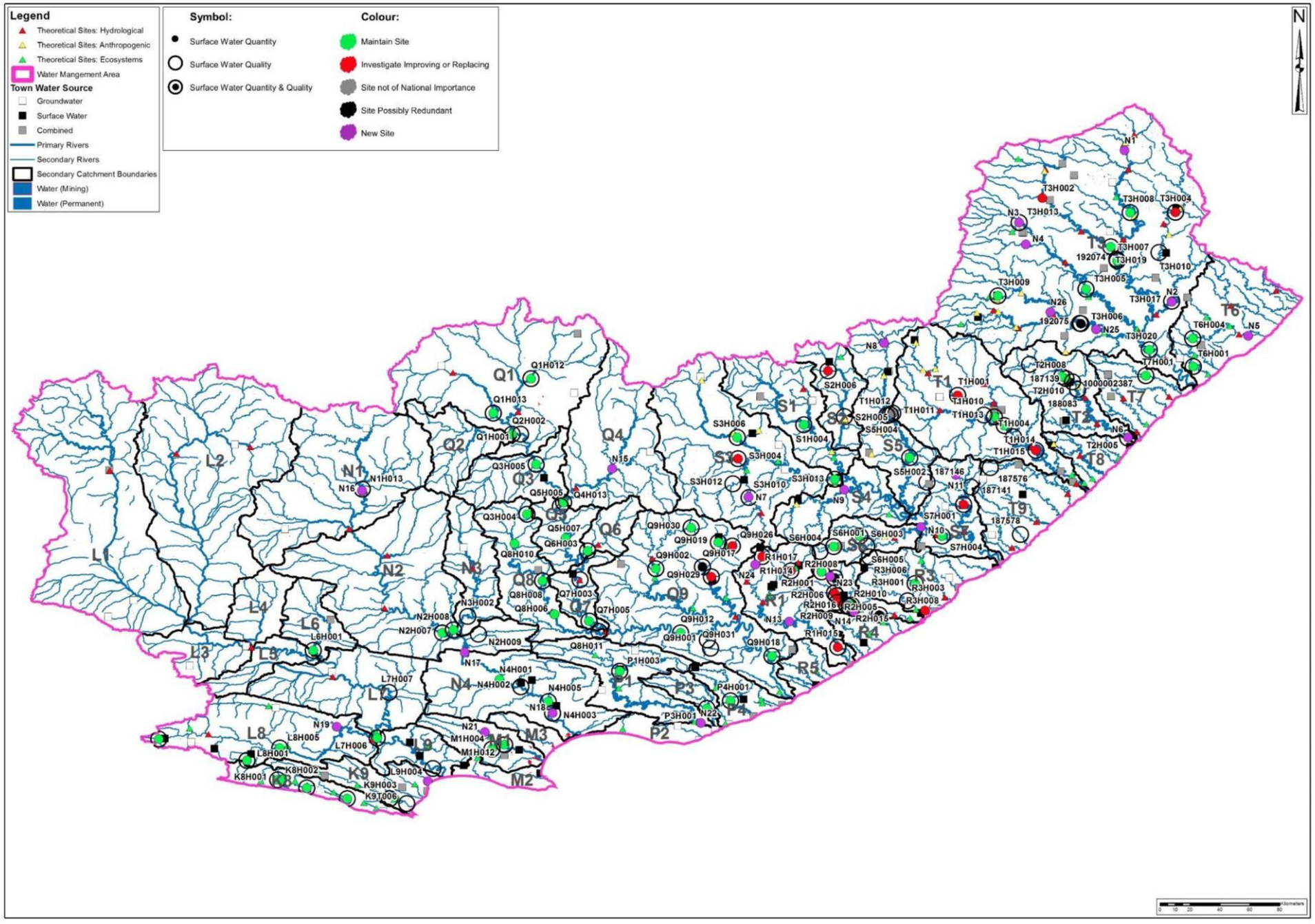


Figure A.7.38 All theoretical and actual surface water monitoring sites with recommended actions

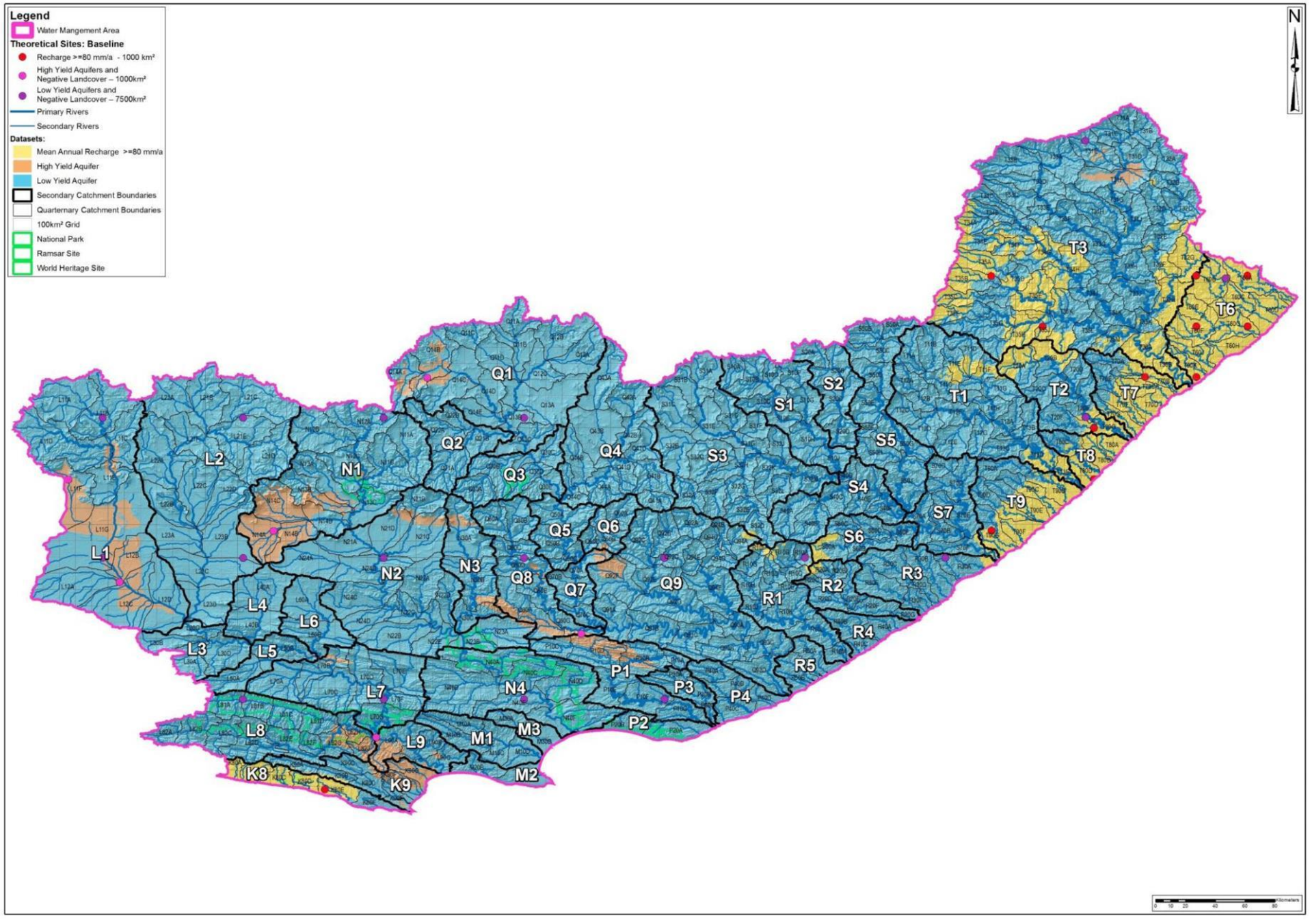


Figure A.7.39 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

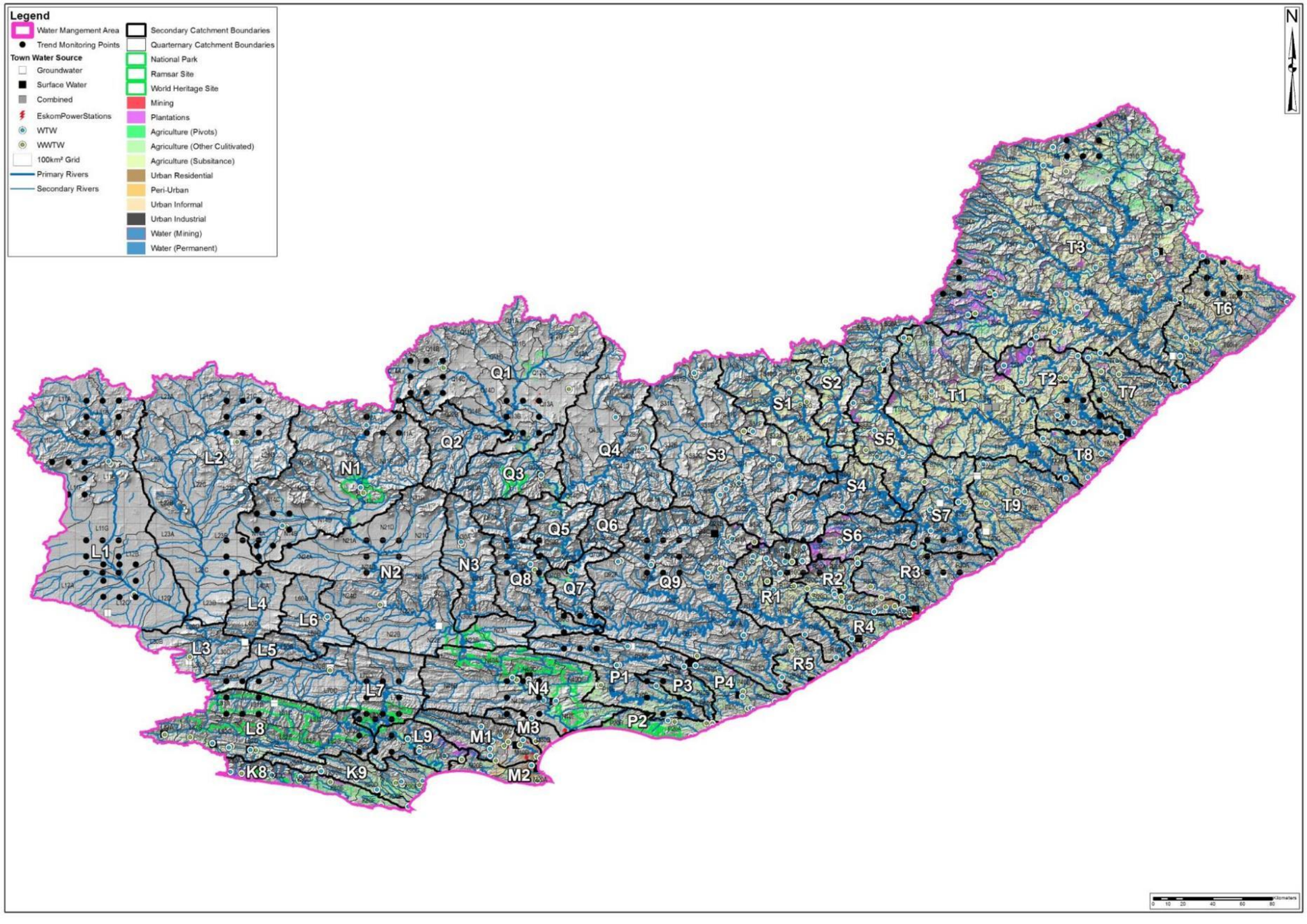


Figure A.7.40 Theoretical groundwater sites based on anthropogenic considerations (Trend)

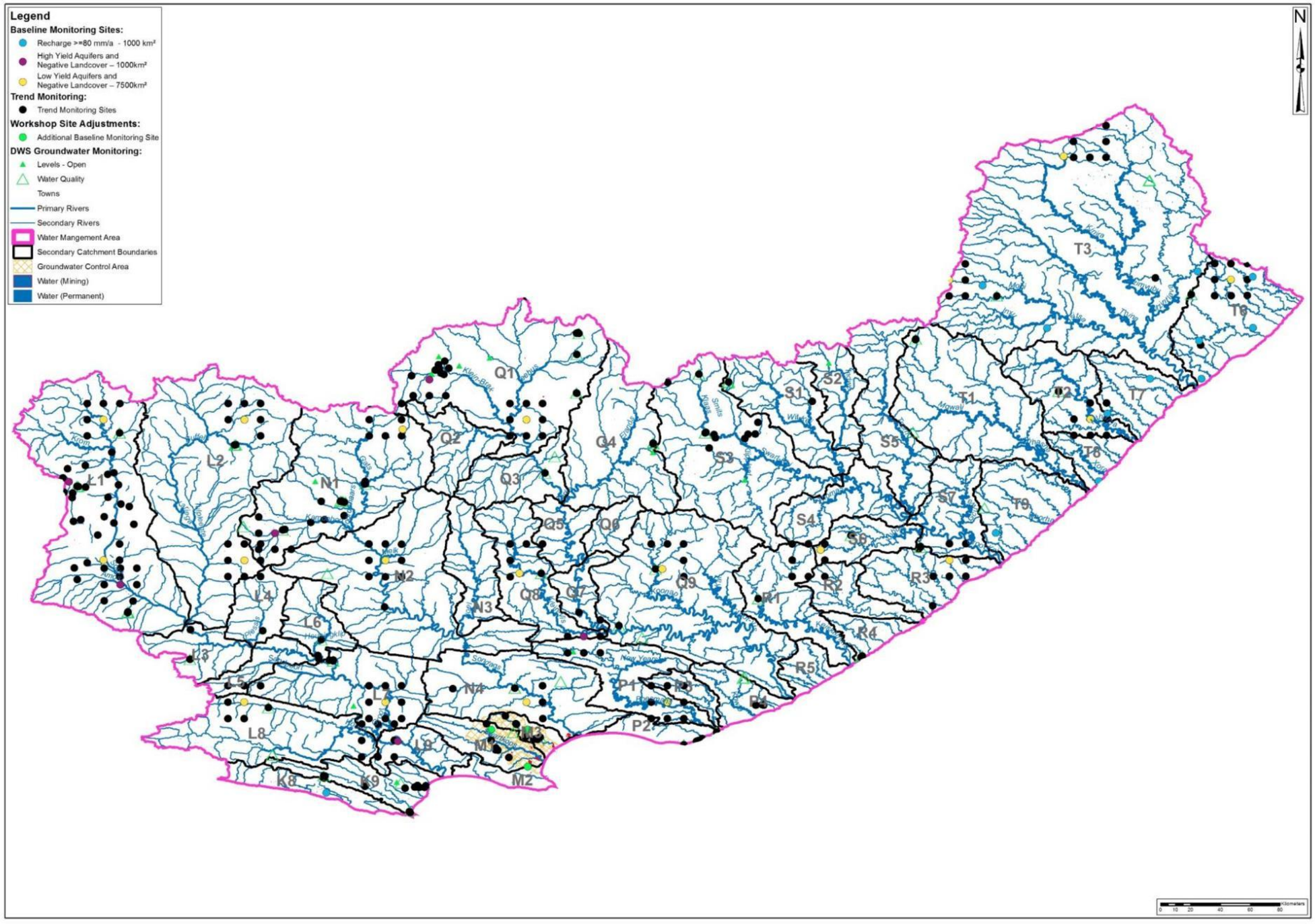


Figure A.7.41 Theoretical and exiting groundwater monitoring sites including additional recommended sites

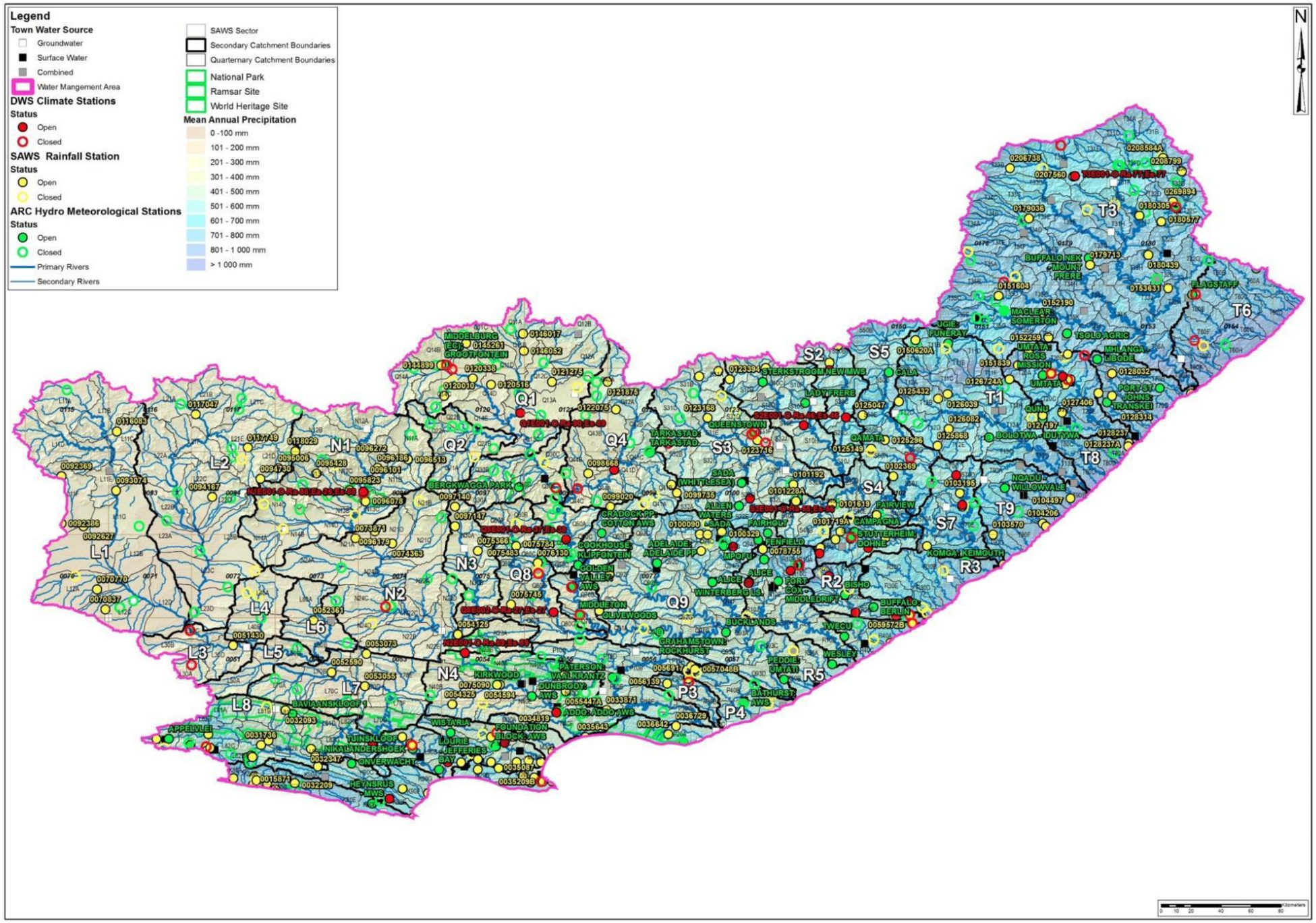


Figure A.7.42 Climatic information for the WMA

ANNEXURE 8

WMA 8: BREEDE-GOURITZ

8. WMA 8: BREEDE-GOURITZ

The Breede-Gouritz WMA is the result of the amalgamation of the previous Breede and Gouritz WMAs. The new WMA is bound by the Indian Ocean to the south, the Berg-Olifants WMA to the west, the Orange WMA to the north and the Mzimvubu-Tsitsikamma WMA to the east. It largely falls within the Western Cape Province, with small portions falling in the Eastern Cape and the Northern Cape Province (small portion of the upper catchments of the Gamka and Groot rivers) (DWS, 2013e).

The Breede-Gouritz WMA includes the catchment area of the Gouritz River and its major tributaries, as well as the catchment of the smaller coastal rivers that lie to the east and west of the Gouritz River mouth, the Breede River and the catchments of the smaller coastal rivers that lie to the west of the Breede River mouth.

There are two large rivers in the WMA, the Breede and Gouritz rivers. The Breede River, with its main tributary the Riviersonderend River, discharges into the Indian Ocean. The Gouritz has three main tributaries, the Groot, the Gamka and Olifants Rivers. There are a number of smaller rivers within the WMA, the Touws, Duivenshoks, Goukou, Hartenbos, Great Brak, Kaaimans, Knysna and Keurbooms Rivers (DWS, 2013e).

The Breede-Gouritz has widely varying precipitation levels. The precipitation ranges from 160 mm in the northern, more inland parts of the WMA to more than 3 000 mm in the high mountainous regions of the Hottentots Holland and Franschhoek.

The Great Karoo and Olifants River catchment regions are classified as very late summer rainfall regions, with large portions of annual precipitation falling between March and May and October through storm events, whereas most of the rain in the Breede valley falls between the months of May and August (DWS, 2013e).

The water resources of the Breede-Gouritz WMA occur in four distinctly different zones. The area that used to be the Gouritz WMA is characterised by the flat open plains of the Great and Klein Karoo, interrupted by steep mountain ranges oriented in an east-west direction which give it three distinct zones of the semi-arid Great Karoo, the Olifants River and coastal belt. The former Breede WMA is characterised by the rolling hills of the Overberg, the Hex River Mountains to the north, the Langeberg Mountains in the east and the Franschhoek and Du Toit's Mountains in the west, which flank the wide Breede River valley.

In terms of groundwater management, the Table Mountain Group (TMG) aquifer holds significant potential and has been investigated and developed by the Overstrand Municipality, the Koo WUA and potential by Oudtshoorn as an option to augment their existing sources of bulk supply.

The TMG aquifer, situated within the Hottentots-Holland, Franschhoek and Du Toit's Mountain ranges are also being evaluated to augment the bulk supply for the Western Cape Water Supply System (Ninham, 2004).

Due to the naturally saline geology of and the diffuse return flows from the irrigated farmlands that wash-off fertilisers and leach natural salts in the area, the surface water of the Breede River is affected by salinity. Elevated salinity occurs naturally over the inland catchments of the Great and Little Karoo as a result of the geology of the area and high evaporation rates.

Point source pollution such as the discharge of inadequately treated wastewater effluent from wastewater treatment works (WWTWs), and irrigation with treated, partial and/or untreated winery, dairy farming, piggery, cheese production and other industrial effluent are further concerns that have an impact of the water quality in the Breede-Gouritz River. In the developed urban areas, particularly the more densely populated coastal towns, manmade interventions result in problems commonly associated with urban water use. These include discharge of water containing waste, WWTW not meeting their required water quality standards for discharge, and point discharge through storm water and/or diffuse pollution from informal settlements (Ninham, 2004).

8.1 REVIEW OF SITES

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and recommendations from the design review workshop in more detail.

8.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Breede-Gouritz WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. Error! Reference source not found. provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

Table 8.1 Number of surface water quantity monitoring sites per secondary catchment

Catchment[(1)]	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River Flow	Dam Volumes	Tidal	Total
G4	10	1	0	6	7	5	6	**25**
G5	5	0	0	0	1	0	2	**3**
H1	18	4	0	1	7	2	0	**14**
H2	4	4	0	2	6	2	0	**14**
H3	10	1	0	1	2	2	0	**6**
H4	25	3	0	1	4	3	0	**11**
H5	3	0	0	0	1	0	0	**1**
H6	10	4	0	1	4	2	0	**11**
H7	4	2	0	2	5	1	1	**11**
H8	1	0	0	0	2	1	0	**3**
H9	0	2	0	1	4	1	1	**9**
J1	14	3	0	1	8	4	0	**16**
J2	14	4	0	1	6	5	0	**16**
J3	27	5	0	1	11	2	0	**19**
J4	2	0	0	0	2	0	0	**2**
K1	4	0	0	1	6	1	2	**10**
K2	5	0	0	1	2	2	1	**6**
K3	2	0	0	0	9	4	1	**14**
K4	1	0	0	0	2	2	0	**4**
K5	1	0	0	0	2	0	1	**3**
K6	1	0	0	0	3	1	2	**6**
K7	0	0	0	0	1	0	1	**2**
Totals	**161**	**33**	**0**	**20**	**95**	**40**	**18**	**206**

According to Error! Reference source not found., there are 95 active river flow and 40 reservoir monitoring sites in the Breede-Gouritz WMA that was evaluated at the workshop to determine redundancy, not being of national importance, while others would require upgrades or to be replaced with new sites.

The number of sites with water quality constituents being monitored in the Breede-Gouritz WMA is provided in **Table 8.2**.

Table 8.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed sites	Number of open sites / monitored variables								
		Chemical	Chemical [1] (Priority Sites)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total sites[2]
G4	**1**	7	2	0	23	0	0	1	0	**33**
G5	**0**	0	2	0	13	0	0	0	0	**15**
H1	**1**	8	2	0	7	0	0	2	0	**19**
H2	**0**	8	1	0	0	0	0	1	0	**10**
H3	**0**	3	0	0	0	0	0	0	0	**3**
H4	**0**	10	3	0	0	0	0	2	0	**15**
H5	**0**	3	2	0	0	0	0	0	0	**5**
H6	**0**	4	1	0	0	3	0	0	0	**8**
H7	**0**	4	1	0	0	0	0	0	21	**26**
H8	**0**	1	1	0	0	0	0	1	0	**3**
H9	**0**	5	1	0	5	0	0	1	0	**12**
J1	**0**	8	3	0	0	0	0	0	0	**11**
J2	**0**	12	2	0	0	0	0	0	0	**14**
J3	**2**	11	1	0	0	0	0	3	0	**15**
J4	**0**	1	1	0	2	0	0	0	0	**4**
K1	**0**	3	2	0	4	0	0	1	0	**10**
K2	**0**	5	1	0	0	0	0	0	0	**6**
K3	**0**	10	2	0	0	0	0	5	0	**16**
K4	**0**	3	2	0	0	1	0	1	0	**6**
K5	**0**	1	1	0	0	0	0	1	0	**3**
K6	**0**	2	1	0	0	0	0	1	0	**4**
K7	**0**	0	1	0	0	0	0	0	0	**1**
Totals	**4**	**109**	**33**	**0**	**54**	**4**	**0**	**20**	**21**	**239**

Notes:

(1) Priority sites are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

As can be seen from **Table 8.2** the main water quality programmes in the WMA include Chemical, Wetland, Eutrophication Microbial and Estuarine monitoring. As stated earlier, the water quality parameters and frequencies will be reviewed during the strategy development and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

8.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 8.4**

8.3.1 River sites with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The sites were not seen as redundant or needing to be upgraded. Reported in **Table 1.3** are the theoretical objectives that have been assigned to these existing river sites.

8.3.2 New river sites

The monitoring sites described in this section are those identified as no longer being able to function adequately and must therefore be replaced, as well as new monitoring points that are recommended for areas where no monitoring is currently taking place.

Table 8.3 Objectives and relative priorities assigned to existing river monitoring sites with no recommended actions

Site Number	Description	Theoretical objective	Relative Priority[#]
K3H001	Duiwe River @ Klein Krantz	PEC|ExistResR,HR	8.0
K5H002	Knysna River @Milwood Forest Res	PEC|ExsitResR,UpPA	8.0
G4H030	Palmiet River @ Monteith @ Krabbe Fontein	PE|ExistResR,UpPA	7.0
K4H002	Karatara River @ Karatara Forest Res	PC|ExistResR,BaselineSen&PA	6.0
K1H005	Moordkuil River @ Banff	PC|ExistResR,HR	6.0
K7H001	Bloukrans River @ Lotterings For. Res	PC|ExistResR	5.5
K4H003	Diep River @ Woodville Forest Res	PC|ExistResR	5.5
H3H011	Kogmanskloof River @ Gold mine	P|Ir, Ur, Base	5.5
H4H017	Bree River @ Le Chasseur	PC|ExistResR	5.5
H1H018	Molenaars River @ Hawequas Forest Res	PC|ExistResR	5.5
H2H006	Hex River @ Glen Heatlie	P|HR,Base,Ir	5.5
H1H007	Wit River @ Drosterskloof	P|BaselinePA,EcoImpSen,Base	5.5
J4H002	Gourits River @ Zeekoedrift	PC|ExistResR	5.5
J1H018	Touws River @ Okkerskraal	PC|ExistResR	5.5
K5H003	Knysna River @ Charlesford	P|PriorEstReq, HR	5.0
K3H005	Touws River @ Farm 162	P|PriorEstReq,Base	5.0
H6H009	Riviersonderend @ Reenen	P|Base,Ir	5.0
G4H006	Klein River @ Hagedisberg Outspan	P|EstReq,Base	5.0
K6H019	Keurboom River @ Newlands	P|Base,PrioirEstReq	5.0
H3H005	Keisie River @ Keisiesdoorn	P|Base	4.5
H2H004	Sanddrifskloof River @ Zandrifts Kloof	P|Base	4.5
J2H010	Gamka River @ Huis River	P|Base	4.5

[#] *Sites are listed in descending order based on relative priority*

Reported in

New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 1.4** are all the proposed monitoring sites for the Limpopo WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

8.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, site descriptions, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 1.4 are all the proposed monitoring sites for the Breede-Gouritz WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed sites.

Table 8-4 Proposed new river monitoring sites

Site number	Latitude*	Longitude*	Theoretical objective	Comment	Relative Priority#
N6	-34.071	19.613	PMC|ExistRes R, Ir, Ur, WWTW	-	10.0
N15	-34.410	19.193	PME|EstFFU	-	9.5
N9	-34.271	21.299	PE|EstFFU,Base	Monitoring point recommended at the outlet of quaternary catchment H90D for hydrological and ecological purposes.	7.0
N8	-34.240	20.985	PC|ExistResR, EcoImpSen	This monitoring point is recommended as a replacement for H8H001 and will thus take on the theoretical objectives assigned to this site.	6.0
N10	-34.093	21.294	PC|ExistResR, EcoImpSen	This monitoring point is recommended as a replacement for H9H005 and will thus take on the theoretical objectives assigned to this site.	6.0
N1	-33.643	19.308	P|Base		4.5
N2	-33.703	19.232	P|Base		4.5
N4	-33.791	19.781	P|Base	Base flow monitoring recommended for the Vink River for planning purposes.	4.5
N7	-34.350	20.752	P|Base	Monitoring point recommended at the outlet of quaternary catchment H70J. This takes into consideration the Slang and Karringmelks rivers.	4.5
N11	-33.992	22.830	P|HR	Monitoring point recommended at the outlet of quaternary catchment K40C for hydrological purposes. This take into consideration the Huis River and the high runoff generated in the upper reache of the Karatara River.	4.5
N12	-34.035	22.989	P|EstFFU	-	4.5
N13	-34.010	23.369	P|Base	A monitoring site is recommended for the quaternary catchment K60F on the Bietou river. No monitoring is currently taking place on this river.	4.5
N14	-34.020	21.578	P|Base	This monitoring point is recommended as a replacement for J4H003 and will thus take on the theoretical objectives assigned to this site.	4.5

Notes:

* *These are proposed coordinates and must be investigated further in order to determine whether they are feasible for the placement of monitoring sites.*

* *Sites are listed in descending order based on relative priority*

8.3.4 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, coordinates, assigned theoretical objectives as well as problems associated with the monitoring sites.

Table 8.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Rel. Priority[#]
G4H014	Bot River @ Roode Heuvel	PEC|Base,PriorEstReq	Very important site for estuarine requirements.	8.0
G4H007	Palmmiet River @ farm 562-Welgemoed	PC|ExistResR,EstFFU+1,HR,Base	Very important station, with possible need for improvement. Investigate.	7.5
H1H006	Bree River @ Ceres Toeken Geb.	PE|Ir, HR, Base	Recordings made by this site are not accurate.	7.5
H1H009	Holsloot River @ Boontjies River	PE|Ir, WWTW	This is an inaccurate site and requires constant calibration.	7.0
H1H003	Bree River @ Ceres Toeken Geb.	PC|WWTW, HR, Base	This is a very old site and has low accuracy when recording high flows.	6.5
K1H004	Brandwag River @ Brandwacht	PE|PriorEstReq	Very important site for estuarine requirements.	6.5
J3H011	Olifants River @ Warm Water	P|PosResR, Base	-	5.0
K3H003	Maalgate River @ Knoetze Kama	P|HR, Base	This site doesn't measure high flows and must be investigated for upgrade.	5.0
H4H018	Poesjenels River @ Le Chasseur	-	This site is subjected to variable submergence during winter. This site must be investigated for improvement.	-
H4H016	Keisers River @ Mc Gregor Toeken Geb.	-	This site has sedimentation problems.	-
J4H003	Weyers River @ Weyers River	-	Make redundant if investigation for a new site occurres.	-

[#] *Sites are listed in descending order based on relative priority*

8.3.5 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Reported in

Table 8.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 8.6 Monitoring sites that are not of national importance

Site Number	Description	Comments
H2H008	Valsgat River @ Hottentots Kraal	Operational site.

8.3.6 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to sever deterioration of the sites, poor quality data produced by the sites or due to the sites being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, coordinates and comments that resulted in the sites classification.

Table 8.7 Redundant river flow monitoring sites

Site number	Description	Comment
K2H002	Great-Brak River @ Wolvedans	Station needs to be closed.
K3H007	Rooi River @ George	Redundant and possibly close station.
K1H018	Beneke River @ Pine Grove Forest	Currently only being used for high flows.
H8H001	Duiwenhoks River @ Dassjes Klip	Make redundant after replaced by N8.
H9H005	Goukou River @ Farm 216	Make redundant after replaced by N10.
H9H004	Goukou River @ Farm 216	Station is redundant.
J1H015	Bok River @ Lot B	Possibly redundant.
J1H016	Gamka River @ Spek Boom Berg	Possibly redundant.

The proposed sites and assigned objectives are described in detail in **Section 8.3.2.**

8.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must therefore be monitored efficiently. Listed in **Table 8.8** are all the required W-components as well as changes and potential improvements to existing reservoir monitoring within the WMA**.**

Table 8.8 New W-component for dams

Site number	Lat	Long	Theoretical objective	Comment	Rel. Priority
N3	-33.6	19.7	PME|W-Comp	A W-component is recommended for Keerom Dam in order to improve the accuracy of the balance calculations for this dam.	9.5
N5	-33.9	20.4	PME|W-Comp	A W-component is recommended for Poortjieskloof Dam in order to improve the accuracy of the balance calculations for this dam.	9.5

In addition to potential stations, there are recommendations made with regards to existing reservoir monitoring stations. These are reported in **Table 8.9**.

Table 8.9 Reservoir monitoring sites that require changes

Site number	Description	Comments
G4R010	Onrus River @ Hemel En Aarde	Investigation must be conducted into the possible calibration of the spills on this dam.

K2R001	Groot Brak R.@Brakrivierssprui ten(Ernest Robertson Dam)	Possibly redundant monitoring.

8.5 ESTUARIES

The Breede-Gouritz WMA's 22 estuaries that falls within the top 20% of estuaries in the country according to a ranking system developed by the RQIS. This study (DWS, 2002) devised a method for prioritising South African estuaries on the basis of conservation importance, and presented the results of a ranking based on the collation of existing data for all South African estuaries. Estuaries are scored in terms of their size, type and biogeographical zone, habitats and biota (plants, invertebrates, fish and birds).The identified estuaries include:

a) Top 10% estuaries

- Bot Estuary
- Breede Estuary
- Groot Brak Estuary
- Heuningnes Estuary
- Keurbooms Estuary
- Klein Estuary
- Knysna Estuary
- Piesang Estuary
- Swartvlei Estuary
- Uilkraals Estuary
- Wilderness Estuary

b) Top 20% Estuaries

- Goukamma Estuary
- Goukou Estuary
- Gourits Estuary
- Groot West Estuary
- Hartenbos Estuary
- Kaaimans Estuary
- Klein Brak Estuary

- Noetsie Estuary
- Onrus Estuary
- Palmiet Estuary
- Rooiels Estuary

The first eleven estuaries fall under the top 10% of estuaries in the ranking systems and all, with the exception of the Swartvlei Estuary, have tidal sites. Four of the eleven top 20% estuaries do not, but it is not deemed important that tidal sites are installed here. River inflow measurements to the top 10% of the estuaries were prioritised during the river site analysis.

8.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.8.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendation of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

8.7 GROUNDWATER MONITORING

The current groundwater monitoring network Breede-Gouritz WMA focus on the general aquifer status (Smart, 2016).

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring site points does not plot on top of mountains.
- Increase spatial density over G primary catchment to 1 000 km^2 so as to generate a set of baseline monitoring points in the primary catchment in pristine areas.
- Set up trend monitoring sites around the newly generated baseline monitoring points in Primary Catchment G.
- Convert current groundwater level monitoring point G4N0013 to baseline groundwater monitoring point.
- Convert current groundwater level monitoring point G4N0012 to baseline groundwater monitoring point.
- Remove protocol for monitoring points around towns except for Bredasdorp which is a future hotspot area.
- Convert G4N0006 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert G4N003 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert G4N004 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert ZQMCAL1-N40|GO-V38-F24W to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert ZQMBRD1-N24|GO-V38-F24W to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Increase spatial densities to 1 000 km^2 over the Hex River / Agter Witzenberg valleys to generate additional baseline monitoring sites.
- Convert ZQMGBW1-N4|GO-V18-F24W to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H6N0003 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert E2N0001 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H1N0045 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.

- Convert H1N0033 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H1N0038 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H2N0521 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert G5N0009 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H4N0050 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H4N0070 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H4N0002 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert H4N0048 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert ZQMONT1-N37|GO-V18-F24W to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Convert G1N0450 to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Increase spatial densities to 1 000 km^2 around the hydraulic fracturing areas and the areas identified for uranium exploration.
- Convert to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- Increase spatial density to 1 000 km^2 over primary catchment K to set baseline monitoring sites.
- Convert to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.
- ZQMGRG1-N42|GO-V38-F24W

J1N0520	ZQMWSB1-N47|GO-V38-F24W
J1N0524	ZQMVRR1-N35|GO-V18-F24W
J2N0550	ZQMTOO1-N21|GO-V18-F24W
J2N0552	ZQMBWW1-N44|GO-V38-F24W
J2N0563	ZQMWRB1-N39|GO-V38-F24W
J2N0572	ZQMWVL2-N30|GO-V38-F24W

J2N0576	ZQMOUQ1-N29|GO-V18-F24W
J2N0591	ZQMPAL1-N23|GO-V18-F24W
J2N0596	ZQMLEU1-N39|GO-V38-F24W
J2N0618	ZQMKUP1-N34|GO-V38-F24W
J2N0618	ZQMKGT1-N18|GO-V18-F24W
J2N0621	
J2N0623	
J3N0057	
J3N0062	
J3N0065	
J3N0069	
J3N0071	
J3N0076	
J3N0077	
J3N0103	
J3N0104	
J3N0121	
J3N0126	
J3N0128	
J3N0129	

APPENDIX A.8

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 8: BREEDE-GOURITZ

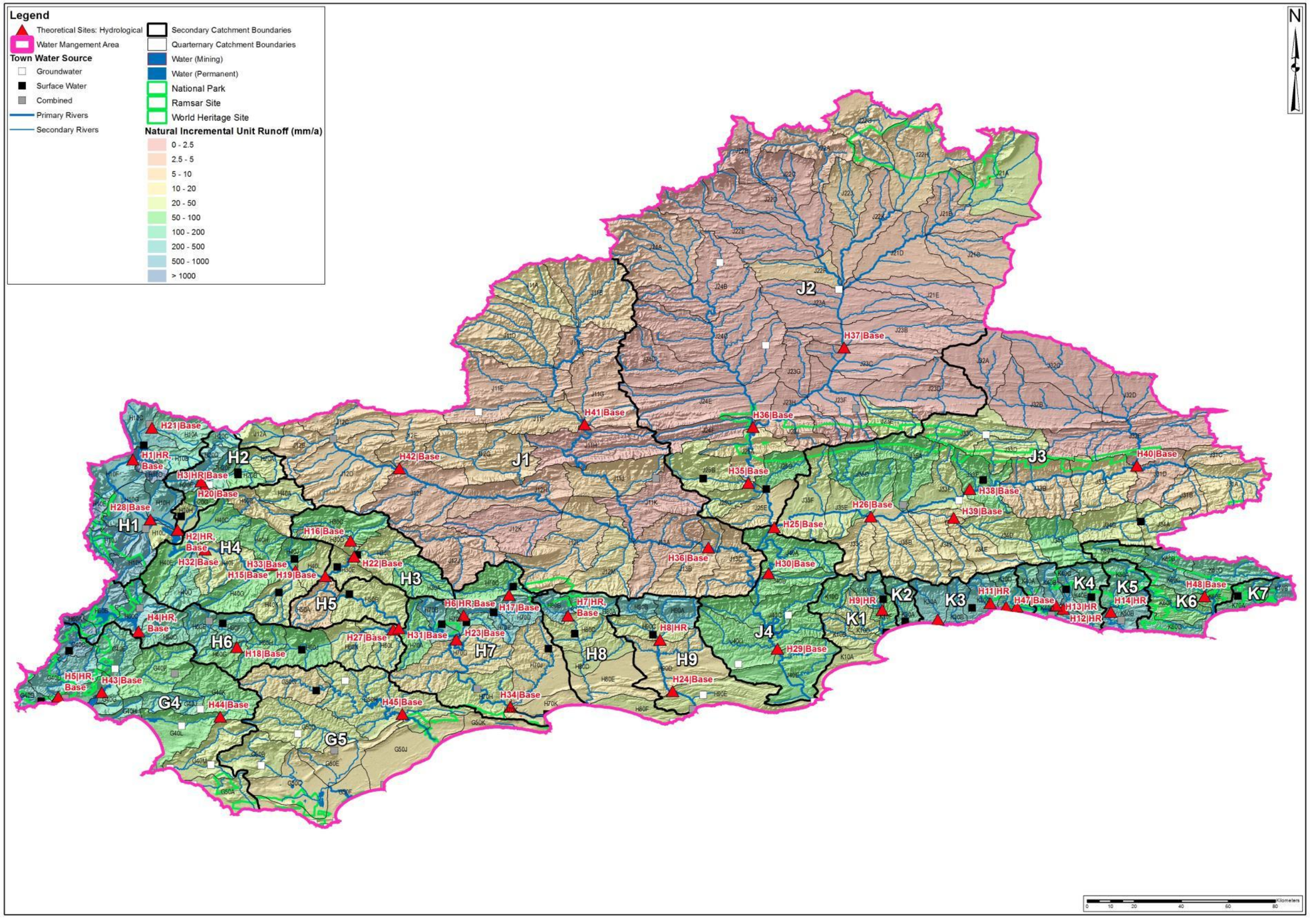


Figure A.8.43 Theoretical surface water sites based on hydrological (runoff) considerations

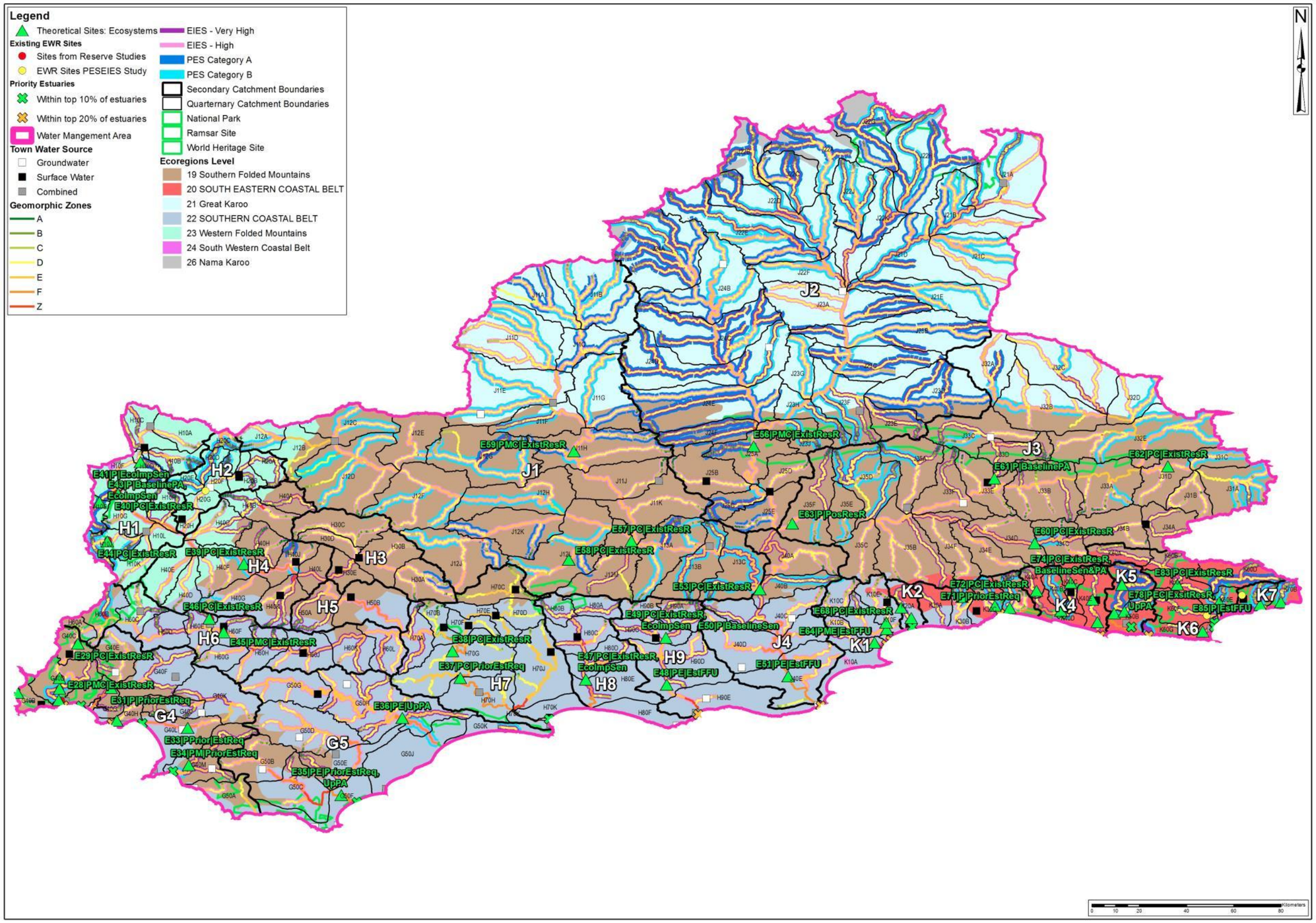


Figure A.8.44 Theoretical surface water sites based on ecosystem considerations

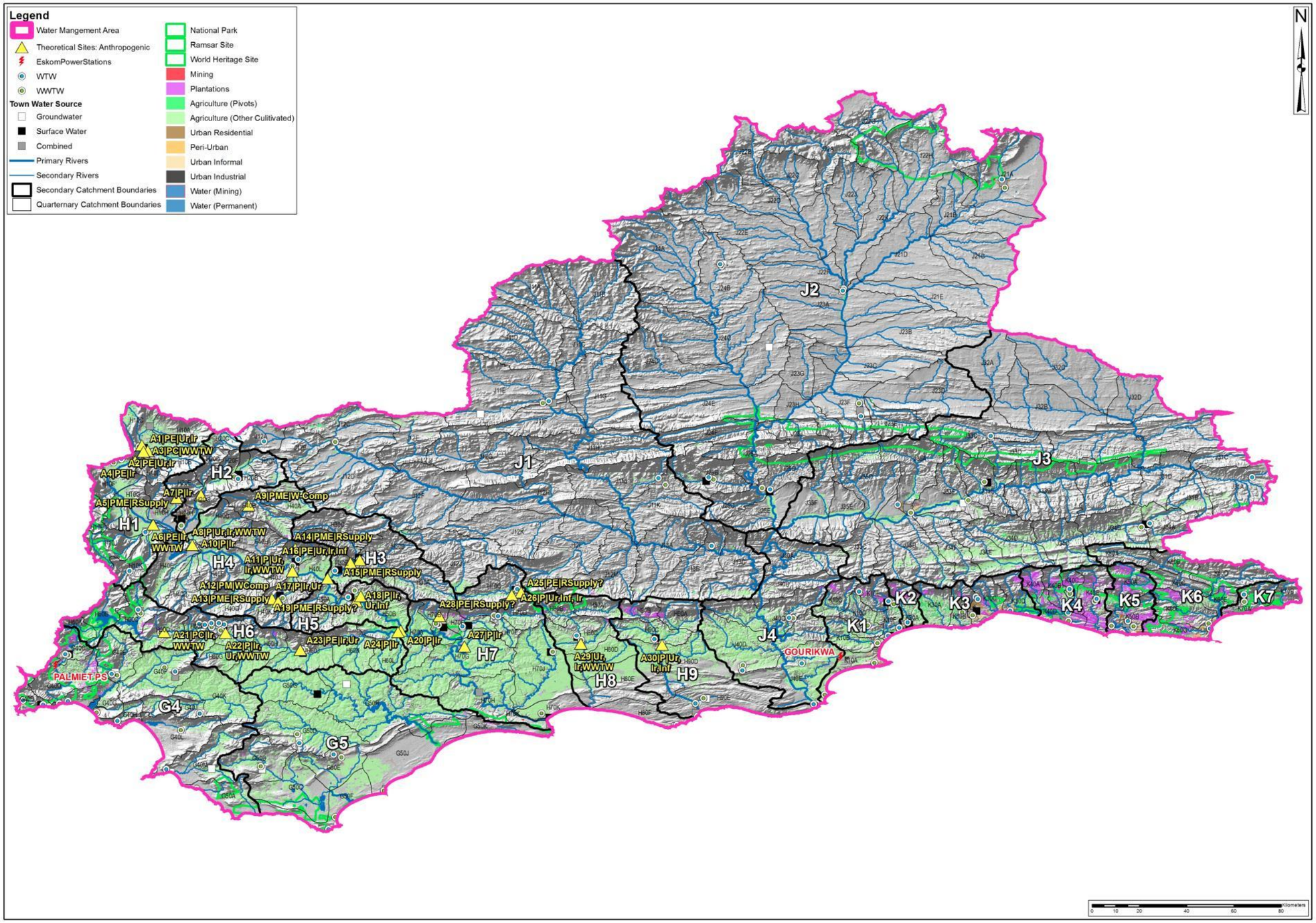


Figure A.8.45 Theoretical surface water sites based on anthropogenic considerations

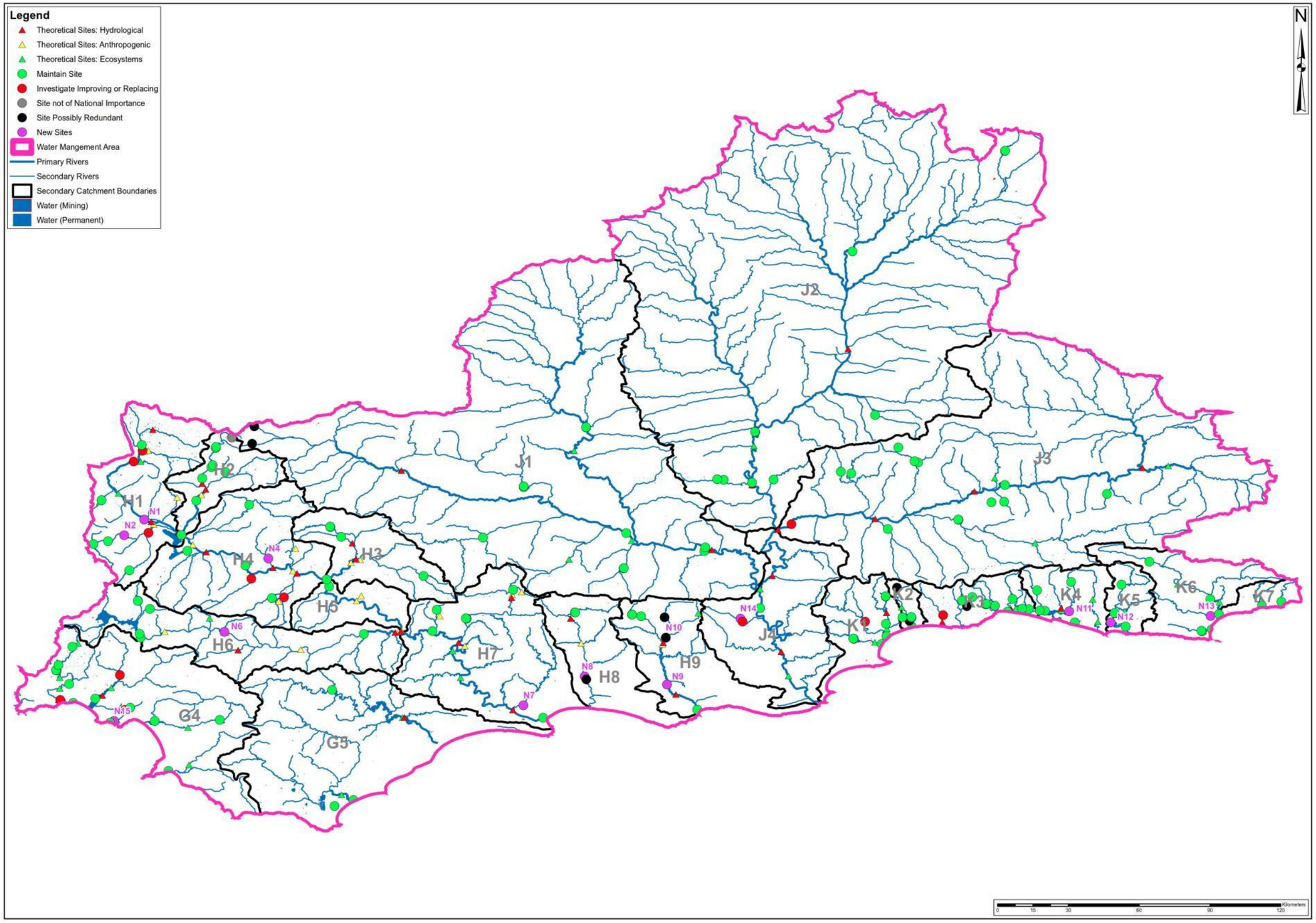


Figure A.8.46 All theoretical and actual surface water monitoring sites with recommended actions

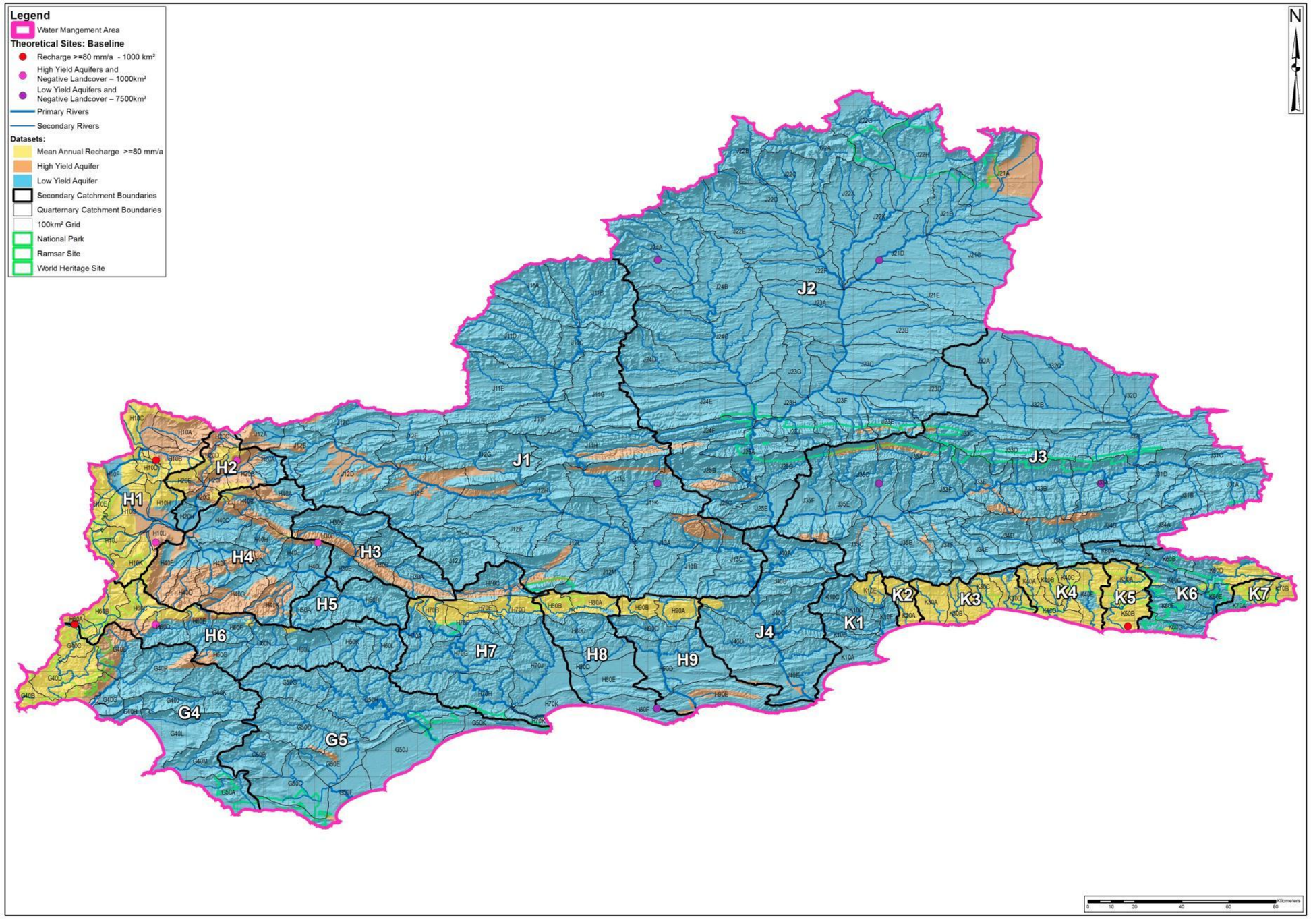


Figure A.8.47 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

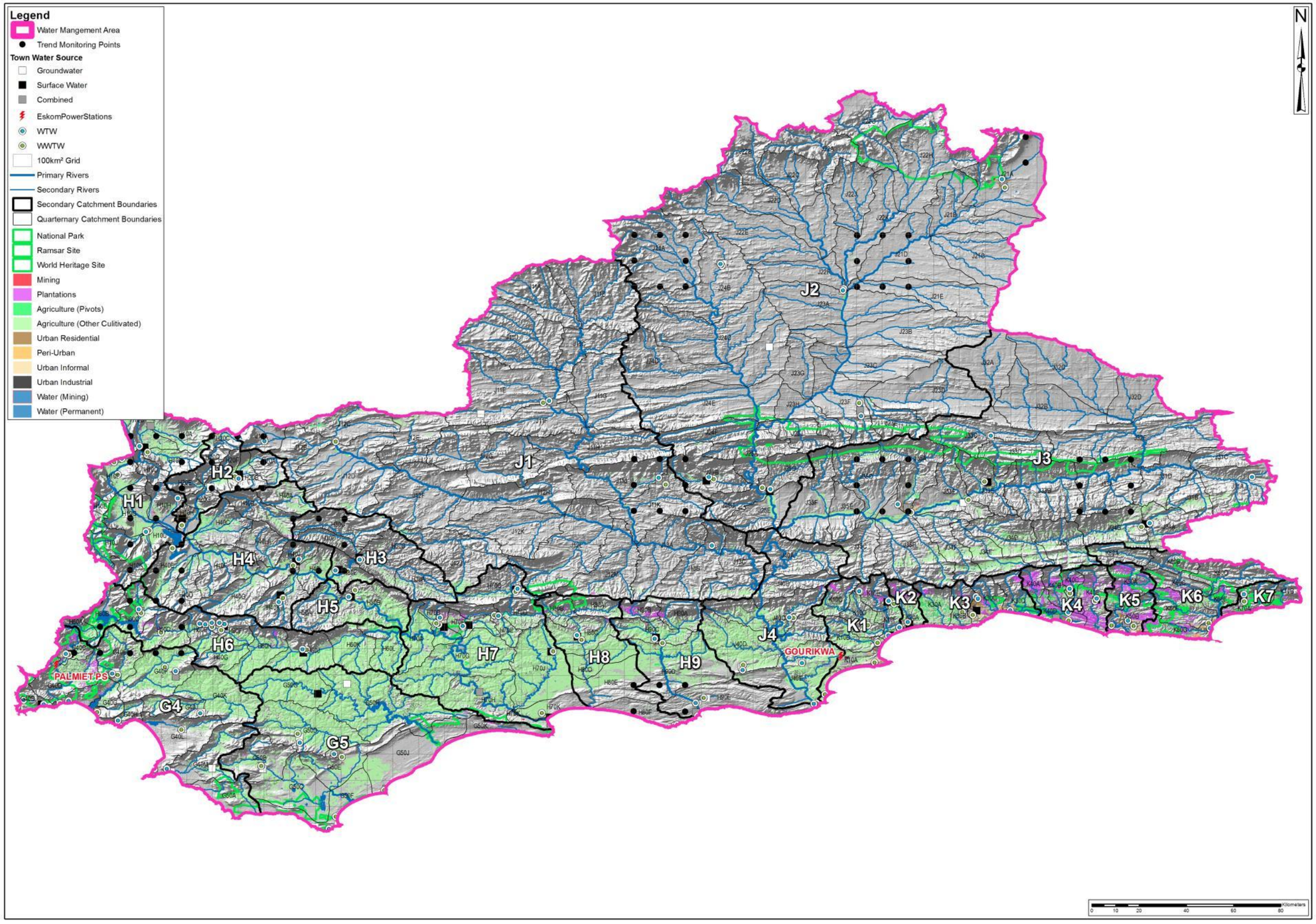


Figure A.8.48 Theoretical groundwater sites based on anthropogenic considerations (Trend)

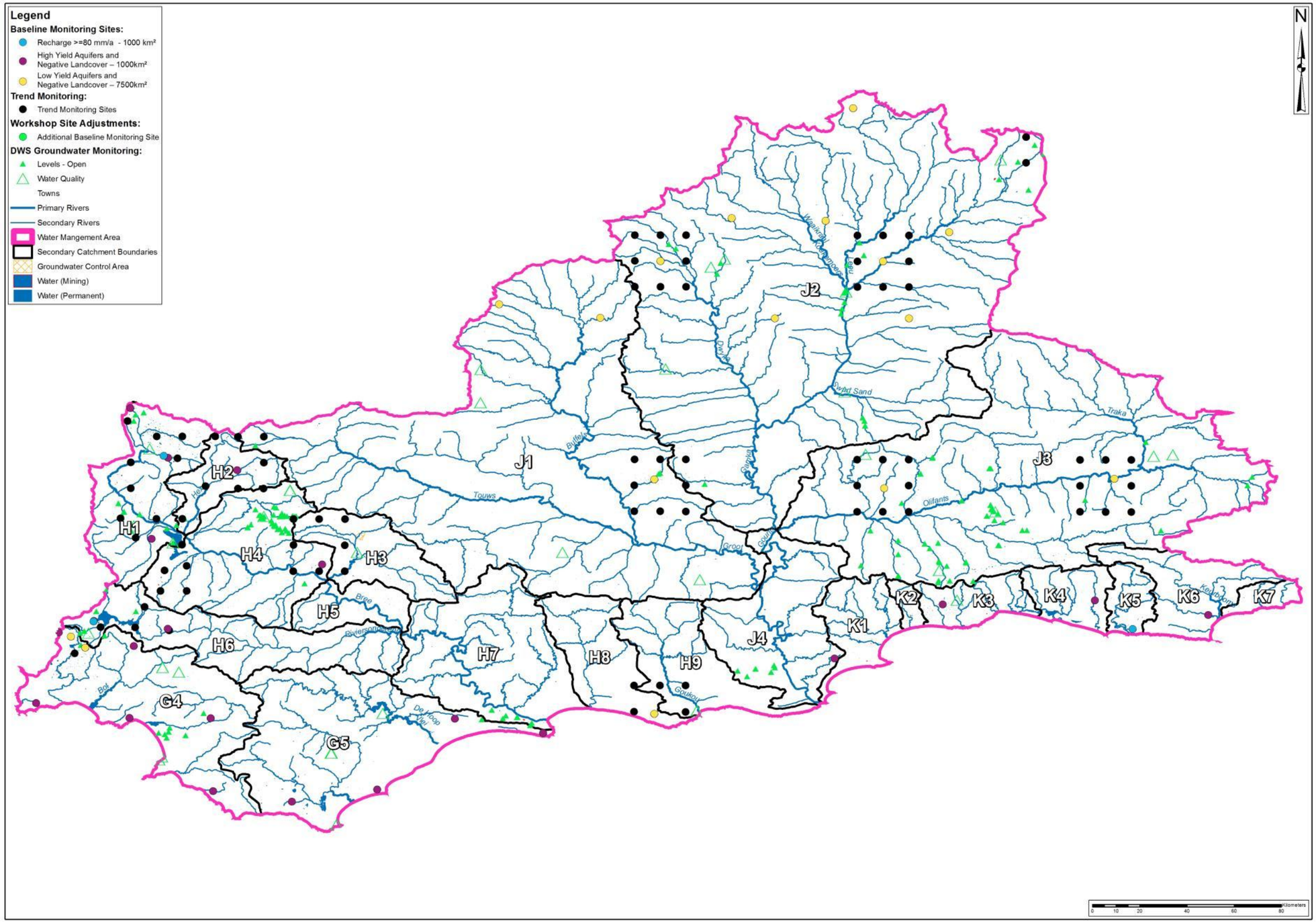


Figure A.8.49 Theoretical and exiting groundwater monitoring sites including additional recommended sites

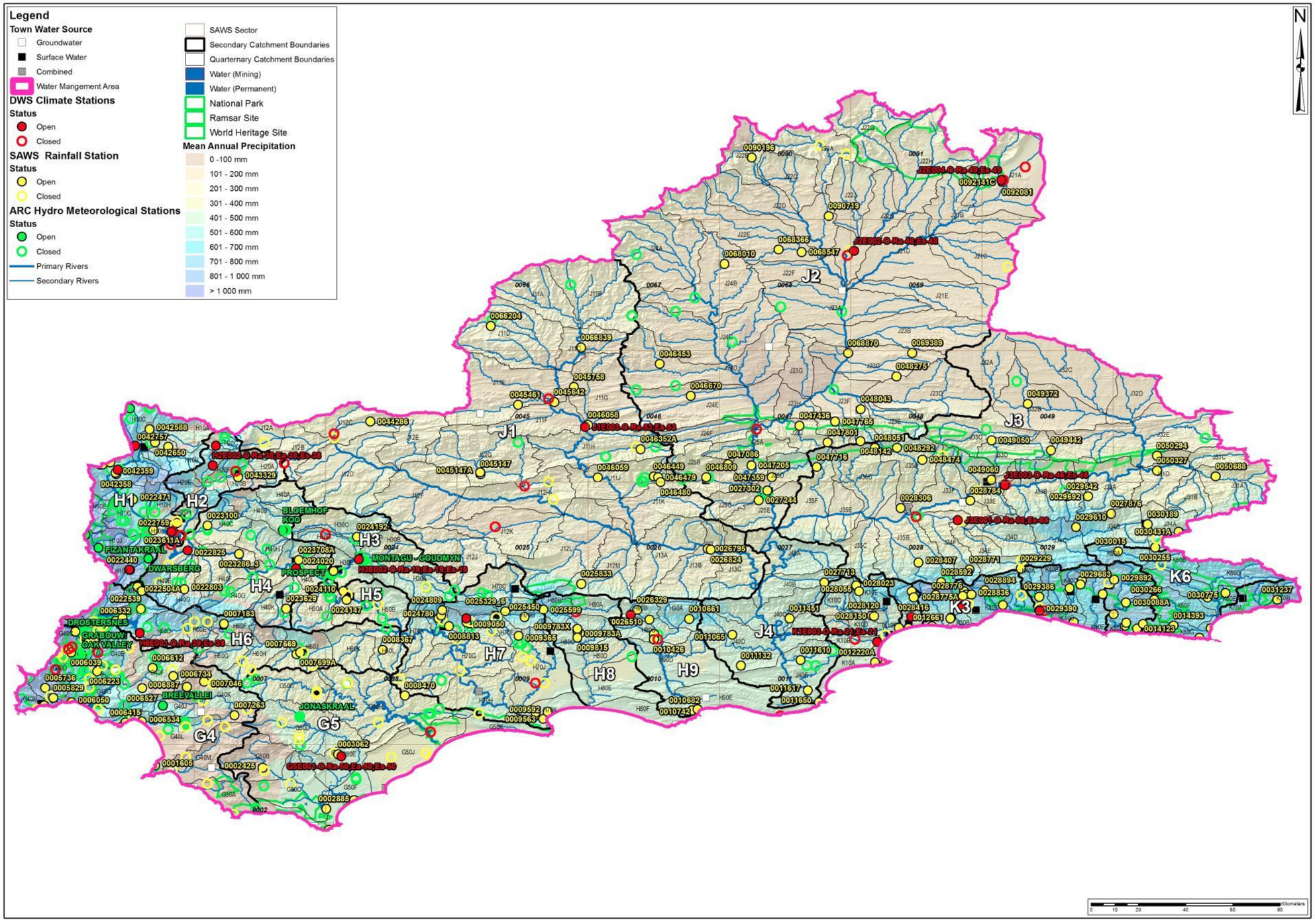


Figure A.8.50 Climatic information for the WMA

ANNEXURE 9

WMA 9: BERG-OLIFANTS

9. WMA 9: BERG-OLIFANTS

The Berg-Olifants Water Management Area (WMA) is the result of the combination of the former Berg and the Olifants-Doorn WMAs. The Atlantic Ocean forms the south-western boundary of the new WMA, while the Orange WMA forms the northern and eastern boundaries, and the Breede-Gouritz WMA the southern boundary. The Berg-Olifants WMA falls largely within the Western Cape Province, with the north-eastern section falling within the Northern Cape Province. The WMA includes the catchment area of the Berg River and its major tributaries, as well as the Olifants River catchments. Additional catchments within the WMA that do not link directly into the Berg or Olifants catchments include, but are not limited to the Diep, Sand, Eerste, Steenbras, Silvermine, Black, Salt and Liesbeeck rivers.

This WMA can be divided into two distinct areas, namely:

- **Berg River catchment**

The Berg River catchments comprise the Berg River itself, along with a number of smaller coastal catchments. This system serves more than 3.2 million people, providing for part of to the City of Cape Town's water supply, Overberg, Boland, West Coast and Swartland towns, as well as to irrigators along the Berg, Eerste and other local rivers (DWS, 2013e).

- **Olifants and Doring River catchments**

The major river is the Olifants River, of which the Doring River (from the south draining the Koue Bokkeveld and Doring area) and the Sout River (draining the Knersvlakte from the northeast) are the main tributaries.

The topographical variation in the Berg River catchment results in a climate which varies considerably within the WMA. The mean annual precipitation (MAP) in the Berg River catchment is spatially varied due to the topographical influence of the high mountain ranges in the Cape Peninsula in the eastern side of the Berg River catchment (Ninham Shand Consulting Services, 2005). In the high lying areas of the Upper Berg River, the upper reaches of the Eerste River and the Steenbras River, the maximum MAP exceeds 3 000 mm/a. In the lowlands, the rainfall varies between 400 and 600 mm/a, being higher in the mountainous areas and lower in the north-west region of the Berg River catchment, where the Berg River flows into the sea (Ninham Shand Consulting Services, 2005).

The topography of the Olifants River catchment can be identified by the sand dunes and rolling hills on the coastal region of the catchment, to the mountainous regions peaking at 2 000 m above sea level in the southern part of the catchment. The north-eastern region of the catchment is characterised by the typical Western Karoo topography, i.e. plains and rocky hills.

The Olifants River rises in the mountainous regions in the south-east of the catchment and flows in a north-westerly direction. The Doring River originates in the south of the catchment and flows in a northern direction to the confluence with the Olifants River just upstream of Klawer. The northern region of the Olifants River catchment has a flatter topography with elevations ranging from 500 to 900 m above sea level. The eastern region of the Olifants catchment is characterised by its mountain ranges, which rise to about 1 500 m above sea level. The rolling hills and plains of the 30 to 40 km wide strip along the coast from the southern boundary of the WMA to the estuary of the Olifants River are known as the Sandveld. The deep sandy deposits overlaying the bedrock in this area are "primary" aquifers which provide a significant groundwater resource (Ninham Shand Consulting Services, 2005).

The Berg-Olifants WMA is referred to as a winter rainfall region with most of the rainfall occurring between May and September. The MAP in the WMA ranges from 100 mm in the far north and east, increasing to 3 000 mm in the mountainous regions in the south and central regions of the WMA (Ninham Shand, 2004).

Groundwater resources are available from primary aquifers along the coastal plain as well as from deeper rock-fractured and confined aquifers, of which the TMG holds the most potential for development. Groundwater is currently utilised from the primary aquifers near Atlantis and on the Cape Flats as well as from deeper aquifers in the Swartland.

Towns that are dependent or partially dependent on groundwater supplies are Loeriesfontein, Calvinia, Nieuwoudtville, Vanrhynsdorp, Bitterfontein-Nuwerus, Doringbaai, Lamberts Bay, Graafwater, Leipoldtville and Elandsbaai. Citrusdal supplements its summer water supplies with groundwater. The Southern Namakwaland Government Water Scheme supplies desalinated groundwater from boreholes to the small towns of Bitterfontein and Nuwerus. This was implemented because of the severe shortage of suitable sources of surface water in those areas and groundwater of unfit quality. This scheme has recently been extended to supply the Rietpoort and Molsvlei communities.

There is poor drinking water quality originating from natural sources and more research and improved discharge standards by local authorities are required. The use and effects of agri-chemicals such as fertiliser, pesticides and herbicides as well as burning tyres and plastics should be strictly monitored and effectively managed. This should be done in alignment with other initiatives in the fruit export and wine industry. The potential of water pollution in all rivers in the area could pose as a threat to public health. The sources of pollution should be identified and better communication on the pollution problems is required (DWS, 2015a).

9.1 SITE REVIEW

Reported in this section are the results, comments and changes made to the existing monitoring network and objectives as per the network design workshop. **Appendix A** provides several maps providing the spatial data used during the identification of theoretical sites in the WMA, the actual theoretical sites identified as well as the current and recommended monitoring for the WMA.

The following sections will describe the results and the recommendations from the design review workshop in more detail.

9.2 OVERVIEW OF MONITORING SITES

The status of river flow monitoring for the Berg-Olifants WMA is described in the Network Inventory Report of this project and provides a summary of the existing monitoring activities per new WMA as captured during September 2014. Error! Reference source not found. provides the number of surface water quantity monitoring sites per secondary catchment for the WMA.

Table 9.1 Number of surface water quantity monitoring sites per secondary catchment

Secondary catchment	Total number of closed sites	Number of open sites						
		Canals	Eyes	Pipeline	River flow	Dam volumes	Tidal	Total
F50D	0	0	0	0	1	0	0	**1**
E1	9	2	0	1	4	2	0	**9**
E2	8	1	0	0	4	0	1	**6**
E3	0	0	0	0	3	0	0	**3**
E4	0	0	0	1	0	1	0	**2**
F6	0	0	0	0	0	0	0	**0**
G1	18	5	0	8	36	3	1	**53**
G2	18	1	0	4	8	1	0	**14**
G3	2	0	0	0	0	1	1	**2**
Totals	**55**	**9**	**0**	**14**	**56**	**8**	**3**	**90**

According to Error! Reference source not found., there are 56 active river flow and 8 reservoir monitoring sites in the Berg-Olifants WMA that was evaluated at the workshop to determine redundancy, not being of national importance, while others were identified for upgrades or to be replaced with new sites.

The number of sites with water quality constituents being monitored in the Berg-Olifants WMA is provided in **Table** 1.3**9.2**.

Table 9.2 Number of surface water quality monitoring sites per secondary catchment

Catchment	Total number of closed Sites	Number of open sites monitoring particular variables								
		Chemical	Chemical (Priority Sites)(1)	Radioactivity	Wetland	Eutrophication	Toxicity	Microbial	Estuaries	Total stations(4)
F50D	**0**	0	0	0	0	0	0	0	0	**0**
E1	**1**	2	4	0	1	1	0	6	0	**11**
E2	**0**	3	2	0	12	0	0	0	0	**17**
E3	**1**	0	1	0	0	0	0	7	0	**8**
E4	**1**	1	0	0	0	0	0	0	0	**1**
F6	**0**	0	0	0	0	0	0	0	0	**0**
G1	**3**	23	6	0	5	9	0	6	6	**50**
G2	**1**	6	3	0	32	0	0	6	0	**47**
G3	**0**	0	1	0	0	1	0	0	0	**2**
Totals	**7**	**35**	**17**	**0**	**50**	**11**	**0**	**25**	**6**	**136**

Notes:

(1) Priority stations are defined as those located in areas of significant anthropogenic or naturogenic water use where the quality of, or intended use of the water can be adversely affected.

(2) Total number of monitoring sites, which does not necessarily equal the sum of the columns (that includes all monitored variables).

As can be seen from Table 1.39.2 the main water quality programmes in the WMA include chemical, wetland, eutrophication microbial and estuarine monitoring. As stated earlier, the water quality parameters and frequencies will be reviewed during the strategy development and the spatial coverage of monitoring sites is the only concern at this stage. Recommendation on the chemical, eutrophication and estuarine monitoring will be made during the Strategy. Hotspot monitoring programmes such as microbial, radioactivity and toxicity programmes cannot be planned for on a national basis due to the changing nature of the sources and constituents being monitored. The Water Research Commission (WRC) is busy developing a wetlands monitoring programme which falls outside of the scope of this study.

9.3 RIVER MONITORING SITES

As part of the network optimisation procedure, the theoretical monitoring sites' objectives close by to existing and new monitoring sites are assigned to them. In this manner existing and new sites can be compared to each other in terms of meeting objectives and therefore relative importance.

In the following section river stations will be reviewed, excluding existing W-components which do not require improvements, or new W-components for reservoirs, which will be discussed in **Section 9.4**.

9.3.1 River stations with only ongoing maintenance requirements

During the review of the WMA surface water monitoring sites, some of the sites were seen as adequate or required for other specific reasons. The stations were not seen as redundant or needing to be upgraded. Reported in **Table 1.3** are the theoretical objectives that have been assigned to these existing river sites.

9.3.2 New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Table 9.3 Objectives and relative priorities assigned to existing river monitoring stations with no recommended actions

Site number	Description	Theoretical objective	Relative priority[#]
G1H031	Berg River @ Misverstand	PMC|ExistResR,Ir,Min	9.5
G1H023	Berg River @ Jantjiesfontein	PEC|PriorEstReq,Base,Ur,Ir	9.0
G1H080	Wemmershoek River @ Wemmershoek Dam	PM|HR,Base	8.0
G1H013	Berg River @ Drieheuvels	PC|ExistRes,Ir,Min,Ur	7.0
G1H024	Berg River @ Kliphoek	PE|Base,PriorEstReq	7.0
G2H037	Jonkershoek River @ Kleinplaas	PE|BaselineSen,UpPA	7.0
G1H008	Little Berg River @ Nieuwkloof	P|HR,Base,Ur,Ir,WWTW	6.5
G2H040	Eerste River @ Klein Welmoed	P|HR,Base,Ur,Ir,Ind	6.5
G2H042	Diep River @ Adderley	P|Base,EstReqFFU,Ur,Ir,	6.0
E1H018	Visgat @ Olifants River	P|HR,Base, Ir	5.5
G1H028	24-River @ Drie-Das-Bosch Diversion Weir for G1H058	P|HR,Base,EcoImpSen	5.5
E1H013	Olifants River @ Citrusdal	P|Base,Ir	5.0
G1H003	Franschhoek River @ Le Mouillage	P|Ir,Ur	5.0
G1H034	Moorreesburg Spruit @ Holle River	P|Ir,Ur	5.0
G1H040	Fish River @ La Fontaine	P|Ur,Ir	5.0
G1H079	Berg River @ Zonquasdrift	P|Ir,Ur	5.0
G2H012	Diep River @ Malmesbury	P|Ur,Ir	5.0
E1H006	Jan Dissels River @ Clanwilliam	P|BaselinePA	4.5
E3H002	Hantams River @ Brakke Rivier	P|Base	4.5
G1H039	Doring River @ Grensplaas	P|Ir	4.5
G1H041	Kompanjies River @ De Eikeboomen	P|Ir	4.5
G1H078	Dwarsriver@Boschenda	P|Ir	4.5

[#] *Sites are listed in descending order based on relative priority*

Reported in

New river sites

The river monitoring sites described in this section are those identified as brand new sites where no previous monitoring has taken place and where the sites would support improved spatial distribution of the network to meet national monitoring objectives.

Reported in **Table 1.4** are all the proposed monitoring sites for the Limpopo WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

9.3.3 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, site descriptions, assigned theoretical objectives as well as problems associated with the monitoring site.

Table 1.4 are all the proposed monitoring sites for the Berg-Olifants WMA, proposed coordinates, assigned theoretical objectives as well as any other comments related to the proposed site.

Table 9.4 Proposed new river monitoring sites

Site number	Latitude	Longitude	Theoretical objective	Comment	Relative priority [#]
N2	-32.607	18.692	PC|PriorEstReq,Base	This additional station is required for the Verlorenvlei RAMSAR site. Site on Krom Antonies,/,Rooi-Elskloof before confluence with Kruismanskloof.	6.0
N1	-32.876	19.097	P|HR,Base,EcoImpSen	Important monitoring point downstream of a protected area. Site required on Ratel as close as possible to the confluence with the Olifants River.	5.5
N3	-31.853	19.032	P|Base,Ir	Measures a large tributary of the Doring. Site as close as possible to the Doring River on the Koebee River.	5.0
N4	-32.396	19.895	P|Base,EcoImpSen	New site required downstream of Oudebaaskraal Dam to measure the Tankwa River (tributary of the Doring River).	5.0

[#] *Sites are listed in descending order based on relative priority*

9.3.4 Existing sites that require changes

The monitoring sites reported in this section are those that require investigations into the following possibilities:

- upgrading of the structure,
- reconstruction of the structure, or
- identifying a new site with a new structure.

Reported in **Table 1.5** are the identified site numbers, coordinates, assigned theoretical objectives as well as problems associated with the monitoring site.

9.3.5 Sites not of national importance

Described in this section are sites that are not important from a national perspective, but are, however, used to satisfy lower priority objectives at local and municipal level.

Table 9.5 Monitoring sites that require changes

Site number	Description	Theoretical objective	Comment	Relative priority
G1H036	Berg River @ Vleesbank	PC|ExistRes, HR,Base,Ir	Recommended that current monitoring site be replaced to enable low flow monitoring at this site.	7.0
G1H020	Berg River @ Daljosafat	P|Base,Ur,Ind,Ir, WWTW	Recommended that monitoring site be upgraded to accurately measure high flows for flood purposes and integrated.	6.5
G2H044	Lourens River @ Strand	PE|Base	Submergence problems developing at the monitoring site. Monitoring is important for flood mitigation purposes. Investigate improvement.	6.5
E2H002	Doring River @ Elands Drift (Aspoort)	PC|Base,ExistRes C	Recommended that monitoring site be investigated for improvement.	6.0
E2H003	Doring River @ Melkboom	PC|Base,ExistRes C	Recommended that monitoring site be reconstructed.	6.0
E3H004	Olifants River @ Lutzville	PC|Base,PriorEst Req	Recommended that monitoring site be investigated for improvement. Site is required for monitoring upstream of estuary.	6.0
G3H001	Kruismanes River @ Tweekuilen	PC|PriorEstReq,Base	Previous closed site requires reconstruction. Important for Verlorenvlei RAMSAR site.	6.0

[#] *Sites are listed in descending order based on relative priority*

Reported in **Table** 1.6 are the identified site numbers, names and comments associated with the monitoring sites that were identified as not important from a national perspective. No theoretical objectives were identified for sites below, supporting the conclusion that they are not of importance to the national network.

Table 9.6 Monitoring sites that are not of national importance

Site Number	Latitude	Comments
E2H007	Leeu River @ Leeuw River	Small site, not important for national network.
E2H010	Kruis River @ Ebenezer	Small site, not important for national network.
G1H014	Zachariashoek River @ Zachariashoek	Experimental site .
G1H016	Kasteelkloof Spruit@Lower @ Zachariashoek	Experimental site .
G1H018	Bakkerskloof Spruit @ Zachariashoek	Experimental site.
G2H020	Eerste River @ Fleurbaai	Used by municipality for flood purposes, high maintenance site due to sedimentation.
G3R002	Wadriftsoutpan @ Elandsbaai	Only surface water levels are measured at monitoring site, important for ecology.

9.3.6 Redundant sites

Reported in this section are sites that, based on the workshop findings, do not add any value to the national monitoring network. This could be due to severe deterioration of the site, poor quality data produced by the site or due to the site being near monitoring points that are better equipped satisfy theoretical site objectives.

Reported in

Table 1.7 are the site numbers, coordinates and comments that resulted in the site classification.

Table 9.7 Redundant river flow monitoring sites

Site number	Description	Comment
G1H009	Brakkloof Spruit @ Knolvlei Bos Res	Monitoring site is redundant, extremely small catchment with no current requirements.
G1H010	Knolvlei Spruit @ Knolvlei Bos Res.	Monitoring site is redundant, extremely small catchment with no current requirements.
G1H011	Watervals River @ Watervalsberge	Monitoring site is redundant, extremely small catchment with no current requirements.
G1H019	Banghoek River @ Jonkershoek	Monitoring site produces inaccurate data, located upstream of existing monitoring site (G1H078) on Dwars River.
G1H021	Little Berg River @ Mountain View	Monitoring site is redundant from national perspective, very small catchment.
G1H043	Sand Spruit @ Vrisgewaagd	Monitoring site is possibly redundant from national perspective.
G2H043	Lourens River	Monitoring site is possibly a redundant tidal site. Not important estuary. G2H044 upstream.

9.4 RESERVOIR SITES

For the purposes of this analysis, it is assumed that all reservoirs are important from a national perspective and must therefore be monitored efficiently. Listed in **Table 9.8** are all the required W-components as well as changes and potential improvements to existing reservoir monitoring within the WMA.

Table 9.8 New W-component for dams

Site number	Latitude	Longitude	Theoretical objective	Comment	Relative priority
N5	-31.993	18.788	PMC|WComp, ExistResC	Recommended that a monitoring site (W-component) be constructed downstream of Bulshoek	9.0

9.5 ESTUARIES

The Berg-Olifants WMA has five estuaries that falls within the top 20% of Estuaries in the country according to a ranking system developed by the RQIS. This study (DWS, 2002) devised a method for prioritising South African estuaries on the basis of conservation importance, and presented the results of a ranking based on the collation of existing data for all South African estuaries. Estuaries are scored in terms of their size, type and biogeographical zone, habitats and biota (plants, invertebrates, fish and birds).The identified estuaries include:

- Berg River Estuary
- Verlorenvlei Estuary
- Olifants River Estuary
- Sand River Estuary
- Diep/Eerste Estuary.

The first three estuaries fall under the top 10% of estuaries in the ranking systems and all have tidal stations. The latter two do not, but it is not deemed important that tidal stations are installed here. River inflow measurements to the top 10% of the estuaries were prioritised during the river site analysis.

9.6 RAINFALL SITES

The locations of all hydro-meteorological sites in the WMA are showed on **Figure A.9.8** in **Appendix A**. Although DWS is not the primary custodian of rainfall data, recommendations of areas where rainfall gauging need to be reinstated, will be made in the final Strategy.

9.7 GROUNDWATER MONITORING

The current groundwater monitoring network Berg-Olifants WMA focus on the general aquifer status (Smart, 2016).

The following recommendations are made to improve the current groundwater monitoring network:

- Apply elevation rule so that baseline and trend monitoring site points does not plot on top of mountains.
- Increase spatial density over groundwater control areas to 500 km^2 to set baseline monitoring points. This rule applies to all groundwater control areas throughout the country.
- Set additional baseline monitoring point in Cape Point (Latitude: -34.304087°; Longitude: 18.441055°).
- Set additional baseline monitoring point in Jonkershoek (Latitude: -33.993411°; Longitude: 18.975148°).

- Convert ZQMCTN1-N43|GO-V38-F24W to baseline monitoring point (Newlands Spring).
- Convert BG00158 to baseline monitoring point (upstream of Berg River Dam).
- Convert G1N0499 to baseline monitoring point (upstream of Berg River Dam).
- Set additional baseline monitoring point in vicinity of Steenbras Dam (Latitude: 34.197051°; Longitude: 18.869654°).
- Convert G2N0635 to baseline monitoring point (Witzand area).
- Convert G2N0101 to baseline monitoring point (Silwerstroom area).
- Set additional baseline monitoring point in vicinity of Waterval Nature Reserve (Latitude: -33.346149°; Longitude: 19.106689°).
- Convert G1N0270 to baseline monitoring point.
- Set additional baseline monitoring point in Elandsfontein Private Reserve (Latitude: -33.093954°; Longitude: 18.202800°).
- Convert E3N0060, E3N0086 and E3N0089 to baseline monitoring sites.
- Set 1 site per 100 km^2 around major dams.
- Set baseline monitoring point in Oorlogskloof Nature Reserve (Latitude: 31.498735°; Longitude: 19.061240°).
- Convert the current monitoring points to trend monitoring site. Apply a buffer of 100 km^2 and remove the theoretical trend monitoring sites that fall within the buffer.

E1N0001	G1N0434	G2N0645
E1N0014	G1N0440	G3N0018
E2N0002	G1N0446	G3N0530
E3N0062	G1N0448	G3N0532
E3N0078	G1N0454	G3N0535
E3N0081	G1N0462	G3N0586
E3N0088	G1N0466	G3N0595
E3N0092	G1N0468	G3N0602
G1N0069	G1N0478	G3N0605
G1N0087	G1N0499	G3N0606
G1N0115	G1N0501	G3N0607
G1N0126	G1N0504	G3N0609
G1N0173	G2N0108	G3N0646
G1N0238	G2N0114	G3N0653

G1N0253	G2N0233	G3N0666
G1N0254	G2N0582	G3N0681
G1N0262	G2N0587	G3N0685
G1N0269	G2N0591	BG00165-N2|GO-V3-F24W
G1N0369	G2N0597	ZQMBVB1-N15|GO-V18-F24W
G1N0374	G2N0602	ZQMCIT1-N52|GO-V38-F24W
G1N0376	G2N0612	ZQMCLV1-N28|GO-V18-F24W
G1N0385	G2N0614	ZQMLSF1-N22|GO-V18-F24W
G1N0385	G2N0620	ZQMMBY1-N6|GO-V18-F24W
G1N0404	G2N0627	ZQMTIK1-N30|GO-V38-F24W
G1N0429	G2N0639	ZQMWLS1-N2|GO-V18-F24W
G1N0432	G2N0642	

APPENDIX A.9

MAPS OF ACTUAL AND THEORETICAL SITES
WMA 9: BERG-OLIFANTS

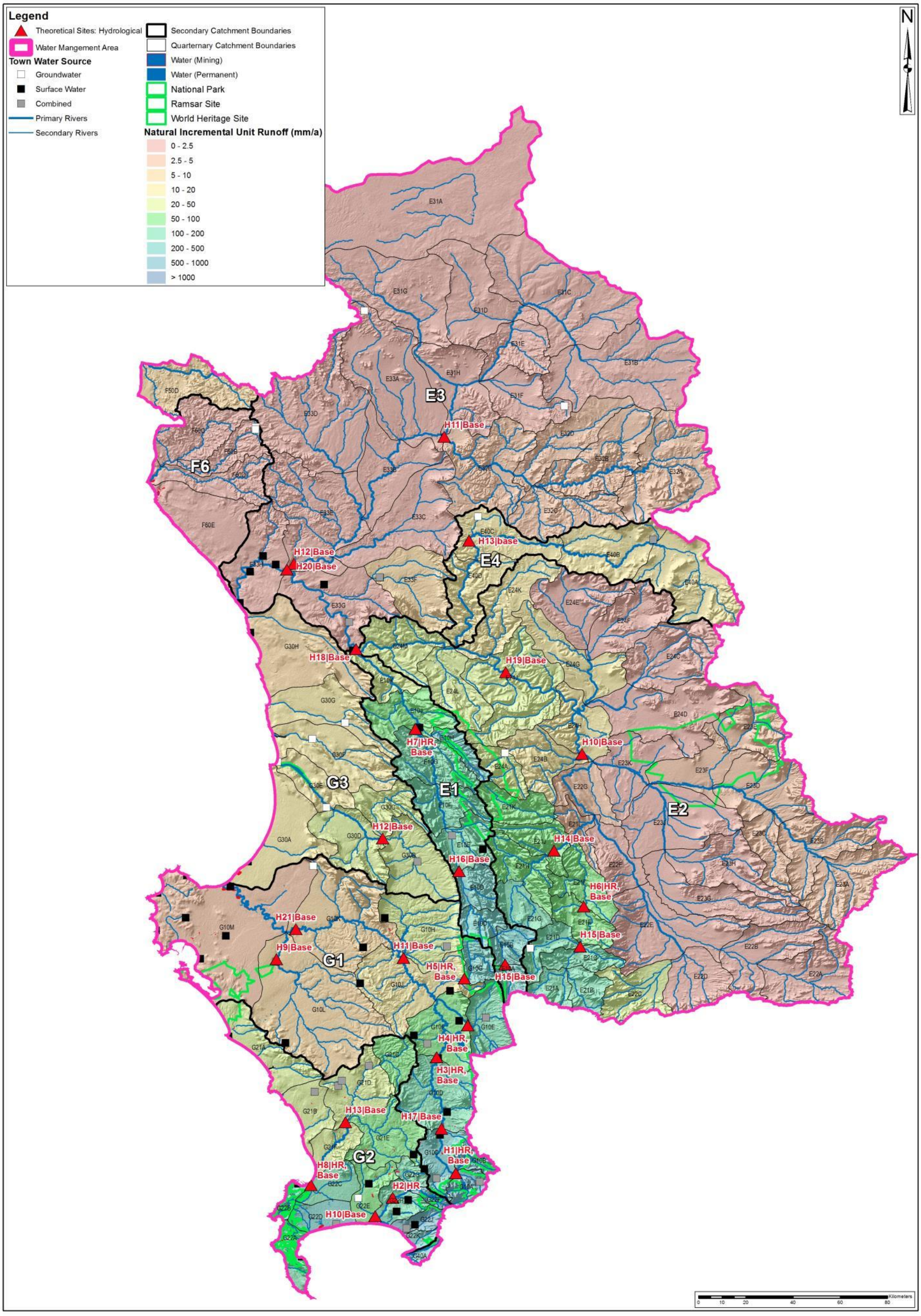


Figure A.9.51 Theoretical surface water sites based on hydrological (runoff) considerations

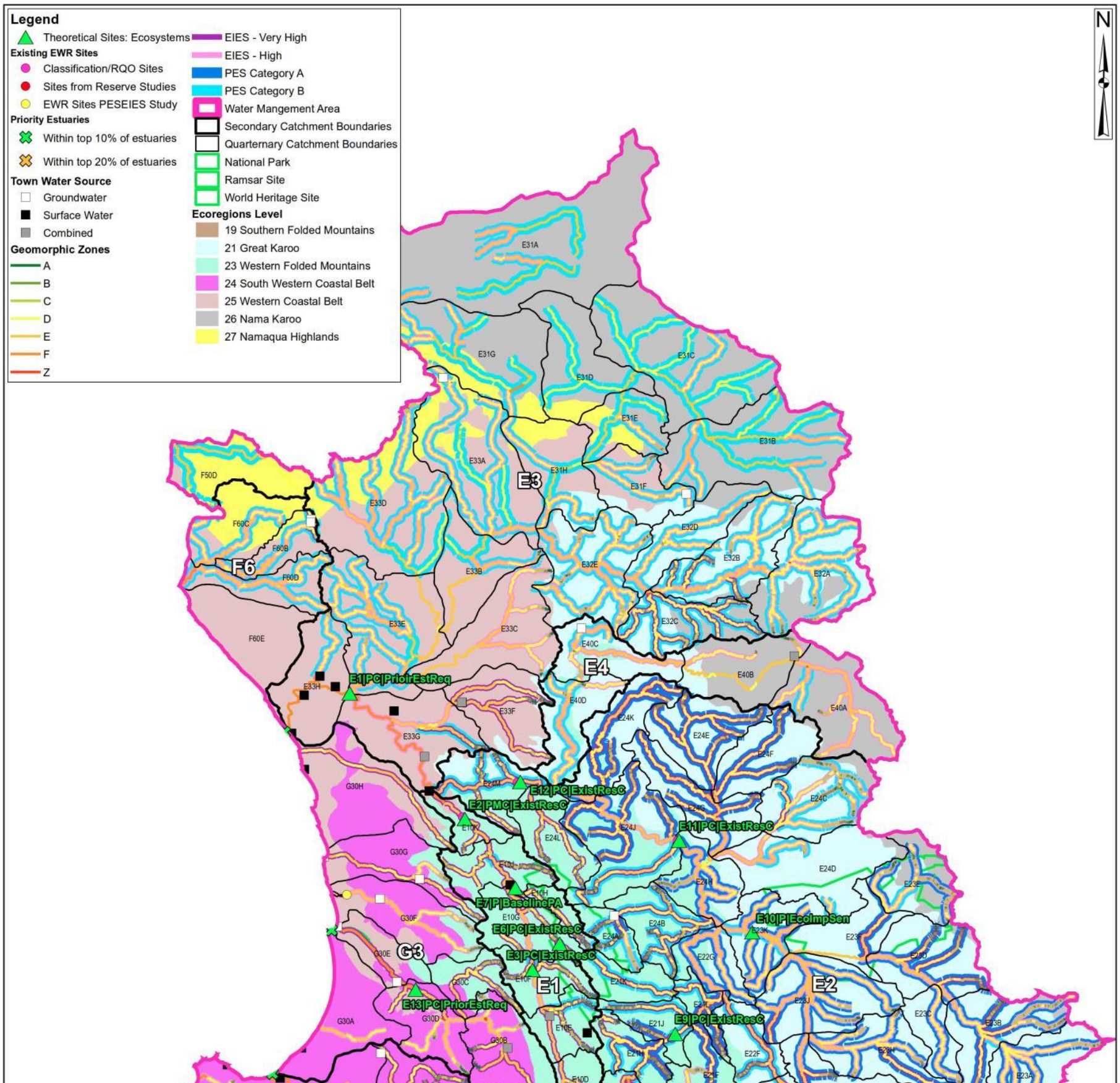


Figure A.9.52 Theoretical surface water sites based on ecosystem considerations

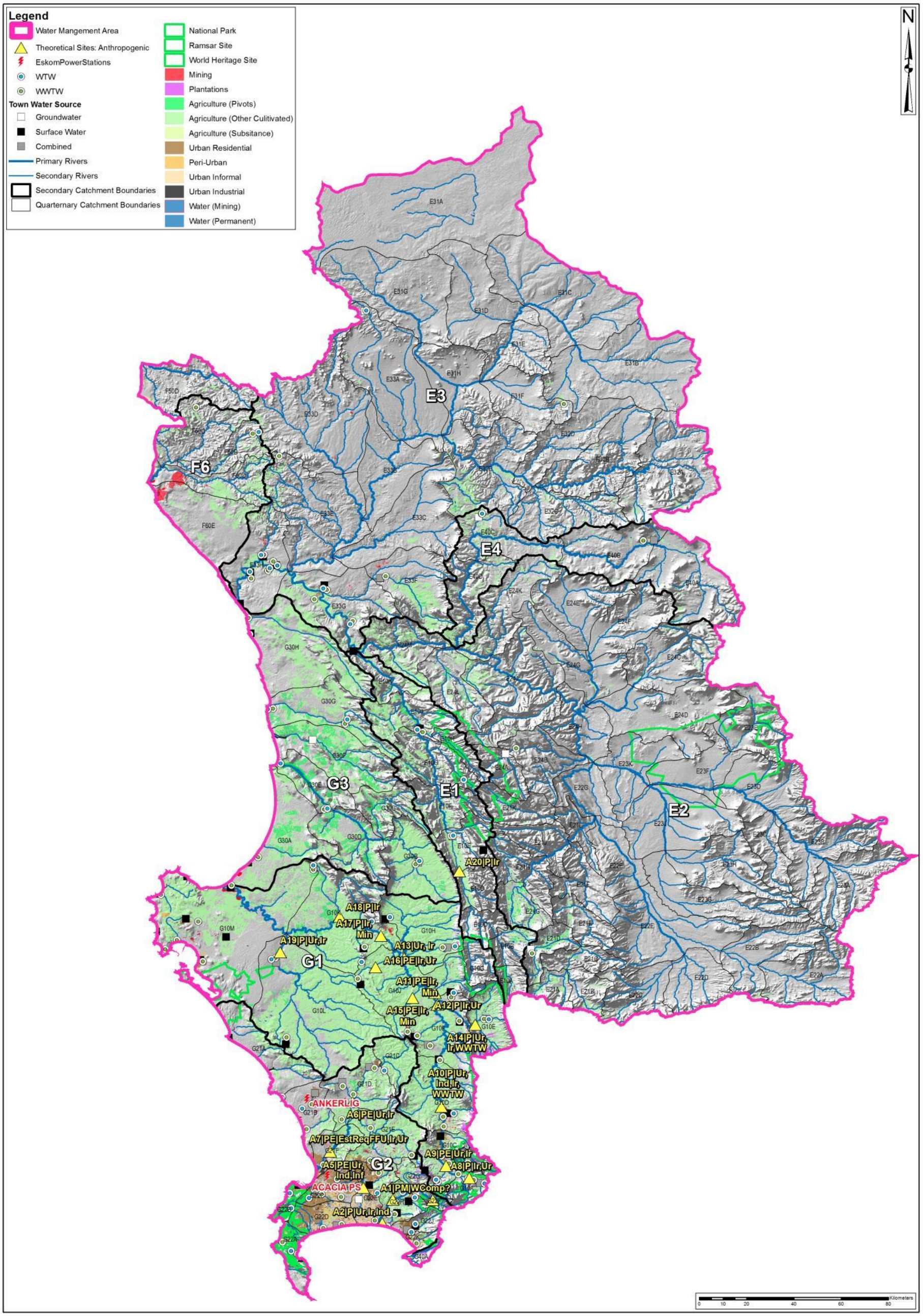


Figure A.9.53 Theoretical surface water sites based on anthropogenic considerations

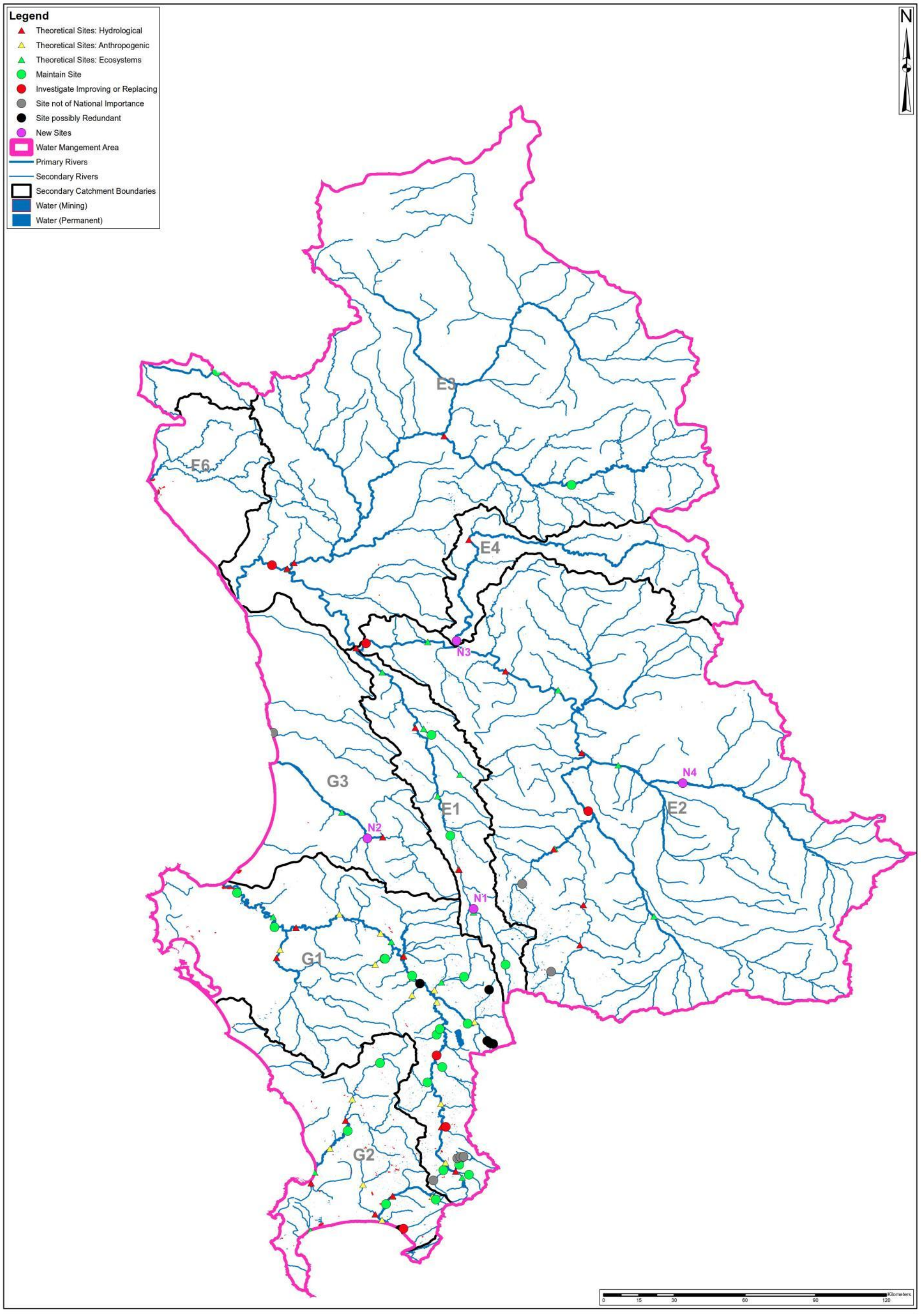


Figure A.9.54 All theoretical and actual surface water monitoring sites with recommended actions

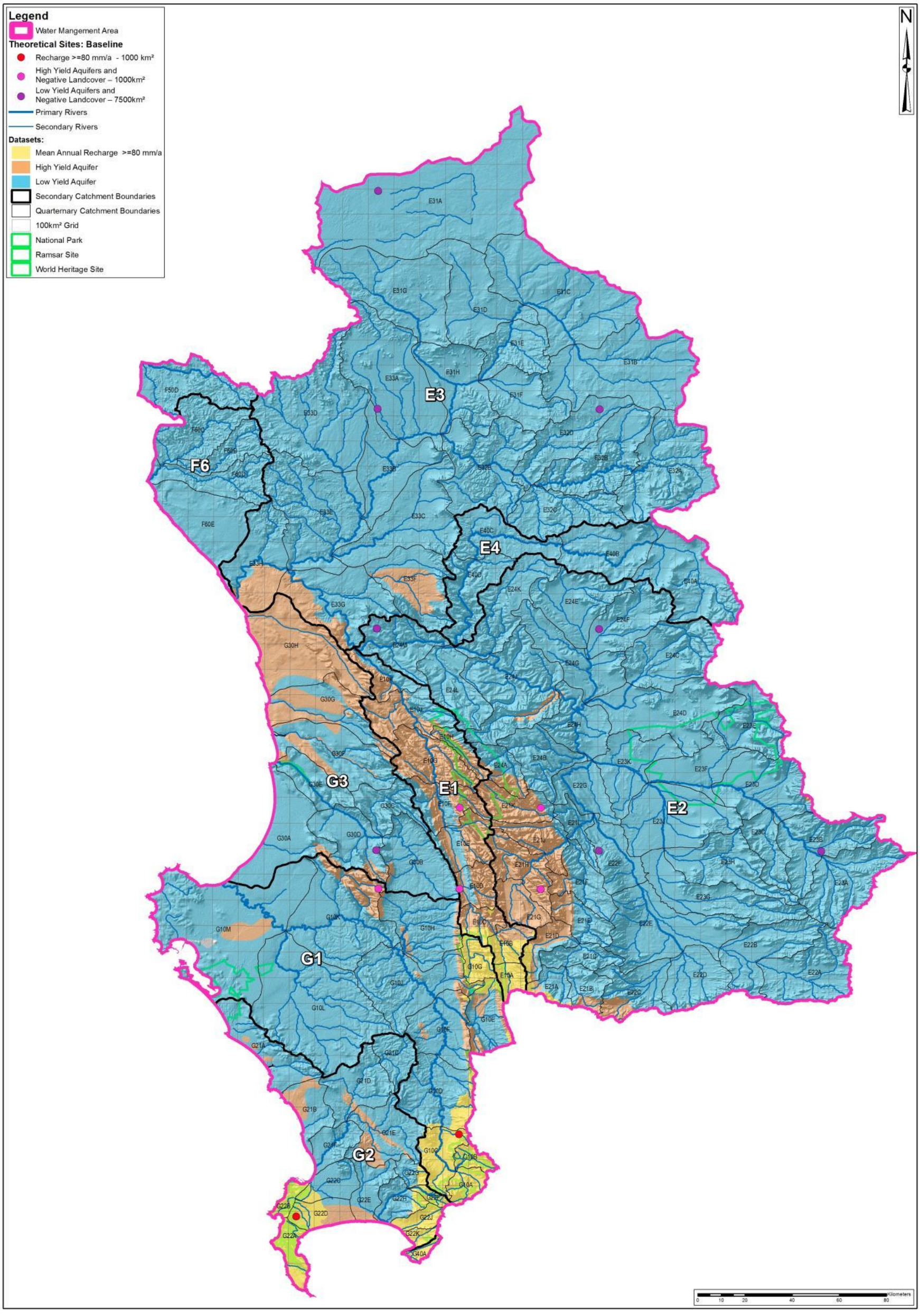


Figure A.9.55 Theoretical groundwater sites based on geo-hydrological considerations (Baseline)

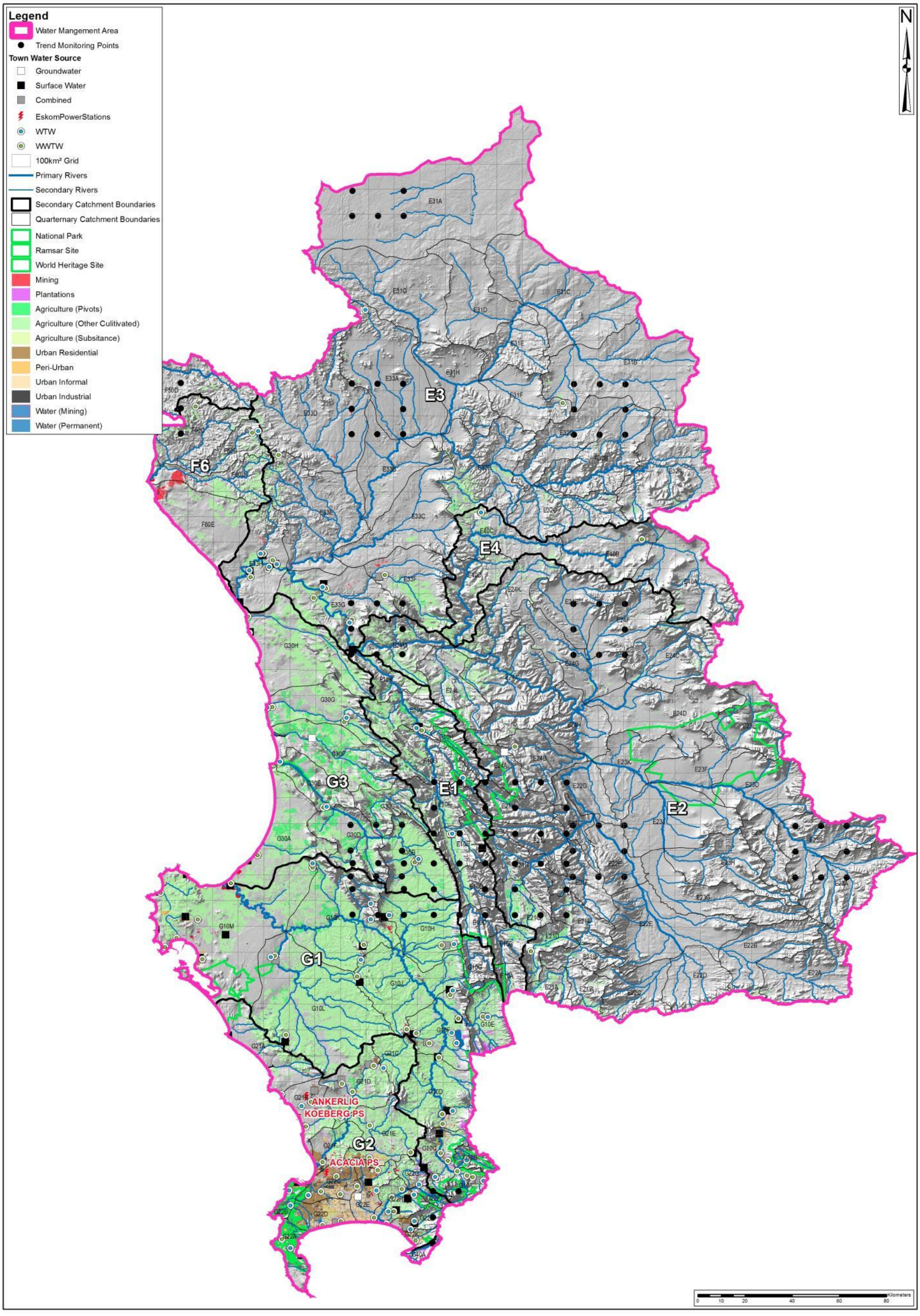


Figure A.9.56 Theoretical groundwater sites based on anthropogenic considerations (Trend)

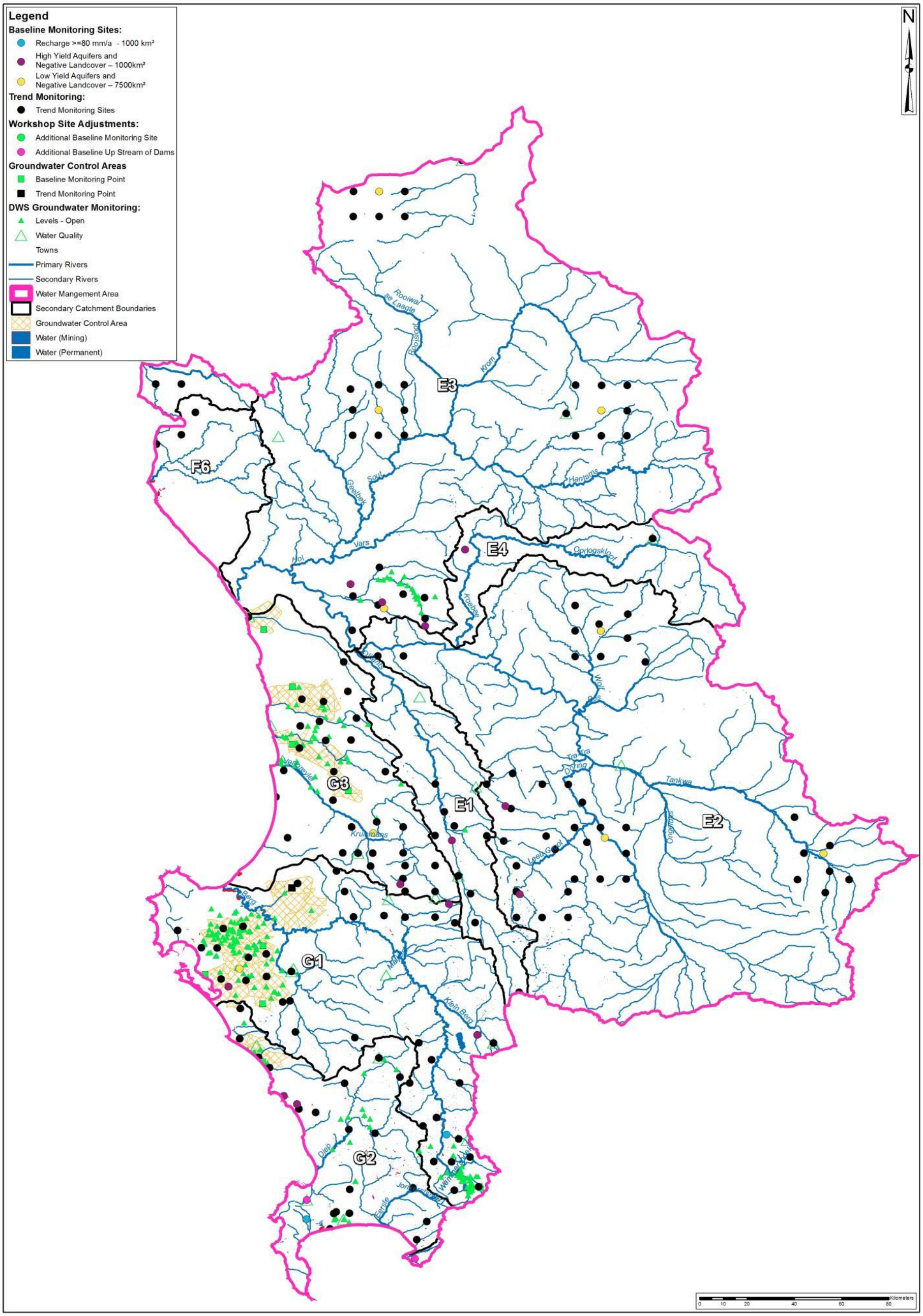


Figure A.9.57 Theoretical and exiting groundwater monitoring sites including additional recommended sites

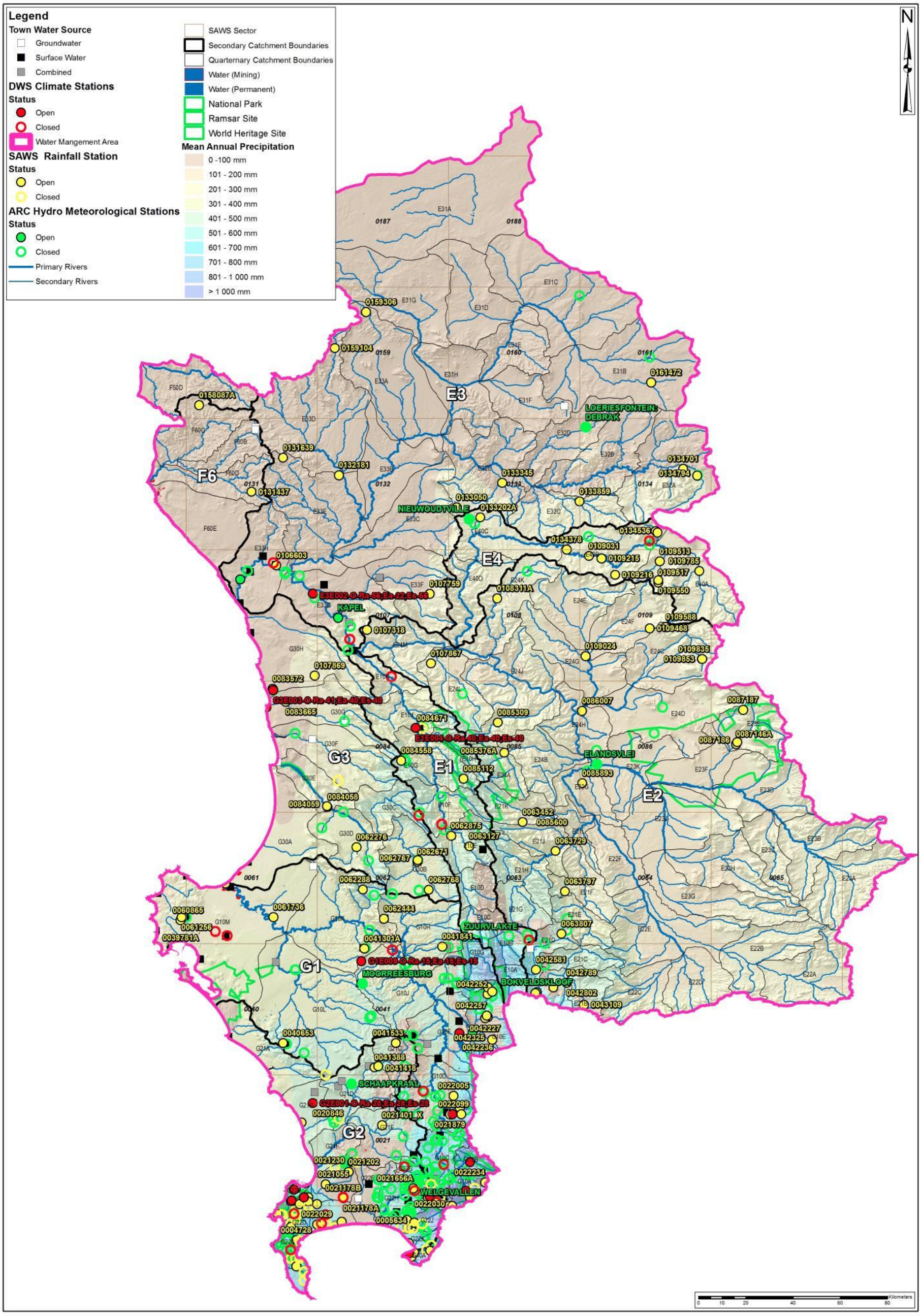


Figure A.9.58 Climatic information for the WMA

APPENDIX B

SPATIAL CRITERIA DESCRIPTION CODES

Table B.1 Codes describing the spatial criteria and data used for selection surface water sites

Abbreviation	Description
Hydrological considerations	
Base	Sites that would contribute towards a representative distribution of natural flows throughout the catchment
HR	Sites that have high incremental unit runoff areas (>=200mm/a) upstream
IntObl	Sites where river cross into or originate from neighbouring countries
Ecosystem considerations	
ExistResC	Sites close to RQO EWR Sites
ExistResR	Sites close to Comprehensive/Intermediate Reserve Studies EWR Sites
PosResR	Possible EWR Sites based on PESEIES Study data
EcoImpSen	Sites with high PESEIES values upstream
UpPA	Sites that are upstream from Protected Areas (National Parks, RAMSAR and World Heritage).
GW	Surface water sites that are required to be monitored for GW RQOs
BaselineSen	Sites that could serve as baseline catchment due to high PES values
BaselinePA	Sites downstream from upper catchment Protected areas that could serve as baseline catchment
PriorEstReq	Sites on rivers upstream from the top 10% of priority Estuaries
PriorEstReqImp	Sites on rivers upstream from the top 10% of priority Estuaries that has a dam that can control the estuary inflows
EstFFU	Sites on rivers upstream from the top 20% of priority Estuaries with significant human development around the estuaries
EstImpFFU	Sites on rivers upstream from the top 20% of priority Estuaries with significant human development around the estuaries and that has a dam that can control the estuary inflows
Anthropogenic Considerations	
Sup	Sites where water supply (use) should be measured
Div	Sites where there are river diversion weirs – this is the measurement of the flow at the weir itself
WComp	Dams without W-components (downstream weirs)
Ur	Sites either upstream or downstream of urban abstraction or urban runoff areas, respectively
IR	Sites either upstream or downstream of irrigation abstraction or return flow areas, respectively
F	Sites downstream from major commercial forestry areas

Abbreviation	Description
DDam	DWS dam sites
Inf	Sites upstream or downstream from rural or information settlement
MI	Sites downstream of Mining activities
AMD	Sites downstream from AMD decanting
RSupply	Regional Bulk Water Supply Dams
WTW	Sites at or upstream from RoR WTW take-offs
WWTW	Sites downstream from individual or a series of WWTW
Esk	Sites downstream from ESKOM Power Stations

APPENDIX C

NATIONAL WATER RESOURCES MONITORING OBJECTIVES

A. SCOPE

The national monitoring network covers the terrestrial, subterranean and coastal fresh water hydrological cycle components of South Africa. The network should ensure adequate national and regional spatial coverages and scientifically sound measurement of quantity, quality and biophysical properties of water resources at appropriate time intervals.

Water resource quantity monitoring includes water flow rates, groundwater and reservoir levels, streamflow levels, tidal elevations and discharge volumes. Water resource quality is monitored in terms of chemical, nutrient, microbiological, radioactivity and sediment properties. Water quality is usually expressed in terms of concentration, but may also be in terms of load. Biophysical monitoring includes, amongst others, assessments of macro-invertebrates, fish, habitat, geomorphology and riparian vegetation.

B. STRATEGIC OBJECTIVES

The national monitoring network provides baseline, status (up to near-real-time) and historical trend reporting of water resources in support of four key strategic monitoring objectives. These are summarised and prioritised in **Table C.1**.

Table C.1 Summary of strategic national monitoring objectives

Priority class	Objective	Description
1	**Resource and Infrastructure Planning**	To provide adequate monitoring data for determining the availability and quality of current and future water resources, aimed at providing strategic decision support for the equitable and sustainable allocation of resources to the population, environment and other economic sectors of society through planned infrastructure development and other interventions
2	**Resource Operations and Management**	To provide timely monitoring data for the efficient operation and management of water resources to ensure the protection of resources and water users and to allocate water equitably and sustainably.
3	**Risk Mitigation**	To provide timeous water resources monitoring data for early-warning systems to mitigate negative impacts on humans, infrastructure, the economy and riverine and coastal ecosystems.
4	**Compliance and Auditing**	To provide water quality and quantity monitoring data to ensure compliance and auditing functions required for water use licensing, and other functions.

OBJECTIVE 1: RESOURCE AND INFRASTRUCTURE PLANNING

The assessment of available water resources is used to support planning decisions through the modelling of water resources systems that allow for:

(i) The sizing, timing and phasing of future infrastructure developments and other interventions.

(ii) The optimisation of system operating rules. The infrastructure in question includes dams, water conveyance systems, as well as water and wastewater treatment works.

Water resources assessments are dependent on ongoing monitoring of:

- Hydro-meteorological data to estimate long-term rainfall (especially at higher altitudes and in high rainfall areas), evaporation, constituent transport (such as salt wash-off), agricultural water use and groundwater recharge characteristics. These data are also essential for estimating the possible impacts of climate change on the future availability and quality of water resources.
- Surface water quantity data for rivers and reservoirs, with adequate spatial coverage and of sufficient period lengths for the calibration of rainfall-runoff models and estimation of long-term resource availability.
- Groundwater levels and eye discharges data to determine recharge for the modelling of aquifers, as well as more complex catchment processes such as surface water-groundwater interaction.
- Reservoir and other infrastructure characteristics data, such as dam capacities, dam basin characteristics, river gauge discharge tables and the capacities of conveyance infrastructure.
- Surface and groundwater quality data to assess the allocable water quality, fitness of use, as well as to model the impact of catchment processes and pollution sources on water quality.
- Sedimentation data to assess sediment loads and associated pollutant transport, as well as to assess the impact of sediment deposition on reservoir storage capacities and yields over time.
- Biophysical data to determine the Reserve for both surface and groundwater resources, in conjunction with all the data sets mentioned above to determine historical, present-day and future projected resource availability and quality.
- Current and historical catchment water use in order to assess current and project future water requirements. The National Water Resources monitoring programme focusses mainly on bulk water use associated with abstractions at large reservoirs and for irrigation schemes. This includes pipelines (e.g. linking water treatment works with reservoirs or well-fields), canals and other bulk conveyance infrastructure.

OBJECTIVE 2: OPERATION AND MANAGEMENT

Water resources systems should be managed and operated according to planned operating and allocation rules to ensure optimal use of the available water resources and the protection of high-priority water users. This requires the ongoing monitored of the following:

- The status of surface and groundwater resources to allow for the adjustment of operations in accordance to long-term planning guidelines. Operating decisions are based on the status of reservoirs storage volumes, river flow at abstraction sites, groundwater levels at well-fields and tidal levels at estuaries. This also includes the quality of resources to allow for the implementation of blending rules, if and where applicable.
- Surface water and groundwater use and return flows at abstraction sites, pipelines and well-fields to allow for the supply of water resources according to planned allocations.
- Quantity and quality indicators for complying with Reserve and Resource Quality Objectives (RQOs) and to implement operating rules according to the resource status.

OBJECTIVE 3: RISK MITIGATION

Risk mitigation includes monitoring of surface water droughts and floods as well as low groundwater levels and seawater encroachment (from a quality perspective), all driven by adequate rainfall measurements. Furthermore, water quality risk mitigation is supported by warnings of the failure of surface and groundwater resources to meet fitness for use criteria. This includes the effects of acid mine drainage (AMD) and hydraulic fracturing as well as industrial and agricultural return flows on the water resources.

OBJECTIVE 4: COMPLIANCE AND AUDITING

Ongoing monitoring of various parameters is required to ensure compliance with the legal requirements associated with the relevant legislation, water use licences and international treaties and agreements. These are summarised below:

- Although there is a responsibility on the individual users to measure their water use and return flows, the national monitoring network has to allow for the monitoring of bulk water use and compliance with water quality criteria.
- Certain parameters must also be monitored for complying with the Reserve and RQOs at particular sites, including river flows and groundwater levels, associated water quality and biophysical data.
- South Africa has several shared river basins, and trans-boundary aquifers with associated internationally agreed flows and levels that must be monitored and maintained.

APPENDIX D

SPATIAL DATASET USED IN THEORETICAL DESIGN

Table D.1 Spatial datasets used in the design of a theoretical network

Dataset description	Origin	Source	Status
A) Hydrological considerations			
Quaternary, tertiary, secondary and primary catchments	Source	Water Resources of South Africa 2005 (WRC, 2008)	Used
1:500 000 primary and secondary rivers	Source	Water Resources of South Africa 2005 (WRC,2008)	Used
Catchment outlet points	Derived	Generated from NASA ASTER 30m GDEM and Quaternary Catchment Data (WRC, 2008)	Used
International boundaries	Source	CD NGI. Municipal Demarcation Board (2011)	Used
Natural cumulative mean annual runoff (million m^3/a)	Derived	Generated from Water Resources of South Africa 2012 (WRC, 2015) MAR Data and WSAM catchment tree	Used
Natural incremental mean annual unit runoff (mm/a)	Derived	Generated from Water Resources of South Africa 2012 (WRC, 2015) MAR, area and WSAM catchment tree data	Used
Natural incremental mean annual runoff as % of MAP	Derived	Generated from Unit Runoff data and Water Resources of South Africa 2005 (WRC) MAP data	Not-used
Topography (slopes)	Derived	Generated from NASA ASTER 30m GDEM	Not used
River network stream-orders - 30 m DEM	Derived	Generated from NASA ASTER 30m GDEM	Not used
Inter-basin transfers	Source	Water Resources of South Africa 2005 (WRC, 2008)	Complete
Dams (including DWS dams)	Origin	DWS Hydstra coordinates for active and inactive dams, land cover and DWS registered dam safety database.	Used
Sedimentation	Source	Water Resources of South Africa 2005 (WRC, 2008)	Used
MAP	Source	Water Resources of South Africa 2005 (WRC, 2008)	Used
MAE	Source	Water Resources of South Africa 2005 (WRC, 2008)	Used
B) Geo-hydrological Considerations			
Geology	Source	Council for Geosciences	Used
Transboundary aquifers	Source	Hydrogeology map of Southern Africa 2010 (SADC)	Used
Vegter aquifer regions	Source	An explanation set of national groundwater maps (WRC)	Not used
High yielding aquifers (aquifer classifications)	Source	1:500 000 Hydrogeological map series (DWAF)	Used
Aquifer vulnerability	Source	Groundwater Resource Assessment: Phase 2 (DWAF)	Used
Groundwater quality (EC, N, F)	Source	Groundwater Resource Assessment: Phase 2 (DWAF)	Used
Baseflow sensitive groundwater areas	Source	Groundwater Resource Assessment: Phase 2 (DWAF)	Used

Dataset description	Origin	Source	Status
C) Environmental considerations			
Ecological water requirement (EWR) Sites	Source and derived	Resource classification and RQO Study EWR sites obtained from DWS: Water Ecosystems. Other EWR sites obtained from various consultants	Used
South African protected areas database	Source	SAPAD, (DEA, 2015)	Used
Present Ecological Status, Ecological Importance and Ecological Sensitivity	Source	Desktop PES, EI + ES (DWS, 2014)	Used
Groundwater Reserve areas	Derived	DWS: WES	Used
D) Anthropogenic Considerations			
Landcover and negative landcover	Derived	Generated from SA Landcover © Geoterraimage (2014): Reduced classes and area summary per class	Used
Eskom power stations	Derived	Generated from www.eskom.co.za	Used
Fracking geo-exploration zones	Source	Petroleum Agency of South Africa	Used
AMD zones and treatment plants	Source	TCTA, 2011.	Used
WWTW and WTW	Source	DWS: Water Services	Used
Drought vulnerability map	Source	DWS:GI	Not used
Groundwater dependent towns	Source	DWS:GI	Used
Current and future bulk water regional schemes RBIG	Source	DWS: Water Services	Used

APPENDIX E

SPATIAL DESIGN PROCEDURE FOR GROUNDWATER THEORETICAL SITES

Groundwater spatial design procedures

A spatial density criteria based approach was followed in setting up the theoretical sites for the national groundwater monitoring network. This approach allowed for the incorporation of best-practices and expert knowledge.

Baseline monitoring

The first step was to setup the baseline monitoring site network, where the United States recommendation to have borehole density of one to eight sites per 2 500 km^2 (*Subcommittee on Ground Water of The Advisory Committee on Water Information, 2013*). The baseline sites must reflect ambient conditions and thus be located in pristine areas. A "negative land cover" spatial data set was generated using the national land cover GIS coverage and creating a negative image of areas where there are currently impacts by land/water use. This was then used to generate a grid of monitoring sites at the mentioned recommended spatial densities.

The aquifer yield class map produced by DWS was overlaid over the grid. In the aquifer yield class of 4 and above the spatial density was increased to 1 000 km^2 per site. In the lower yield aquifer classes, the spatial density was decreased to 7 500 km^2 per site, and the density might increase in heavily utilized aquifers.

The GRA 2 recharge dataset was used to increase the spatial density to 1 000 km^2 in the areas of effective mean annual recharge above 80 mm/a. This produced the first iteration of the baseline groundwater monitoring sites. This iteration takes into account:

- Monitoring localities for transboundary aquifers.
- International obligations in terms of both quantity and quality.
- Baseflow sensitive groundwater areas.
- Sites for background monitoring related to groundwater reserve determinations and setting RQOs.
- Sites for baseline water quality measurements, including areas for proposed unconventional gas development, including shale gas (Karoo), underground coal gasification and coalbed methane extraction.

Associated with each baseline groundwater monitoring site is a rainfall monitoring gauge. The current configuration of rainfall monitoring gauges allows for higher density in mountainous areas, areas of high groundwater interchange with surface water and dolomitic areas. The baseline groundwater monitoring network will take into account the major spring or major groundwater outflows, specifically the dolomite springs. The rainfall monitoring gauges associated with baseline groundwater monitoring sites will be used for Cl and isotope sampling to allow recharge estimations.

Trend monitoring

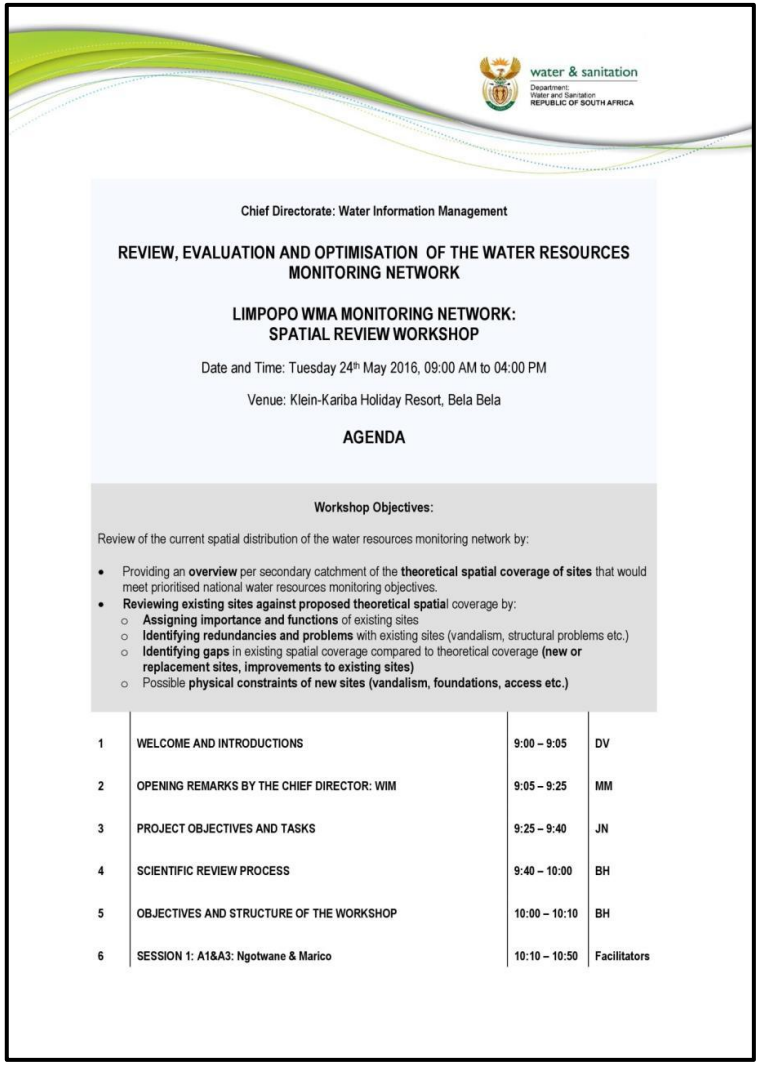
The theoretical trend monitoring sites were selected downstream of baseline monitoring sites. In higher productive aquifers the spatial density was set at 1 site per 100 km^2 around baseline monitoring points. A similar exercise was done around towns to incorporated groundwater dependent towns. The trend monitoring sites allows for trends to be determined in terms of the following:

- Over-exploitation/abstraction of groundwater;
- Groundwater quality degradation from various land use practices; and
- Groundwater water use.

APPENDIX F

NETWORK DESIGN WORKSHOP AGENDAS

WMA 1: LIMPOPO



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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

LIMPOPO WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Tuesday 24th May 2016, 09:00 AM to 04:00 PM

Venue: Klein-Kariba Holiday Resort, Bela Bela

AGENDA

Workshop Objectives:

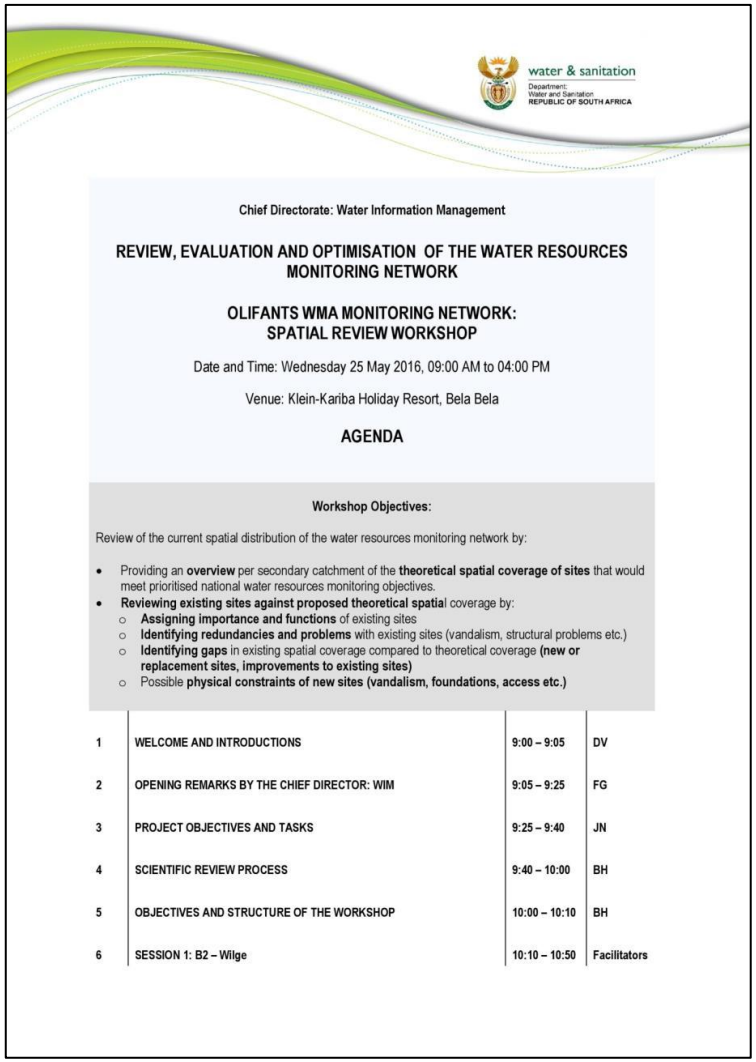
Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	DV
2	OPENING REMARKS BY THE CHIEF DIRECTOR: WIM	9:05 – 9:25	MM
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	JN
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH
6	SESSION 1: A1&A3: Ngotwane & Marico	10:10 – 10:50	Facilitators
	TEA	10:50 – 11:05	All
7	SESSION 2: A2 – Crocodile (West), A4 – Mololo/Matlabas	11:05 – 12:35	Facilitators
8	SESSION 3: A5 - Lephalale	12:35 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
9	SESSION 4: A6 – Mogalakwena, A7- Sand, A8 – Nzhelele, A9 - Luvuvhu	13:30 – 15:30	Facilitators
10	FINAL FEEDBACK	15:30 – 15:45	All
11	CLOSURE	15:45 – 15:50	MM
	TEA	15:50 – 16:00	All

Page 2

WMA 2: OLIFANTS



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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

OLIFANTS WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Wednesday 25 May 2016, 09:00 AM to 04:00 PM

Venue: Klein-Kariba Holiday Resort, Bela Bela

AGENDA

Workshop Objectives:

Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

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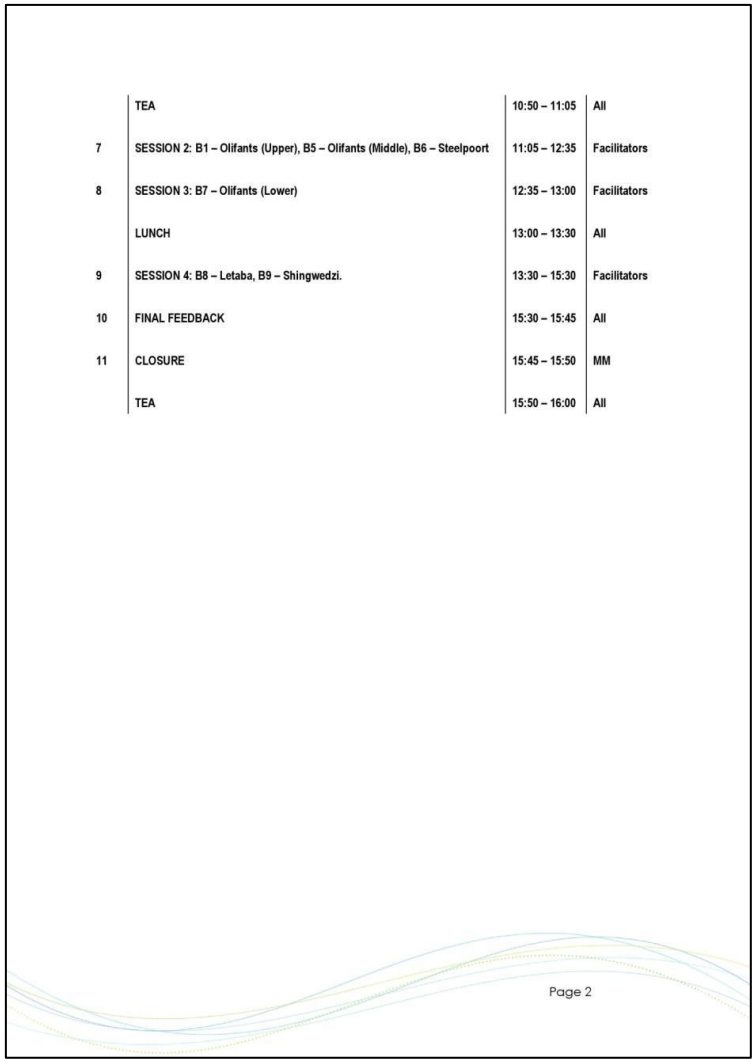
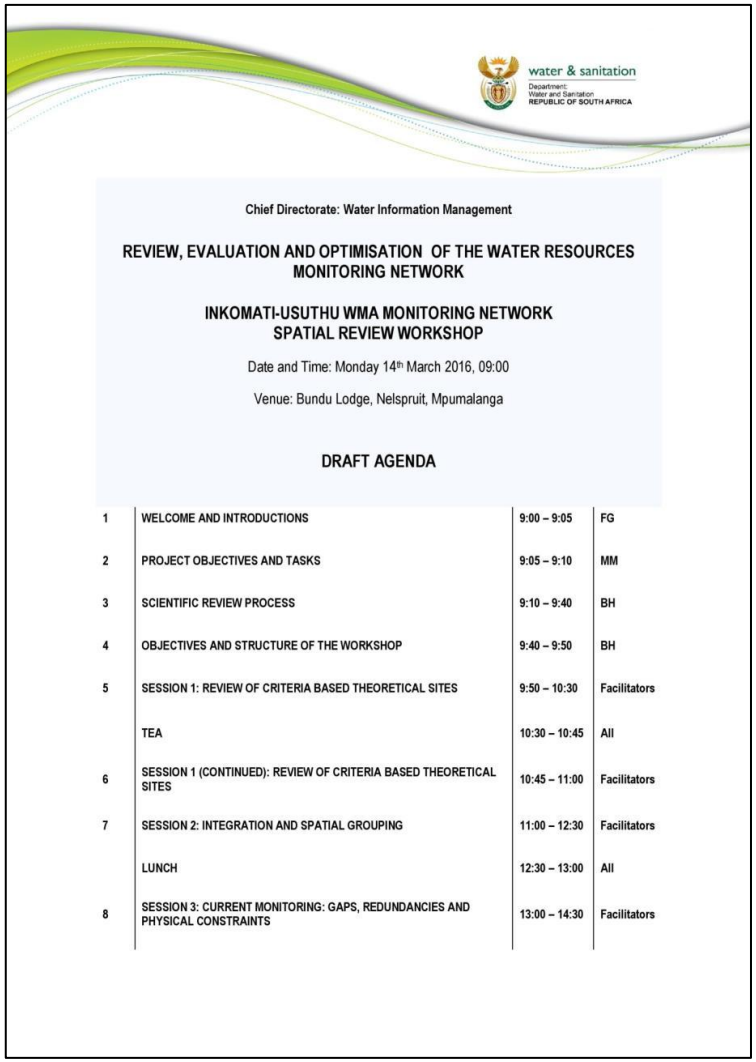
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	JN
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH
6	SESSION 1: B2 – Wilge	10:10 – 10:50	Facilitators



	TEA	10:50 – 11:05	All
7	SESSION 2: B1 – Olifants (Upper), B5 – Olifants (Middle), B6 – Steelpoort	11:05 – 12:35	Facilitators
8	SESSION 3: B7 – Olifants (Lower)	12:35 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
9	SESSION 4: B8 – Letaba, B9 – Shingwedzi.	13:30 – 15:30	Facilitators
10	FINAL FEEDBACK	15:30 – 15:45	All
11	CLOSURE	15:45 – 15:50	MM
	TEA	15:50 – 16:00	All

Page 2

WMA 3: INKOMATI-USUTHU



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REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

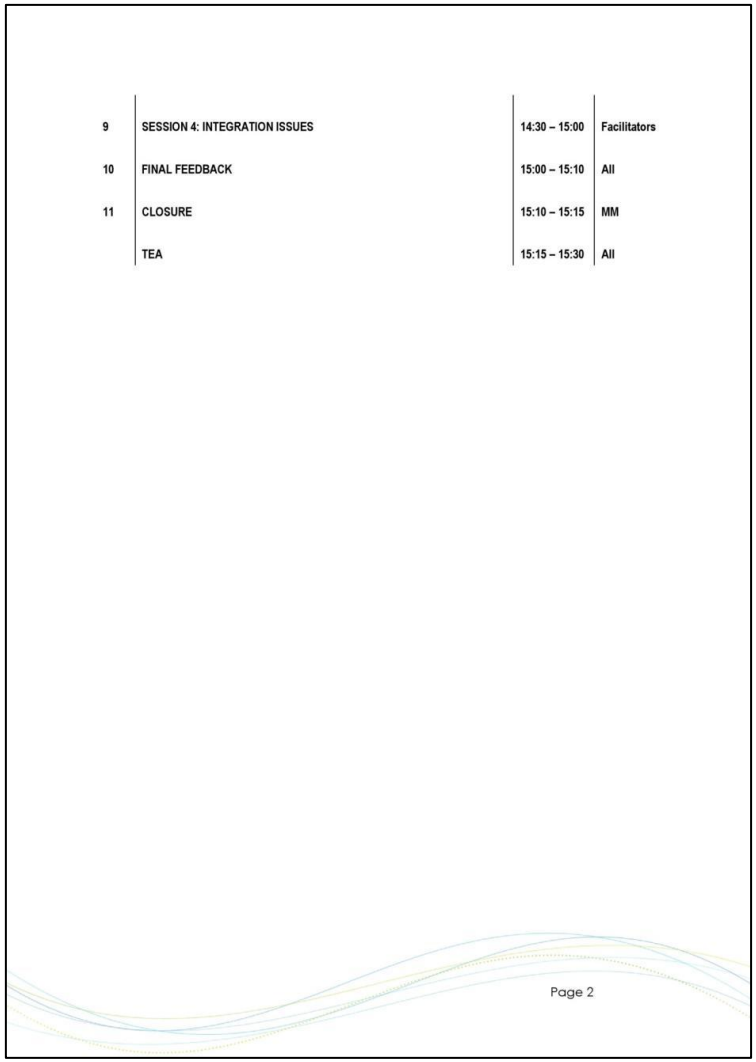
INKOMATI-USUTHU WMA MONITORING NETWORK SPATIAL REVIEW WORKSHOP

Date and Time: Monday 14th March 2016, 09:00

Venue: Bundu Lodge, Nelspruit, Mpumalanga

DRAFT AGENDA

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	FG
2	PROJECT OBJECTIVES AND TASKS	9:05 – 9:10	MM
3	SCIENTIFIC REVIEW PROCESS	9:10 – 9:40	BH
4	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	9:40 – 9:50	BH
5	SESSION 1: REVIEW OF CRITERIA BASED THEORETICAL SITES	9:50 – 10:30	Facilitators
	TEA	10:30 – 10:45	All
6	SESSION 1 (CONTINUED): REVIEW OF CRITERIA BASED THEORETICAL SITES	10:45 – 11:00	Facilitators
7	SESSION 2: INTEGRATION AND SPATIAL GROUPING	11:00 – 12:30	Facilitators
	LUNCH	12:30 – 13:00	All
8	SESSION 3: CURRENT MONITORING: GAPS, REDUNDANCIES AND PHYSICAL CONSTRAINTS	13:00 – 14:30	Facilitators



9	SESSION 4: INTEGRATION ISSUES	14:30 – 15:00	Facilitators
10	FINAL FEEDBACK	15:00 – 15:10	All
11	CLOSURE	15:10 – 15:15	MM
	TEA	15:15 – 15:30	All

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WMA 4: PONGOLA-UMZIMKULU

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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

PONGOLA-MTAMVUNA WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Wednesday, 4 May 2016, 09:00 AM to 04:00 PM

Venue: Aecom Offices, Ridgeview Building, 1 Nokwe Avenue, Ridgeside, Umhlanga Ridge

AGENDA

Workshop Objectives:

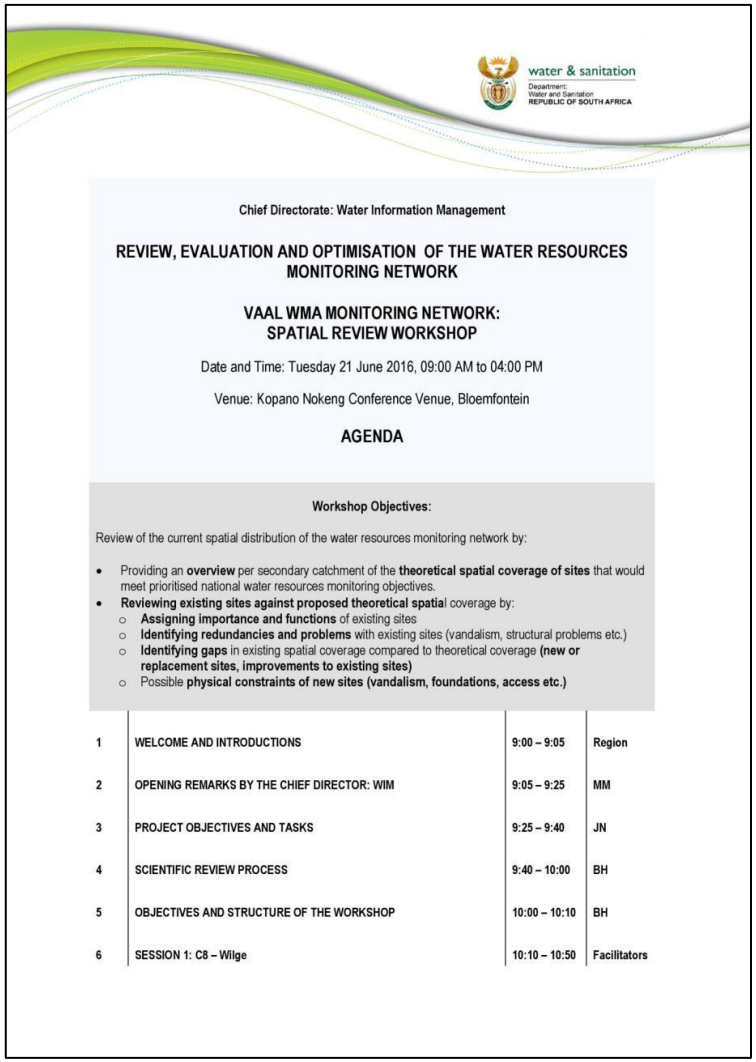
Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	FM
2	OPENING REMARKS BY THE CHIEF DIRECTOR: WIM	9:05 – 9:25	FG
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	ZM
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH
6	SESSION 1: T4 – Mtamvuna, T5 – Mzimkhulu & U8 – Coastal Rivers 1	10:10 – 10:50	Facilitators
	TEA	10:50 – 11:05	All
7	SESSION 2: U1 – Mkomazi, U2 –uMngeni, U4 – Mvoti & U3,5,6,7 – Coastal Rivers 2	11:05 – 12:35	Facilitators
8	SESSION 3: V1 – Thukela, V7 – Boesmans & V2 – Mooi.	12:35 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
9	SESSION 3 (Continued): W1 - Mhlatuze	13:30 – 14:00	Facilitators
10	SESSION 4: W2 – Mfolozi, W3 – Mkuze, W4 - Pongola	14:00 – 15:30	Facilitators
11	FINAL FEEDBACK	15:30 – 15:45	All
12	CLOSURE	15:45 – 15:50	ZM
	TEA	15:50 – 16:00	All

Page 2

WMA 5: VAAL



water & sanitation
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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

VAAL WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Tuesday 21 June 2016, 09:00 AM to 04:00 PM

Venue: Kopano Nokeng Conference Venue, Bloemfontein

AGENDA

Workshop Objectives:

Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	Region
2	OPENING REMARKS BY THE CHIEF DIRECTOR: WIM	9:05 – 9:25	MM
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	JN
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH
6	SESSION 1: C8 – Wilge	10:10 – 10:50	Facilitators
	TEA	10:50 – 11:05	All
7	SESSION 2: C1 – Vaal (Upper), C2 – Vaal (Middle)	11:05 – 12:35	Facilitators
8	SESSION 3: C7 – Renoster	12:35 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
9	SESSION 4: C6 – Vals, C4, - Vet/Sand, C9 – Vaal (Lower), C3 – Harts and D4 – Molopo/Kuruman.	13:30 – 15:30	Facilitators
10	FINAL FEEDBACK	15:30 – 15:45	All
11	CLOSURE	15:45 – 15:50	ZM
	TEA	15:50 – 16:00	All

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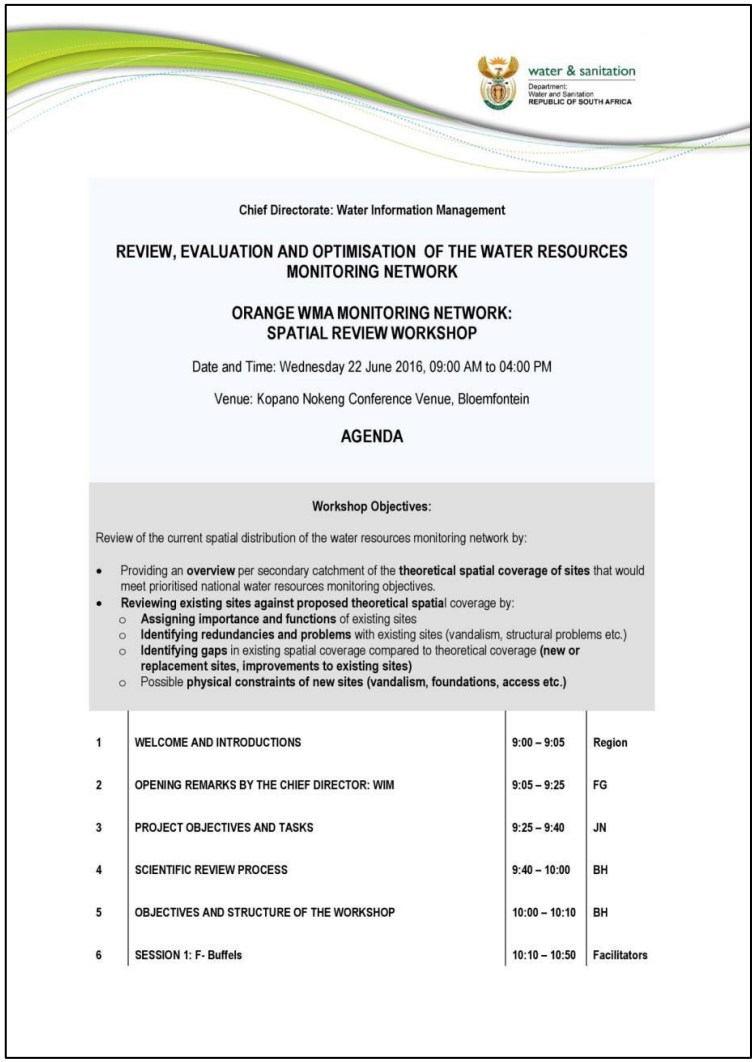
WMA 6: ORANGE



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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

ORANGE WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Wednesday 22 June 2016, 09:00 AM to 04:00 PM

Venue: Kopano Nokeng Conference Venue, Bloemfontein

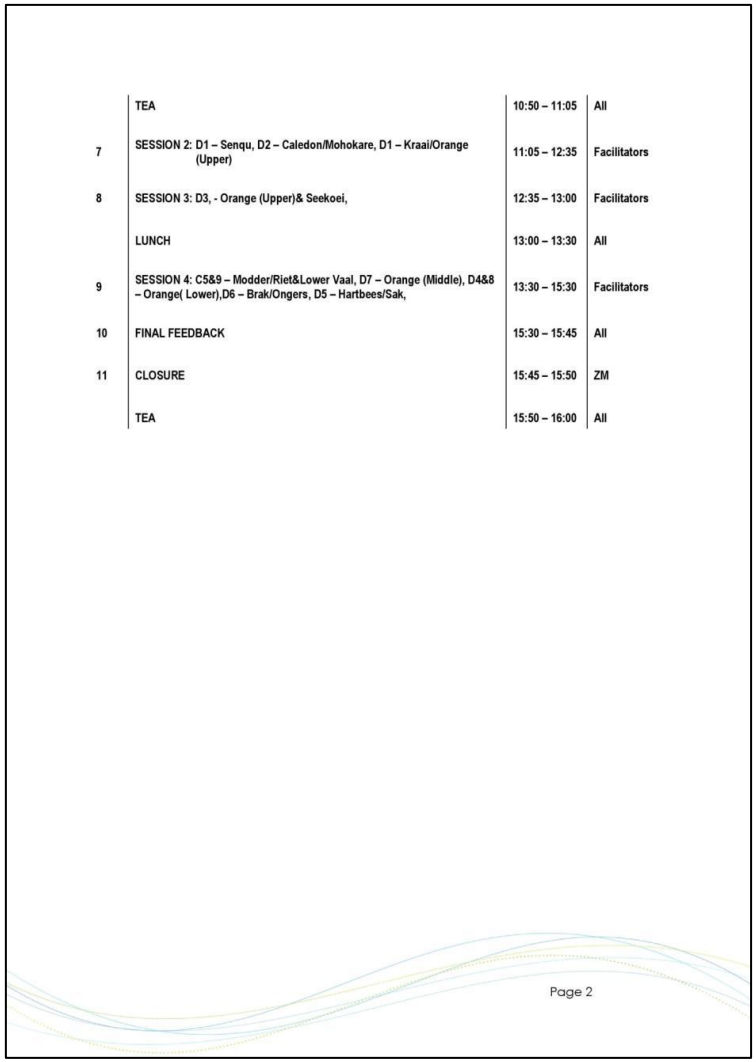
AGENDA

Workshop Objectives:

Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	Region
2	OPENING REMARKS BY THE CHIEF DIRECTOR: WIM	9:05 – 9:25	FG
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	JN
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH
6	SESSION 1: F- Buffels	10:10 – 10:50	Facilitators



	TEA	10:50 – 11:05	All
7	SESSION 2: D1 – Senqu, D2 – Caledon/Mohokare, D1 – Kraai/Orange (Upper)	11:05 – 12:35	Facilitators
8	SESSION 3: D3, - Orange (Upper)& Seekoei,	12:35 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
9	SESSION 4: C5&9 – Modder/Riet&Lower Vaal, D7 – Orange (Middle), D4&8 – Orange(Lower),D6 – Brak/Ongers, D5 – Hartbees/Sak,	13:30 – 15:30	Facilitators
10	FINAL FEEDBACK	15:30 – 15:45	All
11	CLOSURE	15:45 – 15:50	ZM
	TEA	15:50 – 16:00	All

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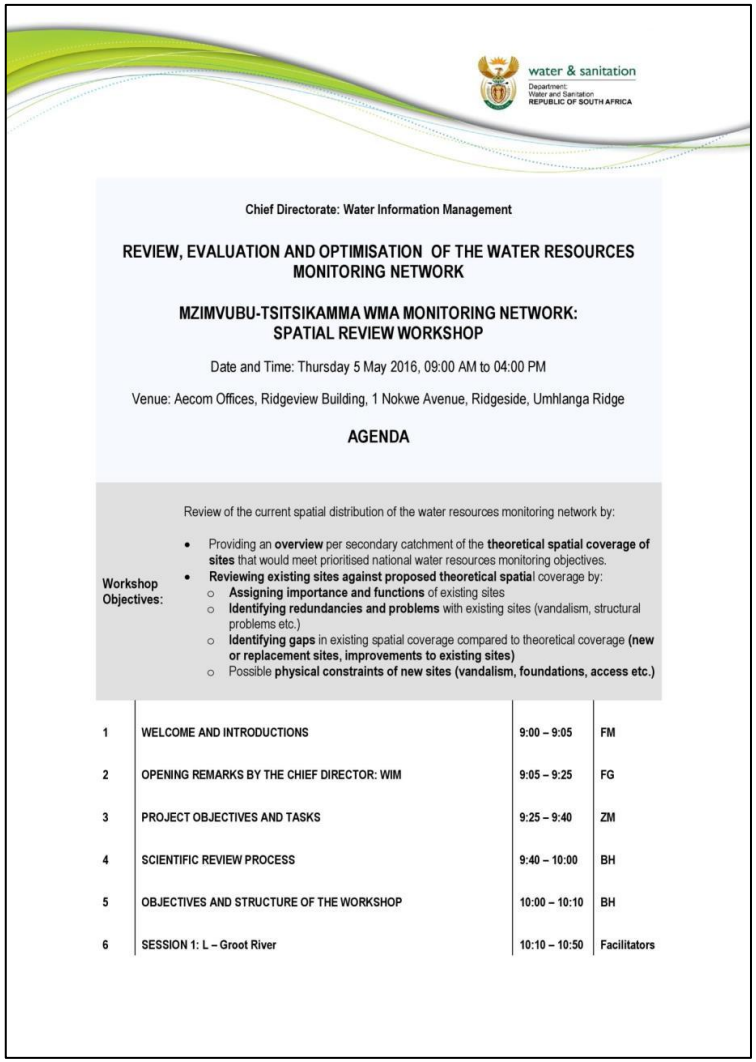
WMA 7: MZIMVUBU-TSITSIKAMMA



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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

MZIMVUBU-TSITSIKAMMA WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Thursday 5 May 2016, 09:00 AM to 04:00 PM

Venue: Aecom Offices, Ridgeview Building, 1 Nokwe Avenue, Ridgeside, Umhlanga Ridge

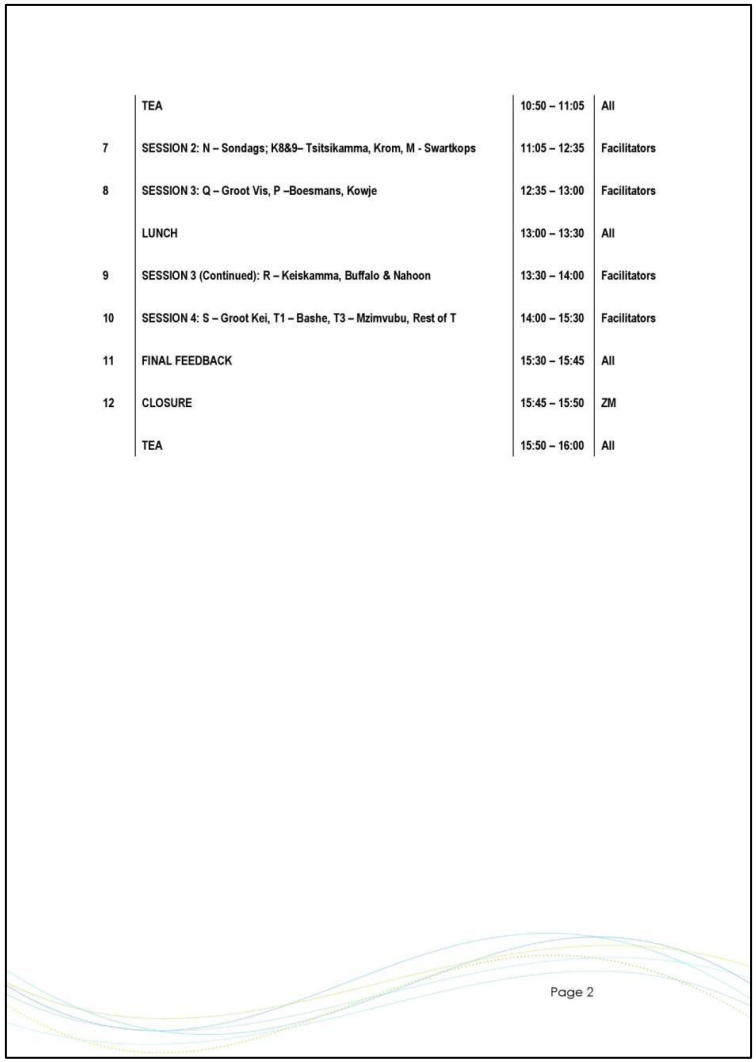
AGENDA

Workshop Objectives:

Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	FM
2	OPENING REMARKS BY THE CHIEF DIRECTOR: WIM	9:05 – 9:25	FG
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	ZM
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH
6	SESSION 1: L – Groot River	10:10 – 10:50	Facilitators



	TEA	10:50 – 11:05	All
7	SESSION 2: N – Sondags; K8&9– Tsitsikamma, Krom, M - Swartkops	11:05 – 12:35	Facilitators
8	SESSION 3: Q – Groot Vis, P –Boesmans, Kowje	12:35 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
9	SESSION 3 (Continued): R – Keiskamma, Buffalo & Nahoon	13:30 – 14:00	Facilitators
10	SESSION 4: S – Groot Kei, T1 – Bashe, T3 – Mzimvubu, Rest of T	14:00 – 15:30	Facilitators
11	FINAL FEEDBACK	15:30 – 15:45	All
12	CLOSURE	15:45 – 15:50	ZM
	TEA	15:50 – 16:00	All

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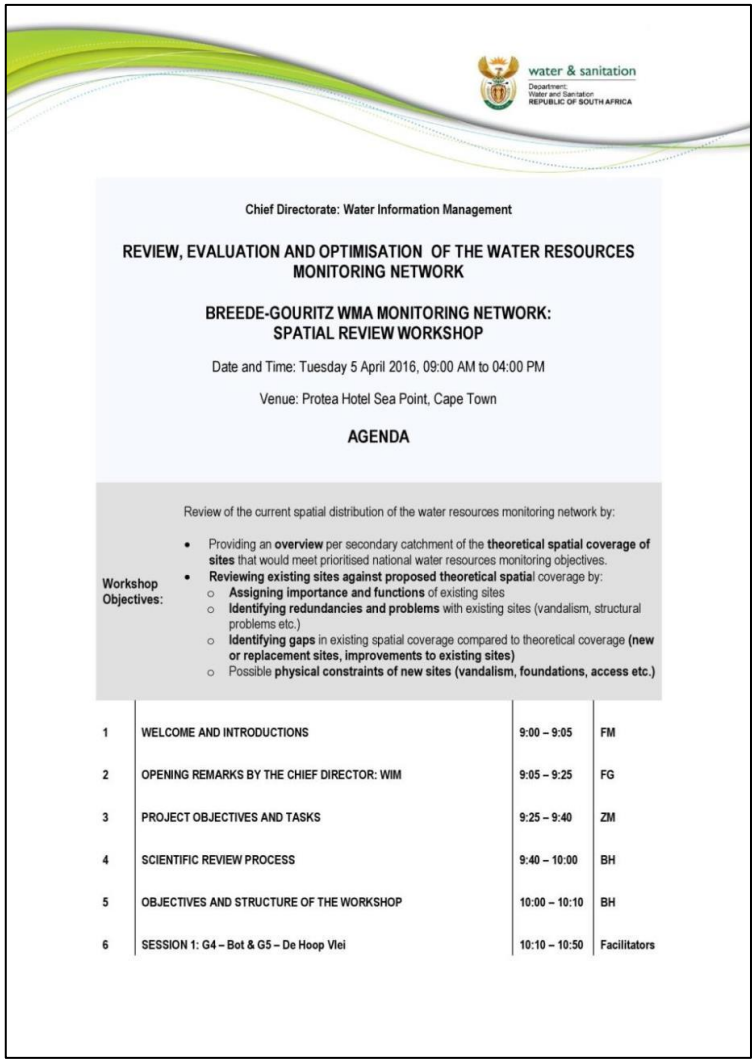
WMA 8: BREEDE-GOURITZ



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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

BREEDE-GOURITZ WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Tuesday 5 April 2016, 09:00 AM to 04:00 PM

Venue: Protea Hotel Sea Point, Cape Town

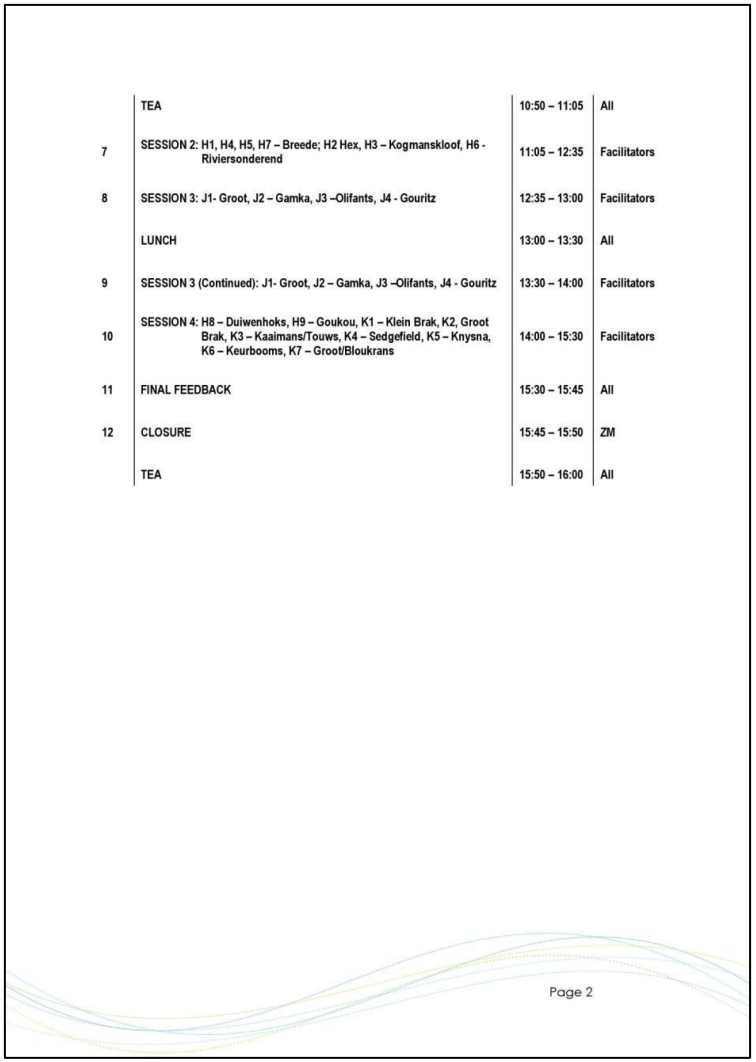
AGENDA

Workshop Objectives:

Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	FM
2	OPENING REMARKS BY THE CHIEF DIRECTOR: WIM	9:05 – 9:25	FG
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	ZM
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH
6	SESSION 1: G4 – Bot & G5 – De Hoop Vlei	10:10 – 10:50	Facilitators



	TEA	10:50 – 11:05	All
7	SESSION 2: H1, H4, H5, H7 – Breede; H2 Hex, H3 – Kogmanskloof, H6 - Riviersonderend	11:05 – 12:35	Facilitators
8	SESSION 3: J1- Groot, J2 – Gamka, J3 –Olifants, J4 - Gouritz	12:35 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
9	SESSION 3 (Continued): J1- Groot, J2 – Gamka, J3 –Olifants, J4 - Gouritz	13:30 – 14:00	Facilitators
10	SESSION 4: H8 – Duiwenhoks, H9 – Goukou, K1 – Klein Brak, K2, Groot Brak, K3 – Kaaimans/Touws, K4 – Sedgefield, K5 – Knysna, K6 – Keurbooms, K7 – Groot/Bloukrans	14:00 – 15:30	Facilitators
11	FINAL FEEDBACK	15:30 – 15:45	All
12	CLOSURE	15:45 – 15:50	ZM
	TEA	15:50 – 16:00	All

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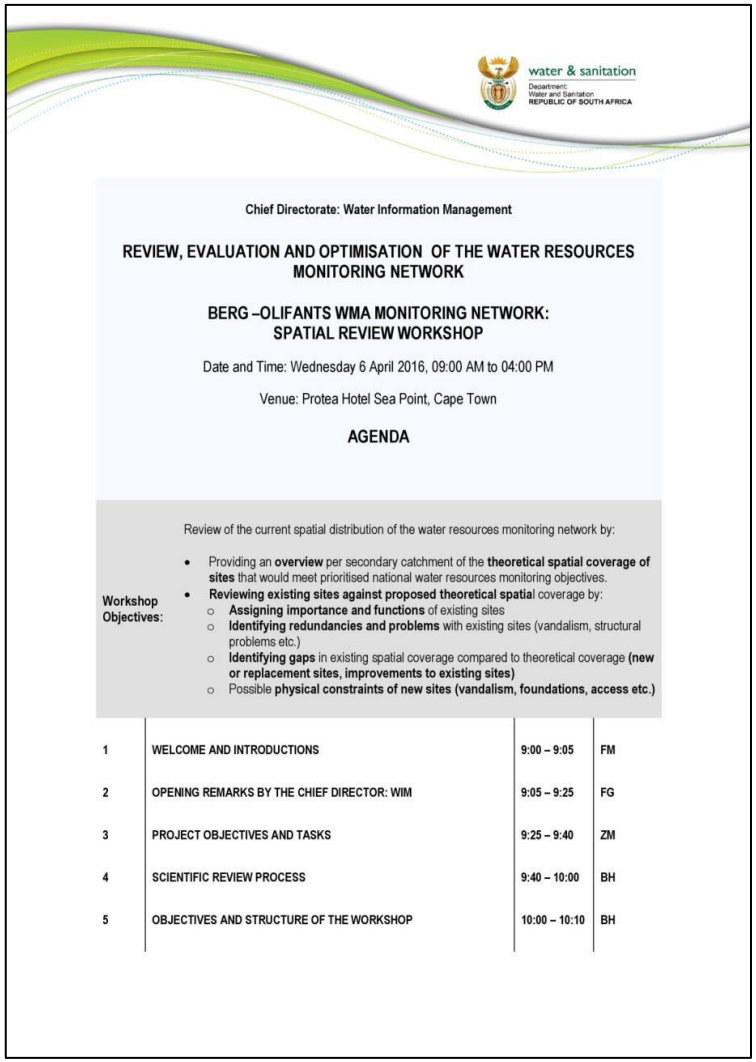
WMA 9: BERG-OLIFANTS



water & sanitation
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Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

BERG –OLIFANTS WMA MONITORING NETWORK: SPATIAL REVIEW WORKSHOP

Date and Time: Wednesday 6 April 2016, 09:00 AM to 04:00 PM

Venue: Protea Hotel Sea Point, Cape Town

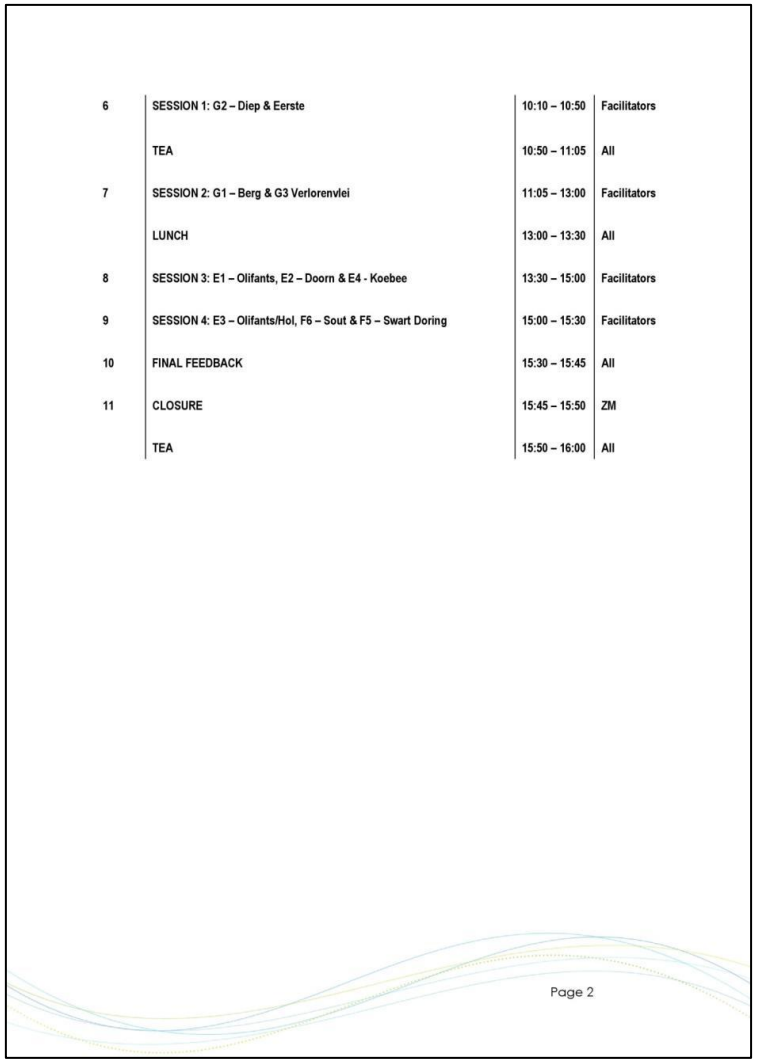
AGENDA

Workshop Objectives:

Review of the current spatial distribution of the water resources monitoring network by:

- Providing an **overview** per secondary catchment of the **theoretical spatial coverage of sites** that would meet prioritised national water resources monitoring objectives.
- **Reviewing existing sites against proposed theoretical spatia**l coverage by:
  - **Assigning importance and functions** of existing sites
  - **Identifying redundancies and problems** with existing sites (vandalism, structural problems etc.)
  - **Identifying gaps** in existing spatial coverage compared to theoretical coverage **(new or replacement sites, improvements to existing sites)**
  - Possible **physical constraints of new sites (vandalism, foundations, access etc.)**

1	WELCOME AND INTRODUCTIONS	9:00 – 9:05	FM
2	OPENING REMARKS BY THE CHIEF DIRECTOR: WIM	9:05 – 9:25	FG
3	PROJECT OBJECTIVES AND TASKS	9:25 – 9:40	ZM
4	SCIENTIFIC REVIEW PROCESS	9:40 – 10:00	BH
5	OBJECTIVES AND STRUCTURE OF THE WORKSHOP	10:00 – 10:10	BH



6	SESSION 1: G2 – Diep & Eerste	10:10 – 10:50	Facilitators
	TEA	10:50 – 11:05	All
7	SESSION 2: G1 – Berg & G3 Verlorenvlei	11:05 – 13:00	Facilitators
	LUNCH	13:00 – 13:30	All
8	SESSION 3: E1 – Olifants, E2 – Doorn & E4 - Koebee	13:30 – 15:00	Facilitators
9	SESSION 4: E3 – Olifants/Hol, F6 – Sout & F5 – Swart Doring	15:00 – 15:30	Facilitators
10	FINAL FEEDBACK	15:30 – 15:45	All
11	CLOSURE	15:45 – 15:50	ZM
	TEA	15:50 – 16:00	All

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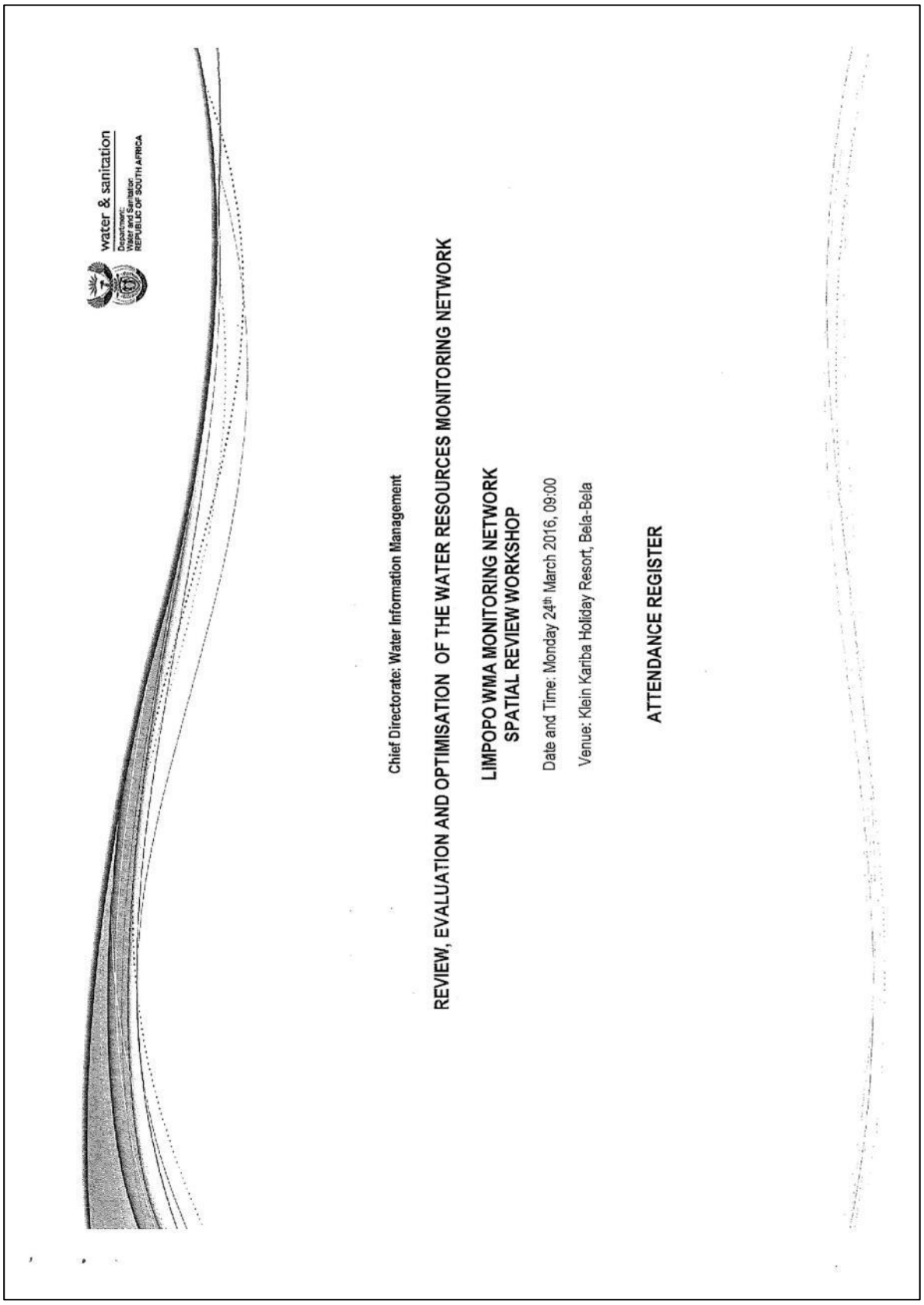
APPENDIX G

NETWORK DESIGN WORKSHOP ATTENDANCE REGISTERS

WMA 1: LIMPOPO



water & sanitation
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Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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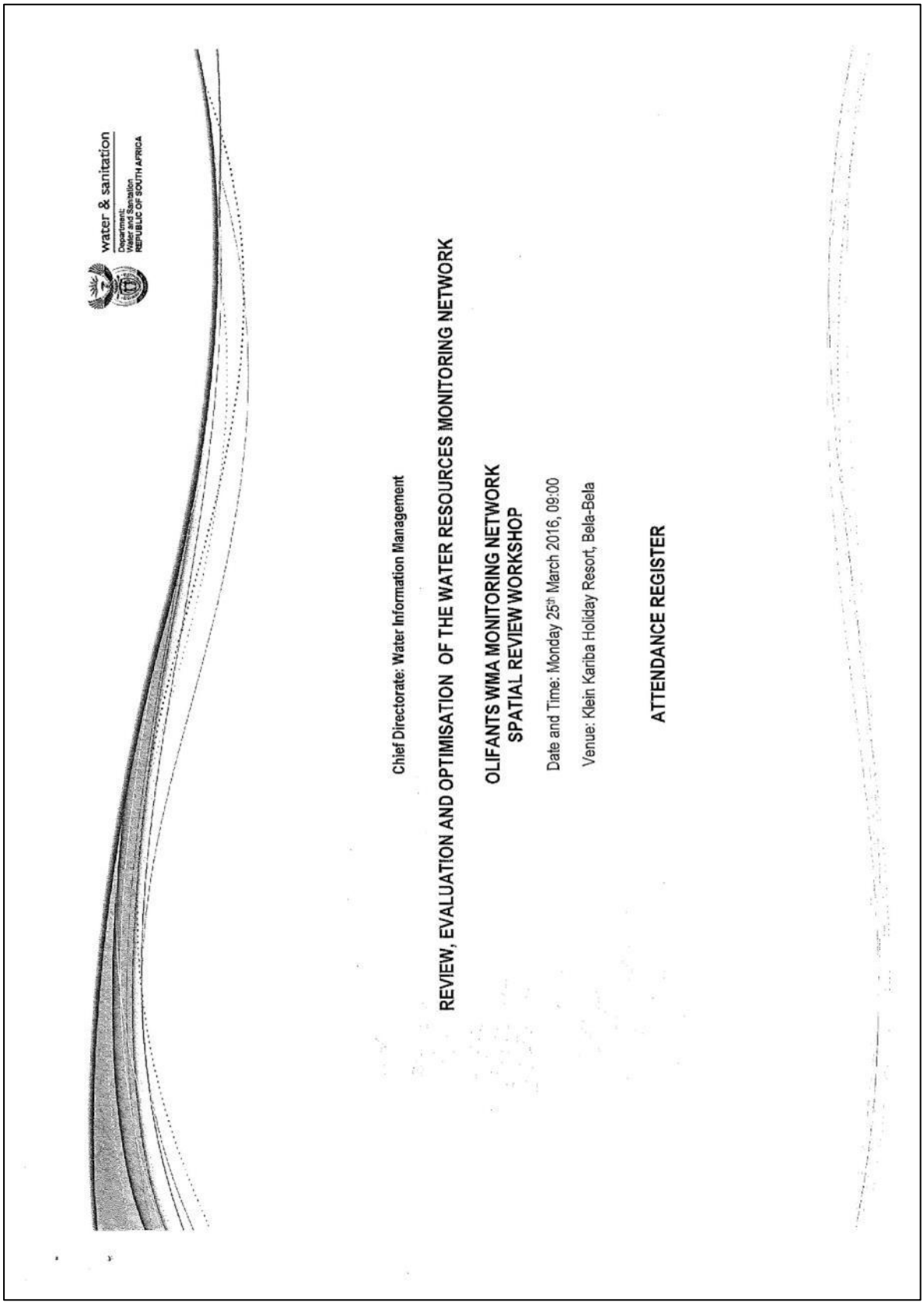
WMA 2: OLIFANTS



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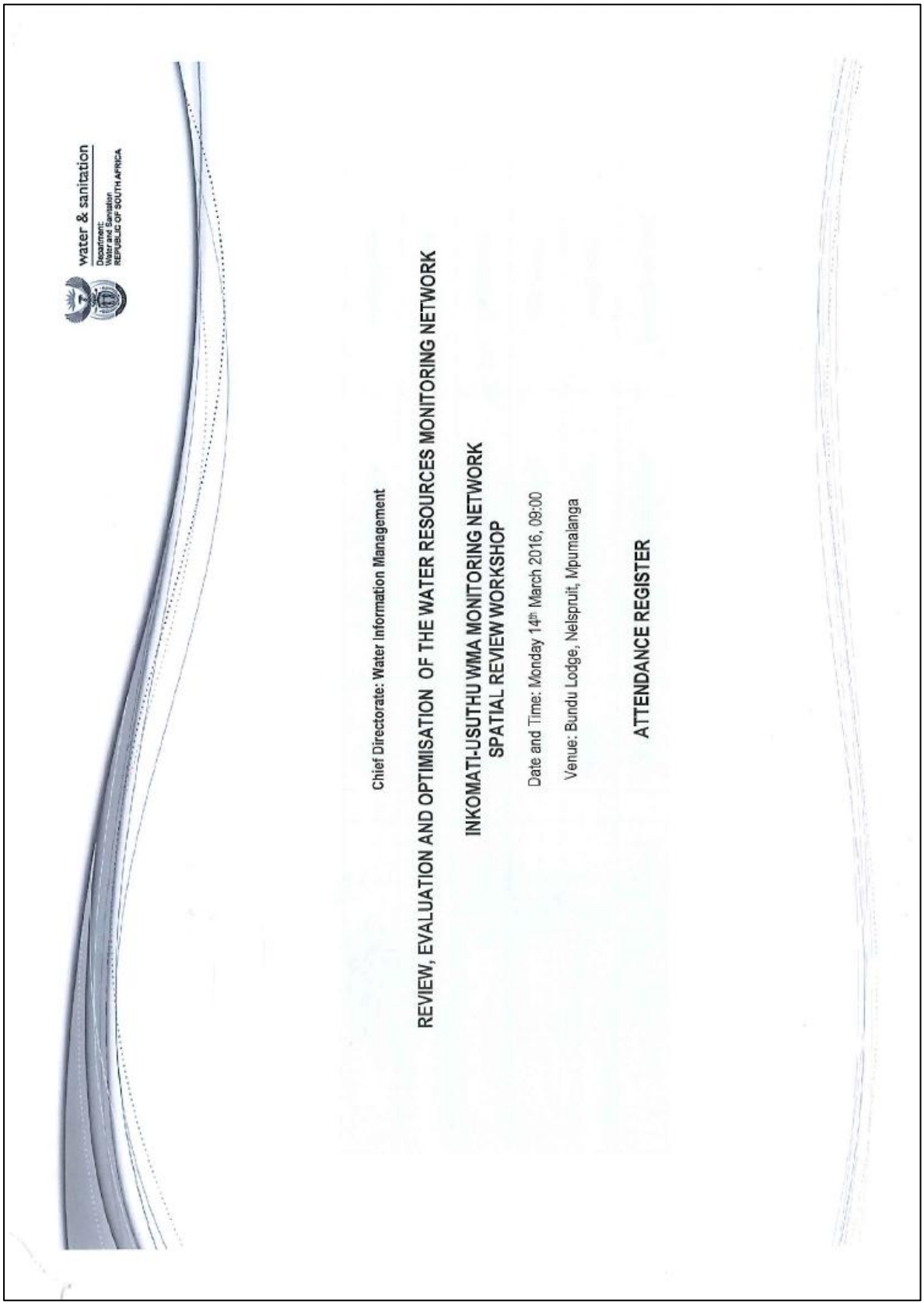
WMA 3: INKOMATI-USUTHU



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REPUBLIC OF SOUTH AFRICA

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Dennis Dlamini	DlaminiDJ@dws.gov.za	DWS	

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Musariri Musariri	MusaririM@dws.gov.za	DWS	

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Welcome Nyalungu	NyalunguW@dws.gov.za	DWS	
Zacharia Maswuma	MaswumaZ@dws.gov.za	DWS	

water & sanitation
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REPUBLIC OF SOUTH AFRICA

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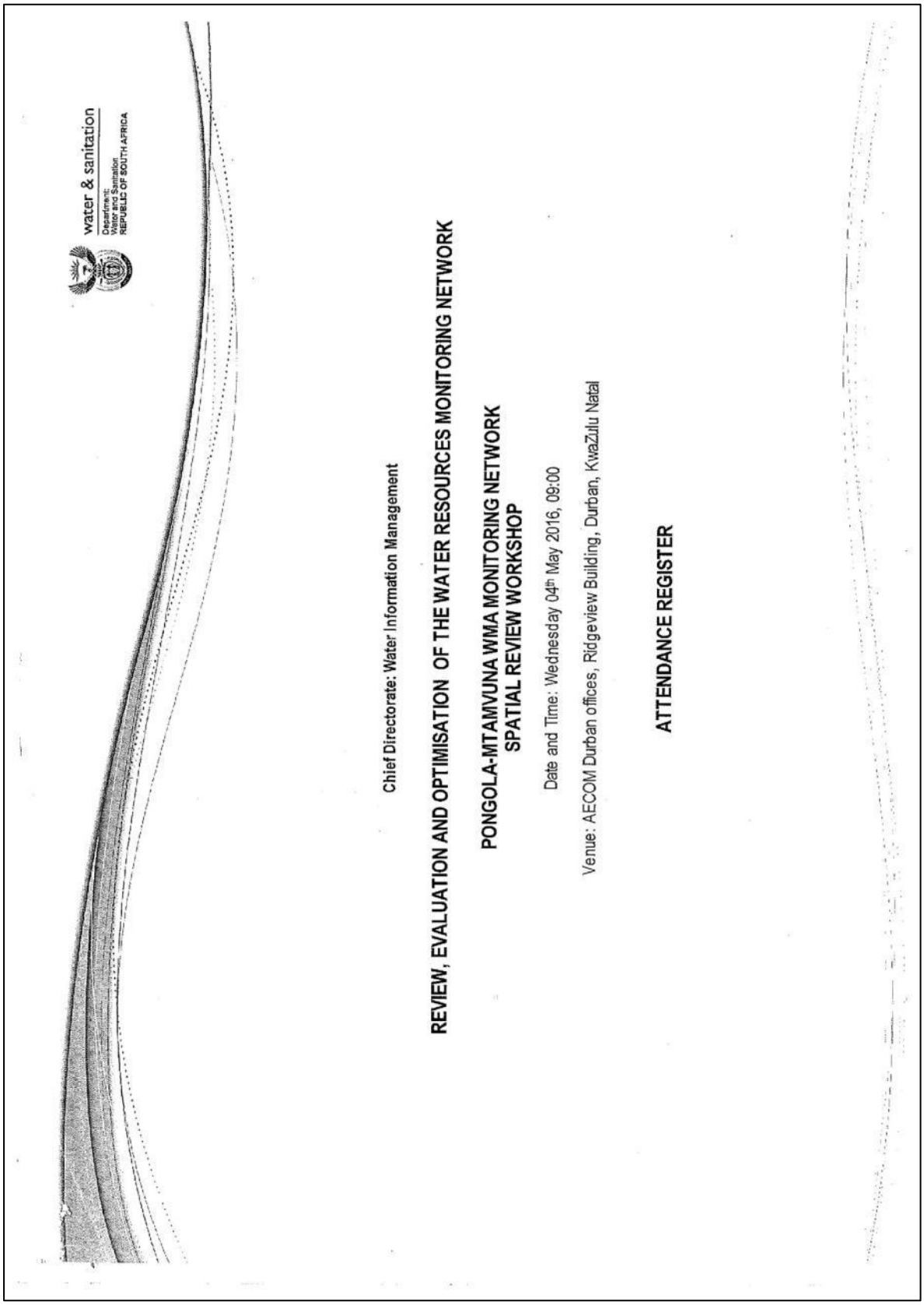
WMA 4: PONGOLA-UMZIMKULU



water & sanitation
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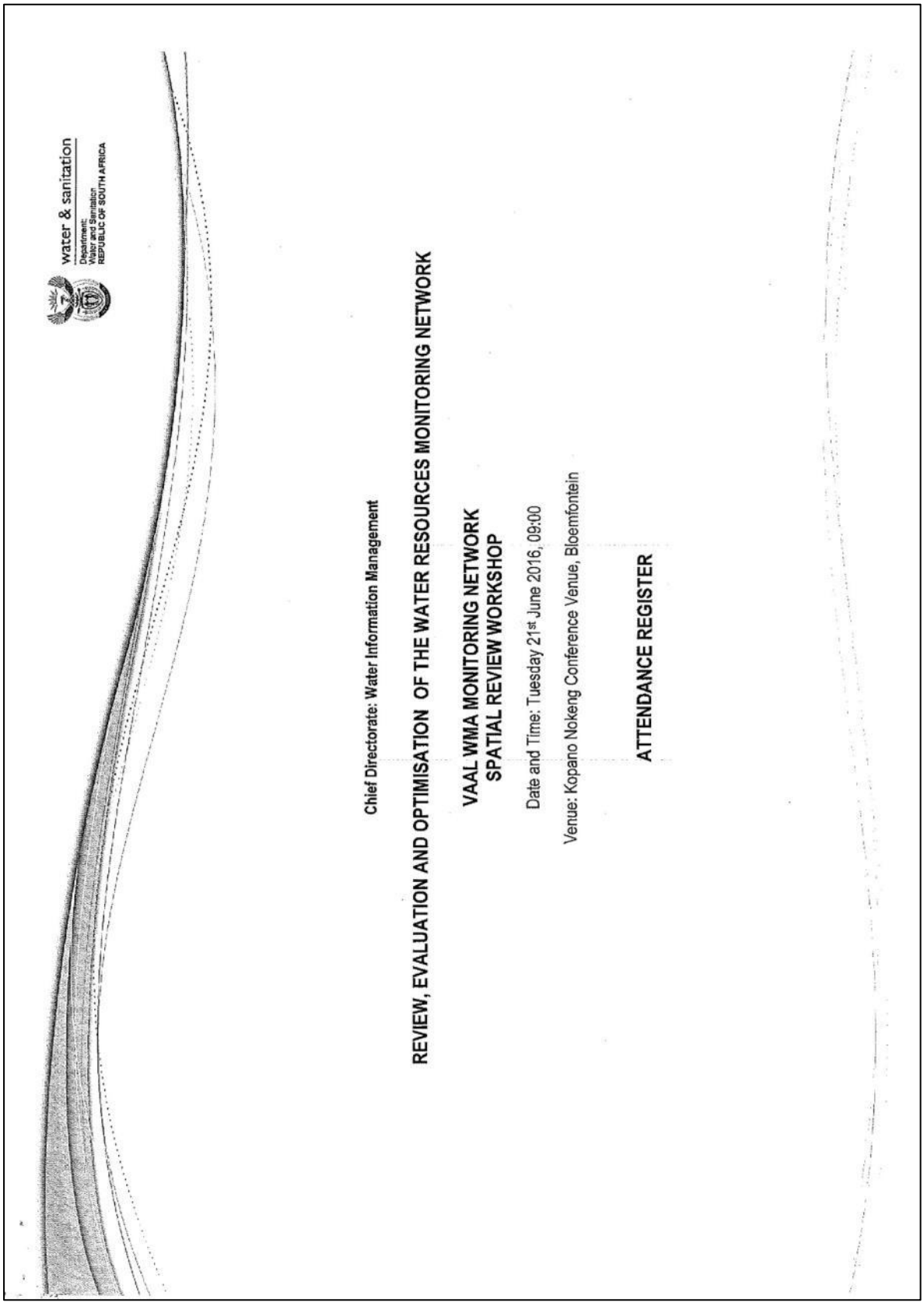
WMA 5: VAAL


water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA
Chief Directorate: Water Information Management
REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK
VAAL WMA MONITORING NETWORK
SPATIAL REVIEW WORKSHOP
Date and Time: Tuesday 21st June 2016, 09:00
Venue: Kopano Nokeng Conference Venue, Bloemfontein
ATTENDANCE REGISTER

Vaal (WMA5) Network optimisation Workshop 21/06/2016 (Kopanang Nokeng)

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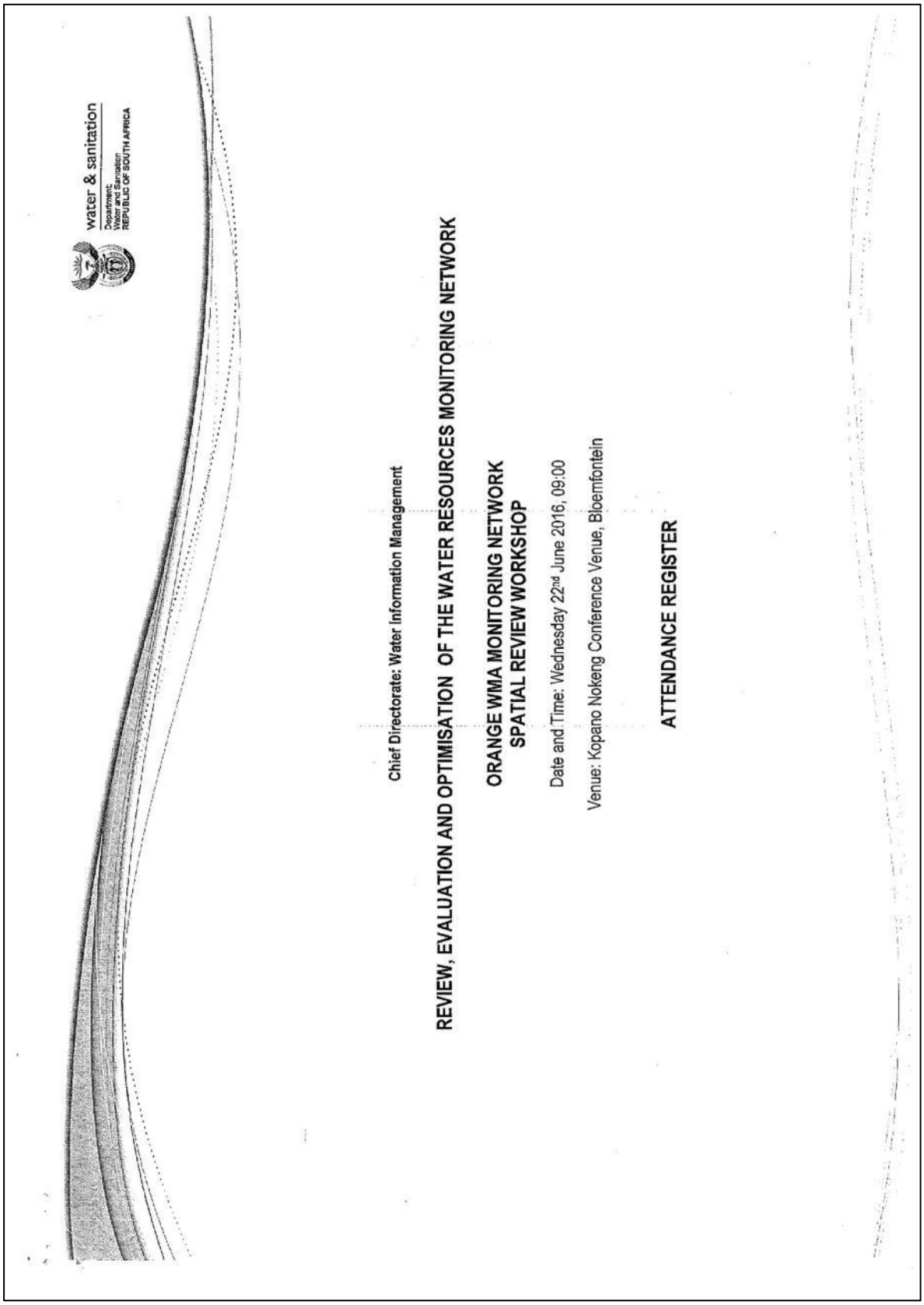
WMA 6: ORANGE


water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA
Chief Directorate: Water Information Management
REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK
ORANGE WMA MONITORING NETWORK
SPATIAL REVIEW WORKSHOP
Date and Time: Wednesday 22nd June 2016, 09:00
Venue: Kopano Nokeng Conference Venue, Bloemfontein
ATTENDANCE REGISTER

Orange WMA Kopano Nokeng
Water monitoring network
optimisation 22/06/2016

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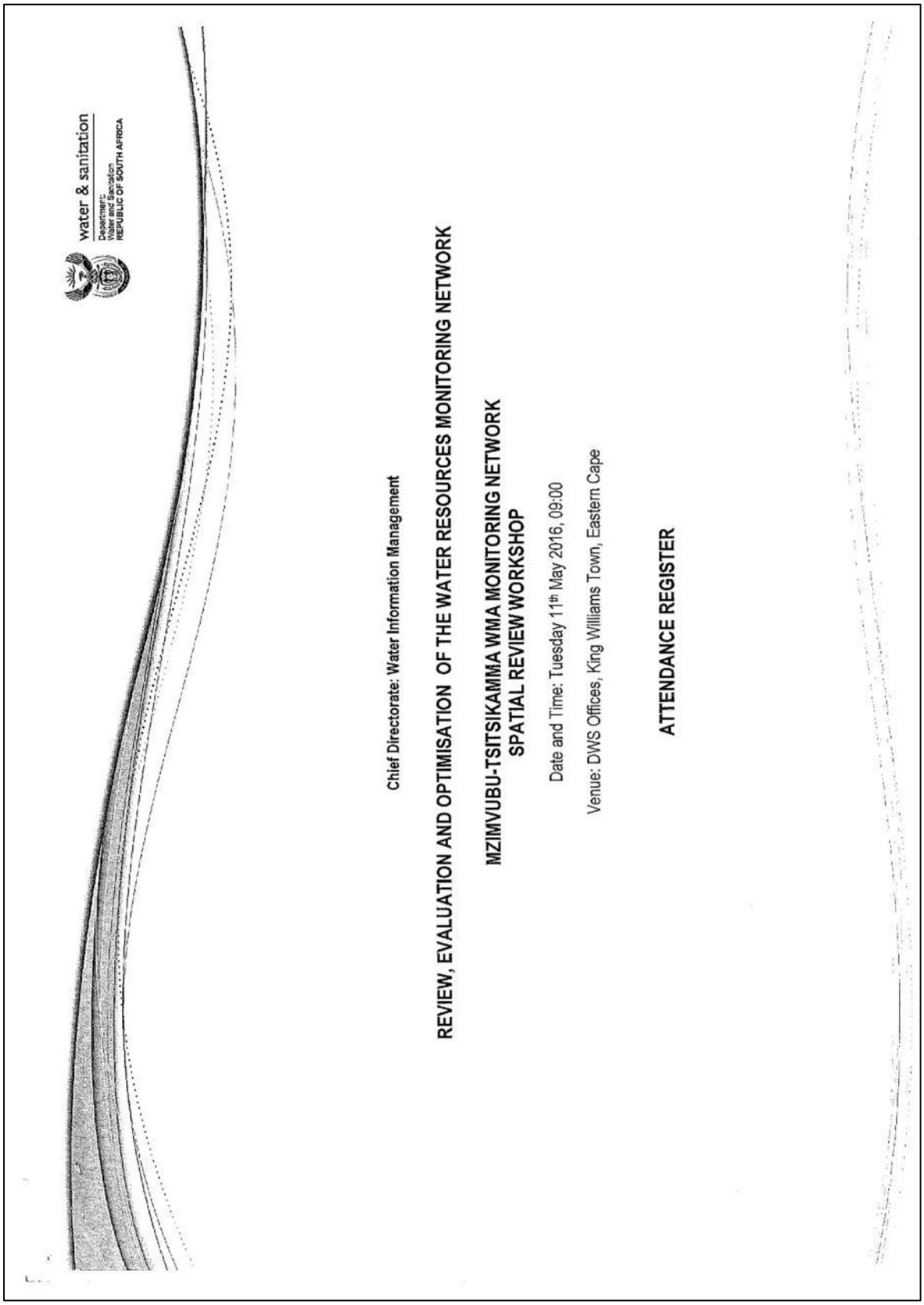
Page 5

WMA 7: MZIMVUBU-TSITSIKAMMA



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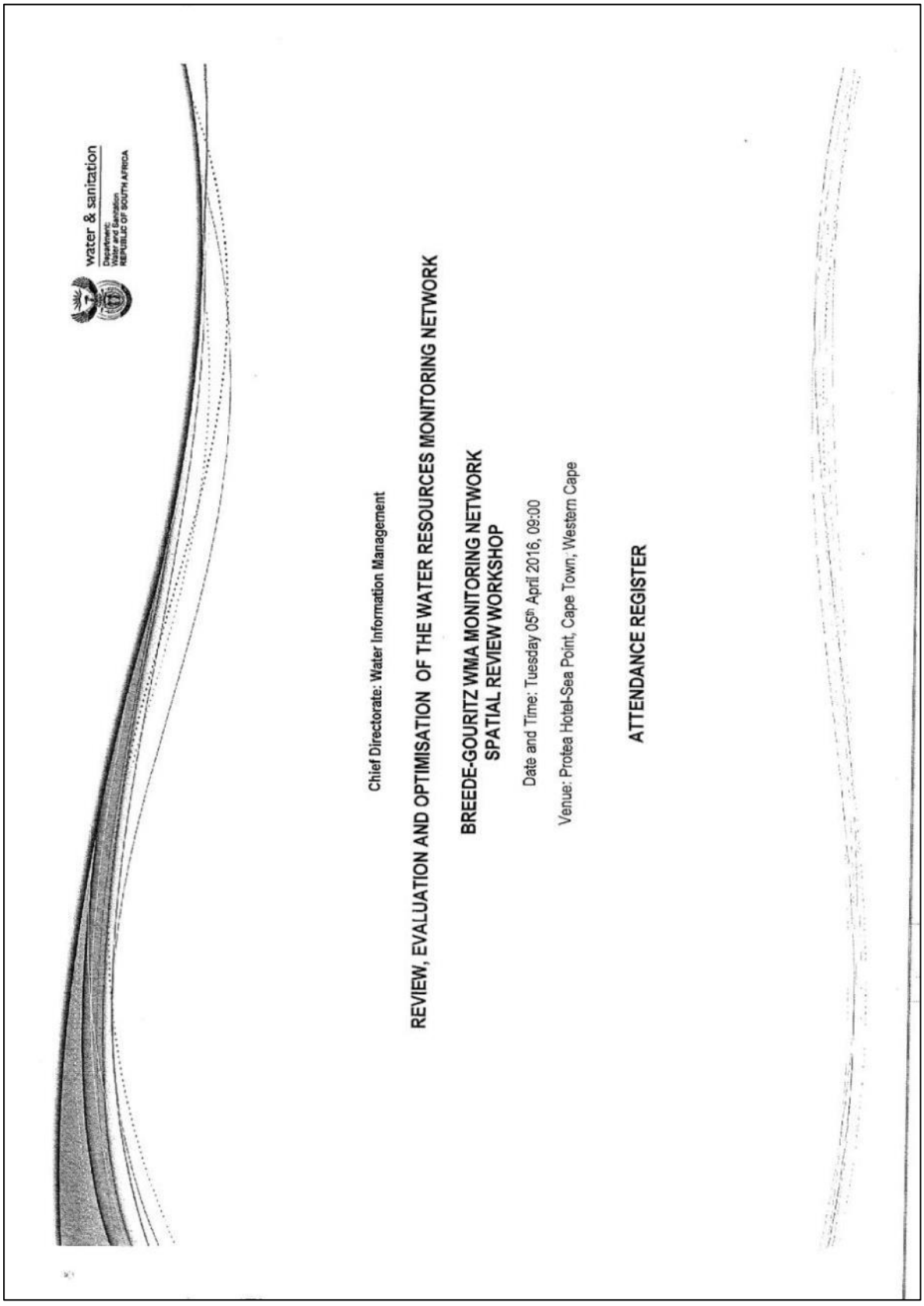
WMA 8: BREEDE-GOURITZ



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Page 5

WMA 9: BERG-OLIFANTS

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REPUBLIC OF SOUTH AFRICA

Chief Directorate: Water Information Management

REVIEW, EVALUATION AND OPTIMISATION OF THE WATER RESOURCES MONITORING NETWORK

BERG-OLIFANTS WMA MONITORING NETWORK
SPATIAL REVIEW WORKSHOP

Date and Time: Wednesday 06th April 2016, 09:00

Venue: Protea Hotel-Sea Point, Cape Town, Western Cape

ATTENDANCE REGISTER

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