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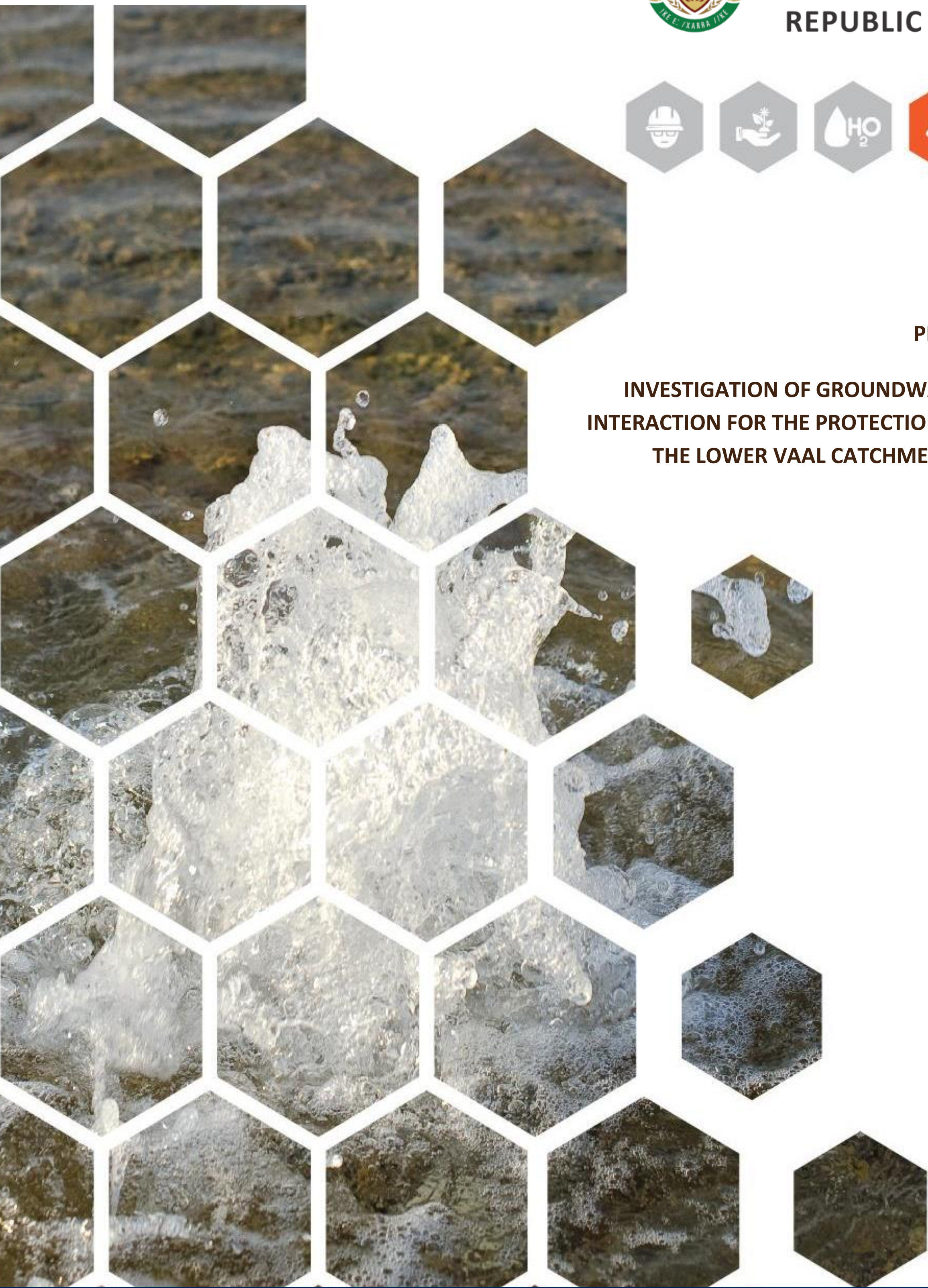

PROJECT NUMBER: WK21047

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

DATE: September 2022

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WP11380

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INVESTIGATION OF GROUNDWATER AND SURFACE WATER INTERACTION FOR THE PROTECTION OF WATER RESOURCES IN THE LOWER VAAL CATCHMENT
WP13380

HYDROCENSUS REPORT

SEPTEMBER 2022

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DOCUMENT INDEX

Report name	**Report number**
Inception Report	RDM/WMA05/00/GWSW/0122
Literature Review and Data Gathering Report	RDM/WMA05/00/GWSW/0222
Gap Analysis Report	RDM/WMA05/00/GWSW/0322
Hydrocensus Report	**RDM/WMA05/00/GWSW/0422**
Quantified Recharge and Baseflow Report	RDM/WMA05/00/GWSW/0123
Protection Zones Report	RDM/WMA05/00/GWSW/0223
External Reviewer Report	RDM/WMA05/00/GWSW/0323
Capacity Building and Training Report	RDM/WMA05/00/GWSW/0423
Main Report on Surface-Subsurface Interactions	RDM/WMA05/00/GWSW/0523
Close-out Report	RDM/WMA05/00/GWSW/0623

Bold indicates this report

APPROVAL

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DATE:	September 2022
AUTHORS:	Project Team
EDITOR:	Fourie I.
REVIEWERS:	Sami. K; Project Management Team
LEAD CONSULTANT:	WSM Leshika Consulting
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REPORT SCHEDULE

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First draft	July 2022
Final	September 2022

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1 INTRODUCTION

1.1 Study Context

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

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

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

1.2 Purpose of Report

This report is submitted to Department of Water and Sanitation (DWS) by WSM Leshika Consulting in terms of the contract to provide an interim report on hydrocensus results.

This report and details the following aspects of the work carried out:

- First consultation meetings;
- Hydrocensus Data Collection.

1.3 Background

The Department of Water and Sanitation appointed WSM Leshika Consulting (Pty) Ltd – ISD as a professional service provider for "Investigation of Groundwater and Surface Water Interaction for the Protection of water Resources in the Lower Vaal Catchment". The appointment is for a period of 24 (twenty-four) months – starting November 2021-November 2023. As part of the hydrocensus study, the following key information is required as deliverables and outputs that are applicable to the project, and are expected to be achieved:

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

2 STUDY AREA

2.1 Description

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

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

The Molopo river forms an international boundary with Botswana and contains transboundary aquifers. The most significant is the Khakea-Bray dolomitic aquifer in D41C, D and F and Z10D in Botswana. It was investigated by ORASECOM (2018). The aquifer is divided into 6 resource units. Calculated recharge for the entire aquifer is 14.79 Mm^3/a. In the Resource Unit directly shared between South Africa and Botswana, recharge is 6.21 Mm^3/a. 1220 km^2 (59%) of the 2061 km^2 lie within South Africa and the remainder (41%) is in Botswana. In 2016 a restriction was implemented reducing the total abstraction to 8.2 Mm^3/a on the South African side. To this volume must be added 0.6 Mm^3/a, of irrigation on the Botswana side, along the Molopo River. The current combined groundwater use of 8.8 Mm^3/a in the resource unit which is shared exceeds the calculated recharge of 6.21 Mm^3/a in the shared compartment, hence why the significant water level decline that occurred in the study area, of up to 60 m. It is likely that the recharge to the other resource units drains to the shared unit since no natural outlets or springs exist.

2.2 Municipalities

The District and Local Municipalities in the study area are shown in **Figure 2-1.** Municipalities consulted as part of the study include: (1) Francis Baard Municipality, (2) Phokoane Municipality, (3) Magareng Municipality, (4) Dikgatlong Municipality, (5) Sol-Plaatjie Municipality, (6) Naledi Municipality. All these municipalities get water from Sedibeng Water and Vaalhaarts Water. Sedibeng Water was dissolved in 2022 and is being merged with Bloem Water and Magalies Water.

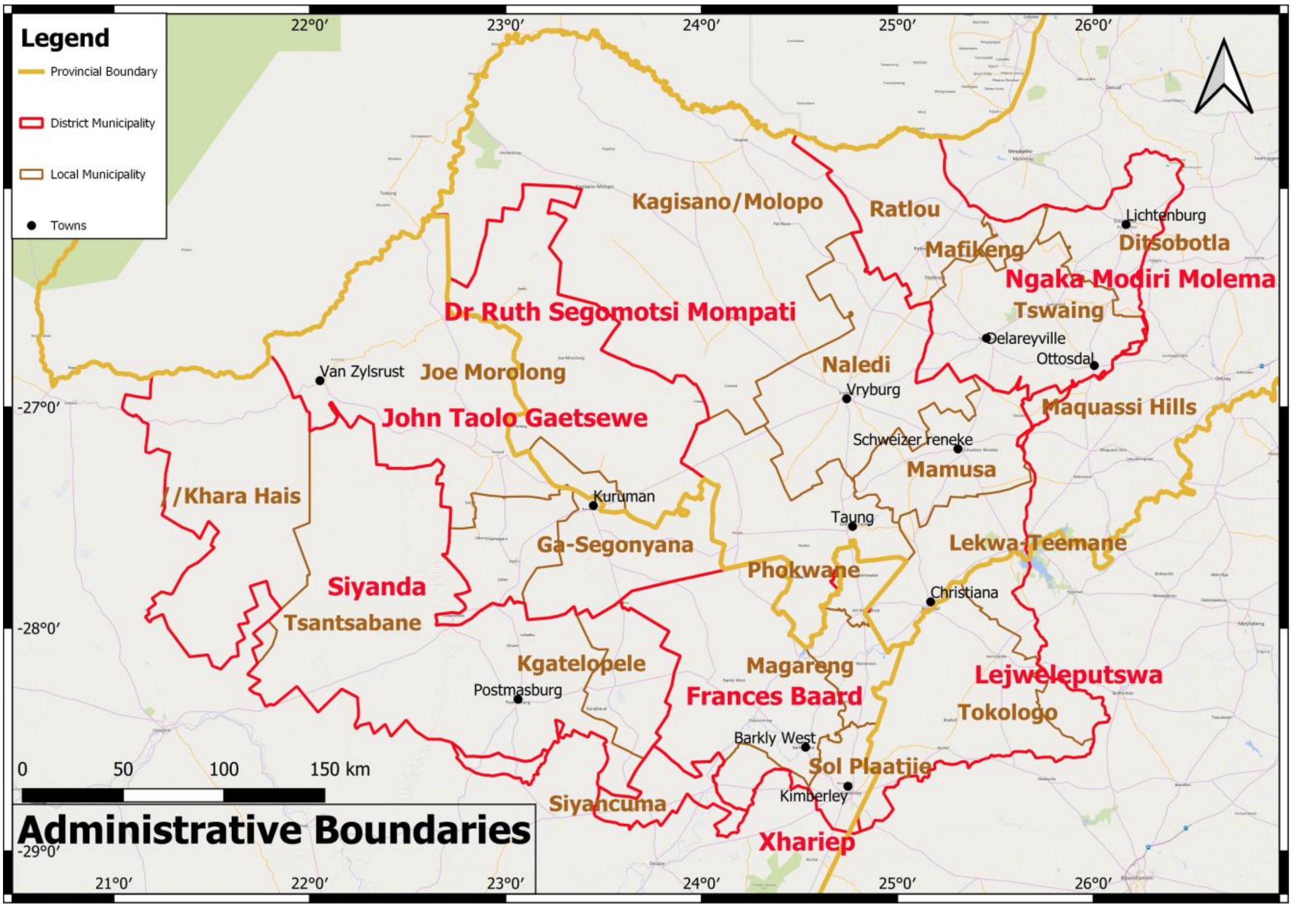

Figure 2-1 Municipalities

3 HYDROCENSUS

3.1 Project Development

The Work Plan was submitted by WSM Leshika Consulting for the adaptation of the generic guideline for the implementation of the project and the requirements of the communication strategy – comprised the Stakeholder Engagement Plan (**Table 3-1**) which was discussed and agreed on. A virtual meeting was held in this regard – 20th April 2022. At this meeting agreement was also reached upon the time frames for deliverables, as well as the list of stakeholder groupings to be included in the consultation process. The inception and development meeting served the following purposes:

- Introduce the Professional Service Provider (PSP)
- Establish common ground amongst role-players; and
- Development of a Project Execution Plan.

Table 3-1 Stakeholder Engagement Plan Framework

PROJECT - TO INVESTIGATE GROUNDWATER SURFACE WATER INTERACTIONS FOR THE PROTECTION OF THE WATER RESOURCES IN THE LOWER VAAL CATCHMENT OVER A PERIOD OF TWENTY-FOUR (24) MONTHS				
Item No:	**Main Activity**	**Outcome**	**Target Output**	**Key Performance Indicator**
1.1	First Consultation with Stakeholders	All Stakeholders give the Project a Buy-In	Roles and Responsibilities of all Stakeholders are clearly defined in terms of Project Implementation.	• The Stakeholders approval of the Project. • Identification of all relevant water users to form part of the Project Steering Committee (PSC) - inclusive of all stakeholders. • Notes and/or Minutes of First Consultation Meetings and Engagements.
1.2	One-on-One Sessions with affected Stakeholders	Department, Municipality, Water Boards, Irrigation Boars, etc form part of the Project Steering Committee and assist WSM Leshika Consulting as the Project Agent to work smoothly in conducting a hydrocensus.	The PSC is Established and Terms of Reference for the PSC signed off – explaining each member's roles and responsibilities.	• Composition of the PSC representatives of the municipality, Water Boards, Irrigation Boards, etc. for the "Project Programme".
1.3	Conducting a Hydrocensus	The site has a clear, approved framework within which project implementation can proceed and against which performance can be measured. The actions include: • Obtain WARMS data	• Data obtained from stakeholders • Concerns of stakeholders identified - .	• Compilation of hydrocensus report

PROJECT - TO INVESTIGATE GROUNDWATER SURFACE WATER INTERACTIONS FOR THE PROTECTION OF THE WATER RESOURCES IN THE LOWER VAAL CATCHMENT OVER A PERIOD OF TWENTY-FOUR (24) MONTHS				
Item No:	**Main Activity**	**Outcome**	**Target Output**	**Key Performance Indicator**
		• Hydrocensus of relevant institutions • Identification of wetlands and protected areas • Identification of contaminant sources • Analysis of water quality status		

3.1 First Consultations

A series of one-on-one meetings (site visits) and interactions were held between the dates – 13th June 2022 and 15th June 2022 with the following stakeholders: (1) Francis Baard Municipality, (2) Phokoane Municipality, (3) Magareng Municipality, (4) Dikgatlong Municipality, (5) Sol-Plaatjie Municipality, (6) Naledi Municipality, (7) Vaalhaarts Water and (8) Sedibeng Water to inform Technical Services Managers on the information required as part of the Hydrocensus. Details of meetings and interactions are as follows:

Stakeholder Name	Stakeholder Representative	Meeting Date	Results (if any)
Francis Baard Municipality	Rorisang Setshogoe	13th June 2022	The municipality coordinated all the meetings with various municipalities
Magareng Municipality	Tumelo Thage	13th June 2022	Hydrocensus data will be collated, and sent to WSM Leshika Consulting
Dikgatlong Municipality	Desmond Makaleni	13th June 2022	Hydrocensus data will be collated, and sent to WSM Leshika Consulting
Sol-Plaatjie Municipality	Sabelo Mkhize Boy Dhluwayo	14th June 2022	Hydrocensus data will be collated, and sent to WSM Leshika Consulting
Phokoane Municipality	Lubabalo Jange	13th June 2022	Hydrocensus data will be collated, and sent to WSM Leshika Consulting
Vaalhaarts Water	Anita Kooverjee Niel Van Eeden	13th June 2022	Hydrocensus data will be collated, and sent to WSM Leshika Consulting
Sedibeng Water	Frans De Vos	13th June 2022	Hydrocensus data submitted – as part of the Ages Report on the Regional Geohydrological Potential Assessment for Ganyesa, North West Province
Naledi Municipality	Leon Pretorius	14th June 2022	Hydrocensus data still being collated

3.2 Hydrocensus Data Collection

The information requirements provided to stakeholders as part of the meeting and data collection is listed in **Table 3-2.**

Table 3-2 Information requirements provided to stakeholders

Data Requirement	Response
Water use data: surface and groundwater monthly water use. Historical, present and forecast.	Data for 2022 only was sent to WSM Leshika from Vaalharts

Water Quality data: water quality analyses, results and frequency;	No data is collected
Waste water discharge volumes and quality data;	No data received
Water monitoring: historical to present water levels in monitoring boreholes. Location of boreholes and status (functional, blocked, collapsed etc);	Borehole monitoring still resides with the DWS. This has been obtained from HYDSTRA
Registered water use volume;	Obtained for Vaalharts
Area served: towns and population.	○ Phokwane (Population 65 000) ○ Magareng (Population 25 000) ○ Dikgatlong (Population 45 000) ○ Greater Taung (Sedibeng Water) (Population 180 000) ○ Naledi (Sedibeng Water) (Population 66 000)

3.2.1 Vaalharts water use

Data was received from Vaalharts Water. The Vaalharts Irrigation scheme is the largest in South Africa and one of the largest irrigation schemes in the world, covering 369.50 km^2. Water from a diversion weir in the Vaal River flows through a 1,176 km long network of canals. This system provides irrigation water to a total of 39,820 ha scheduled land, water supply to six towns and water to other industrial water users.

The data obtained consisted of registered use (**Table 3-3)** and allocations and current use in 2022 (**Table 3-4).** Vaalharts Water is provided water for irrigation, industry, and water supply from the Vaalharts canal and the Spitskop dam. 350.438 Mm^3/a is registered for irrigation and 13.328 allocated to industry.

Table 3-3 Water allocations from Vaalharts

Source	Allocation Volume (Mm3/a)	Quaternary	Water use sector
Spitskop dam	3.289	C33C	Irrigation
Vaalharts	28.041	C33C	Irrigation
Vaalharts	0.319	C33C	Industry
Vaalharts	7.266	C33C	Industry
Spitskop dam	0.021	C33C	Industry
Spitskop dam	12.806	C33C	Irrigation
Vaalharts	270.723	C33C	Irrigation
Vaalharts	5.722	C33C	Industry
Vaalharts	31.839	C33C	Irrigation

Vaalharts	2.74	C33C	Irrigation
	362.766		

Actual use differs from the registered allocations. Present day use indicates only 26% of the water is utilised, with only 94.986 Mm^3/a released. Of this volume, 8.402 Mm^3/a is utilised for water supply to Phokwane, Dikgatlong and Magareng. However, releases to the canal at Warrention (C9H018), indicate that abstractions from the Vaal have been increasing over time and often exceed 400 Mm^3/a (**Figure 3-1)**.

Table 3-4 Actual use from Vaalharts Water

Water Use	Use (Mm3/a)
Agriculture	31.728
Industry	0.068
Water Supply	8.402
Other	0.382
Downstream users	30.398
Total	70.978
Releases	94.986

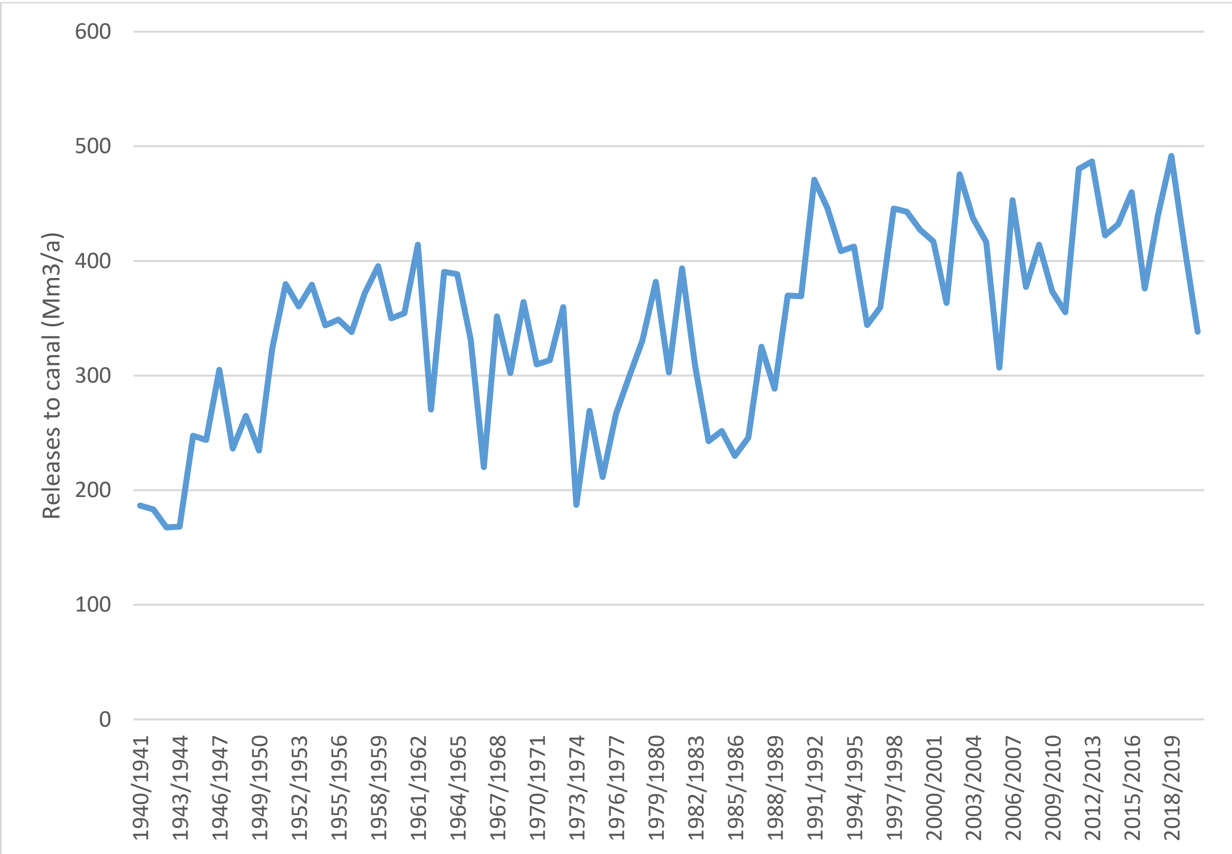

Figure 3-1 Releases into the Vaalharts Canal

3.2.2 *Kalahari east scheme*

The Kalahari-East Water Supply Scheme delivers 100 l/s and serves 278 farms covering 1 480 624 hectares of land. The total length of the pipelines is more than 1200 kilometres. This water supply scheme is run by the Kalahari East Water Users Association. Water is pumped from the Sishen mine into the Vaal Gamagara pipeline' from where the Kalahari-East water supply scheme withdraws water at a maximum rate of 103 l/s.

3.2.3 *Vaal-Gamagara scheme*

The Vaal Gamagara Regional Water Supply was completed in 1968 and transferred to Sedibeng Water in 2008. Uptake is at the Delportshoop Water Treatment Works and runs past the towns of Ulco, Lime Acres and Postmasburg before ending at Olifantshoek, in the Northern Cape.

The scheme supplies water to the following sectors (iX engineers, 2019):

- Local municipalities: Dikgatlong, Kgatelopele, Tsantsabane, Gamagara and Joe Morolong;
- Mines and industries
- Solar projects
- Water supply schemes: Kalahari East water supply scheme
- Government and parastatal institutions: Lohatla Military Base, Transnet and Eskom; and
- Agriculture: mainly stock watering along the scheme, and domestic use.

The current water demand of 25 Mm^3/a should increase to approximately 28 Mm^3/a by the year 2030. Some towns supplement water with their own boreholes and taking this into account, it is estimated that the municipalities will require 8.02 Mm^3/a from the scheme by 2038.Current water supply is 5 Mm^3/a. Estimates for other users are: mines 15.8 Mm^3/a, solar plants 0.5 Mm^3/a, and Kalahari East Water User Association, government, parastatal entities another 4 Mm^3/a.

3.2.4 *Water supply*

Irrigation, industrial and mining water use are easier to compile since use is registered and sometimes measured. Water supply use is more widespread and more difficult to compile since often it is not registered nor monitored. From the hydrocensus information and data collection, an estimate of water use was compiled (**Table 3-5)** by Local Municipality and water scheme.

The total water use is 94.798 Mm^3/a, of which 48.179 is from surface water. Average per capita consumption is 145 l/c/d. 6.258 Mm^3/a is from the Vaal via the Vaal-Gamagara scheme. It is possible some abstraction has been missed since the water use for Greater Taung, Tswaing and Ratlou seem low. The location of water supply schemes is shown in **Figure 3-2**.

Table 3-5 Estimated use for water supply

Municipality	Population	Water Supply Scheme	Source	Use (Mm³/a)	Surface water (Mm³/a)	Groundwater (Mm³/a)	l/c/d
Tsantsabane	44455	Postmasburg	Vaal Gamagara pipeline	0.8	0.8		150
			8 boreholes	0.627		0.627	
			Kalahari East	1	1		
Kgatelopele	23356	Danielskuil	2 boreholes	0.69		0.69	238
		Lime Acres, Papkuil, Owendale	Vaal Gamagara	1.2	1.2		
Siyacuna	1662	Campbell	2 springs 3 boreholes	0.142		0.142	234
		Schmidtdrift					
Sol Plaatjie	244206	Kimberley	Vaal at Riverton	18.62	18.62		217
Tokologo	28233	Boshof	boreholes	0.73		0.73	130
			Pipeline from Vaal				
		Hertzogville	boreholes	0.61		0.61	
			Pipeline from Vaal				
Lekwa-Teemane	61832	Utlwanang/Christiana	Vaal river	2.234	2.234		213
		Bloemhof	Bloemhof dam	2.572	2.572		
Magareng	31926	Warrenton	Vaalharts canal	3.262	3.262		280
			Boreholes				
Dikgatlong	50966	Delpoortshoop	Vaal Gamagara	0.697	0.697		238
		Ulco	Vaal river	2.14	2.14		
		Barkly west	Vaal river	1.298	1.298		
			boreholes				
		Holpan	boreholes				
		Windsorton	Vaalharts	0.286	0.286		
			boreholes				
Phokwane	63345	Jan Kempdorp	Vaalharts	1.461	1.461		217
		Ganspan	Boreholes				
		Hartswater	Vaalharts	1.187	1.187		

		Magogong	boreholes				
		Pampierstad	Vaalharts	2.359	2.359		
Gamagara	55578	Kathu	boreholes	4.65		4.65	287
			Vaal Gamagara	0.2	0.2		
		Dibeng	Boreholes	0.405		0.405	
		Olifantshoek	Vaal Gamagara	0.559	0.559		
Greater Taung	183963	Taung-Pudimoe	Vallharts	4	4		94
			boreholes	1.028		1.028	
		Reivilo	boreholes	0.093		0.093	
		Manthestad	boreholes	0.046		0.046	
		Bogosing	Vaalharts	0.362	0.362		
		Madipelesa	boreholes	0.092		0.092	
		Kgomotso	Harts river	0.48	0.48		
		Motsweding	boreholes	0.056		0.056	
		Mokgareng	boreholes	0.132		0.132	
Ditsobotla	200994	Boikhutso	boreholes	2.34		2.34	169
Ditsobotla		Biesvlei	boreholes	0.92		0.92	
Ditsobotla		Doornbult, Shiela, Omega, Grootpan	boreholes	9.11		9.11	
Ratlou	116644	Maipeng	boreholes	0.091		0.091	9
		Setlagoli	boreholes	0.197		0.197	
		Marapo	boreholes	0.009		0.009	
		Kraaipan	boreholes	0.104		0.104	
Tswaing	142341	Delareyville	boreholes	0.727		0.727	70
		Agisanang	boreholes	0.641		0.641	
		Letsopa	boreholes	1.041		1.041	
		Atamaleng	boreholes	1.246		1.246	
	75793	Vryburg	Vaalharts	0.58	0.58		141

Naledi			boreholes	3.1		3.1	
		Stella	boreholes	0.23		0.23	
Mamusa	70665	Schweizer-Reneke	Wentzel dam	1.08	1.08		112
			boreholes	1.4		1.4	
		Amalia	boreholes	0.321		0.321	
		Glaudina	boreholes	0.078		0.078	
Kagisano	112778	Morokweng	boreholes				138
		Pomfret	boreholes				
		Ganyesa	boreholes				
		Tlakmeng	boreholes				
		Piet Plessis	boreholes				
		Heuningsvlei	boreholes	5.685		5.685	
Ga-Segonyana	86626	Kuruman Bankhara Kono	boreholes	4.522		4.522	235
		Mothibistad	boreholes	2.015		2.015	
		Kagung	boreholes	0.191		0.191	
		Batlharos	boreholes	0.69		0.69	
Joe Morolong	105872	Hotazel	Vaal Gamagara	0.402	0.402		121
		Van Zylsrust	boreholes	0.147		0.147	
		Other schemes	Kalahari East and boreholes	3.113	1	2.113	
Khara Hais	90683		Kalahari East and boreholes	0.8?	0.4?	0.4?	24
Total	1791918			94.798	48.179	46.619	145

Red is an estimated water use by per capita consumption since no data is available. The pipeline has a capacity of 100 l/s, of which 75 l/s is allocated in the Lower Vaal.

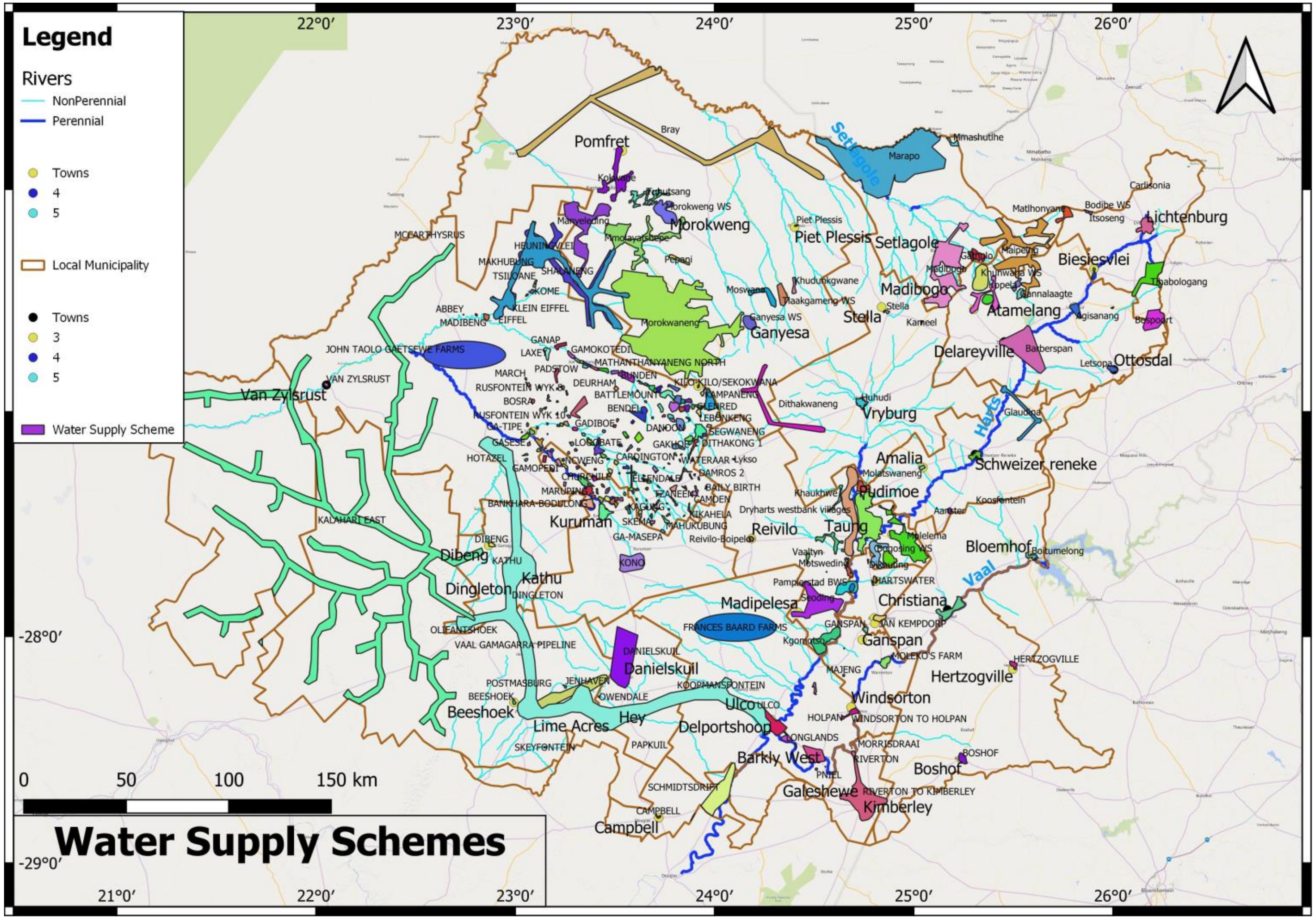

Figure 3-2 Water supply schemes

4 REGISTERED WATER USE

WARMS Registered water use data was obtained from DWS.

4.1 Surface Water

Surface water use is shown in **Figure 4-1 and Table 4-1.** The largest registered use is for the Vaal-Harts irrigation scheme at 270 Mm^3/a. Total use is 759.906 Mm^3/a. It is concentrated on the Vaal and Harts rivers. Registered water use for water supply is lower than the 48 Mm^3/a estimated in Table 3-5.

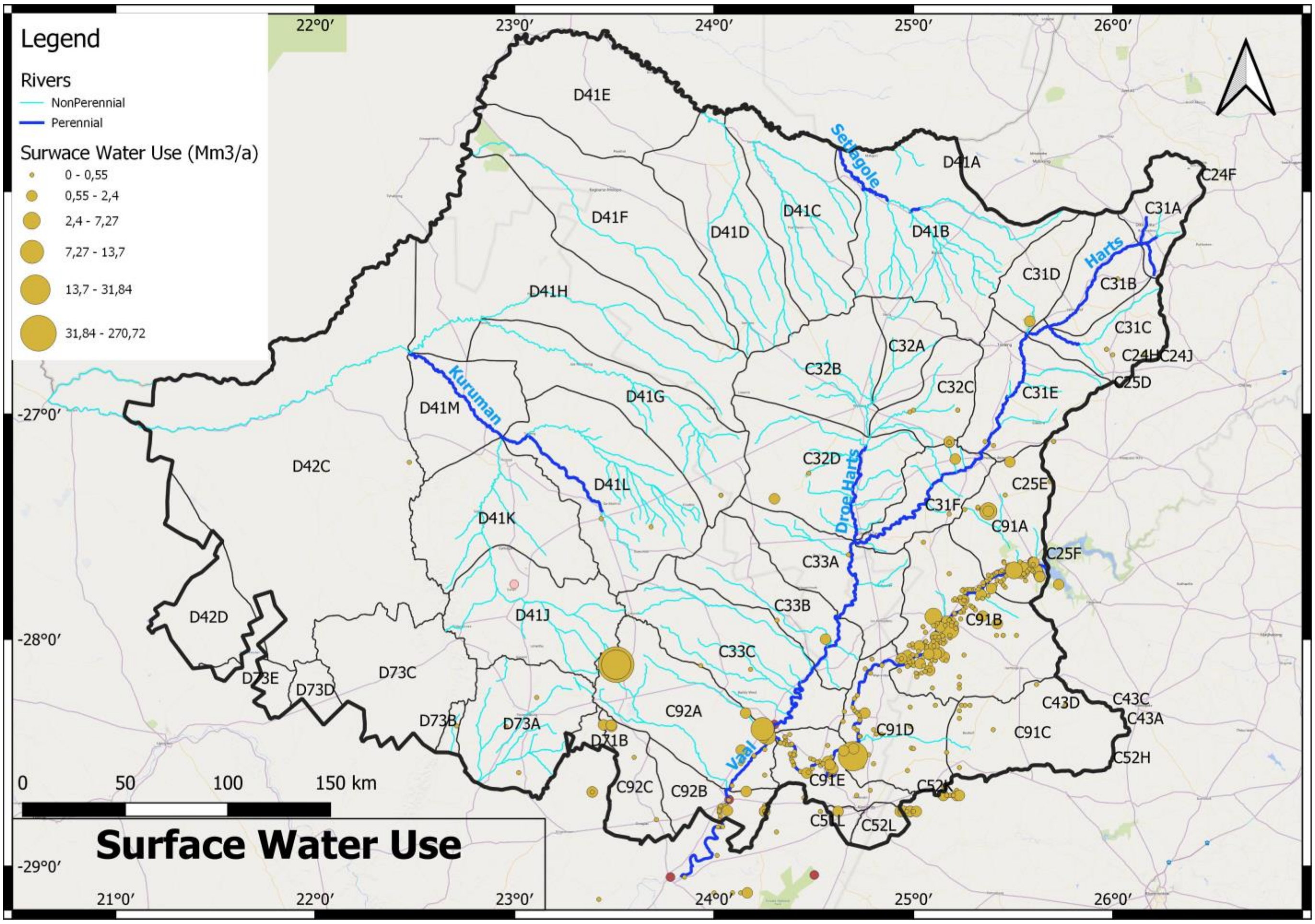

Figure 4-1 Surface water use

Table 4-1 Surface water use by sector

Sector	Use (Mm^3/a)	Percent
AGRICULTURE	694.612	91.41
INDUSTRY	16.658	2.19
MINING	15.054	1.98
WATER SUPPLY SERVICE	33.583	4.42

4.2 Groundwater Use

Registered groundwater use in WARMS amounts to 266.28 Mm^3/a, excluding Schedule 1 domestic and livestock water use. 69% of this use is for irrigation (**Table 4-2).** Groundwater use is dispersed in the study area, which the largest use near Vryburg and Postmasburg (**Figure 4-2).**

Table 4-2 Registered groundwater use by sector

Sector	Use (Mm^3/a)	Percent
AGRICULTURE	183.67	68.98
INDUSTRY	2,664	1.0
MINING	35.77	13.43
WATER SUPPLY SERVICE	44.179	16.59

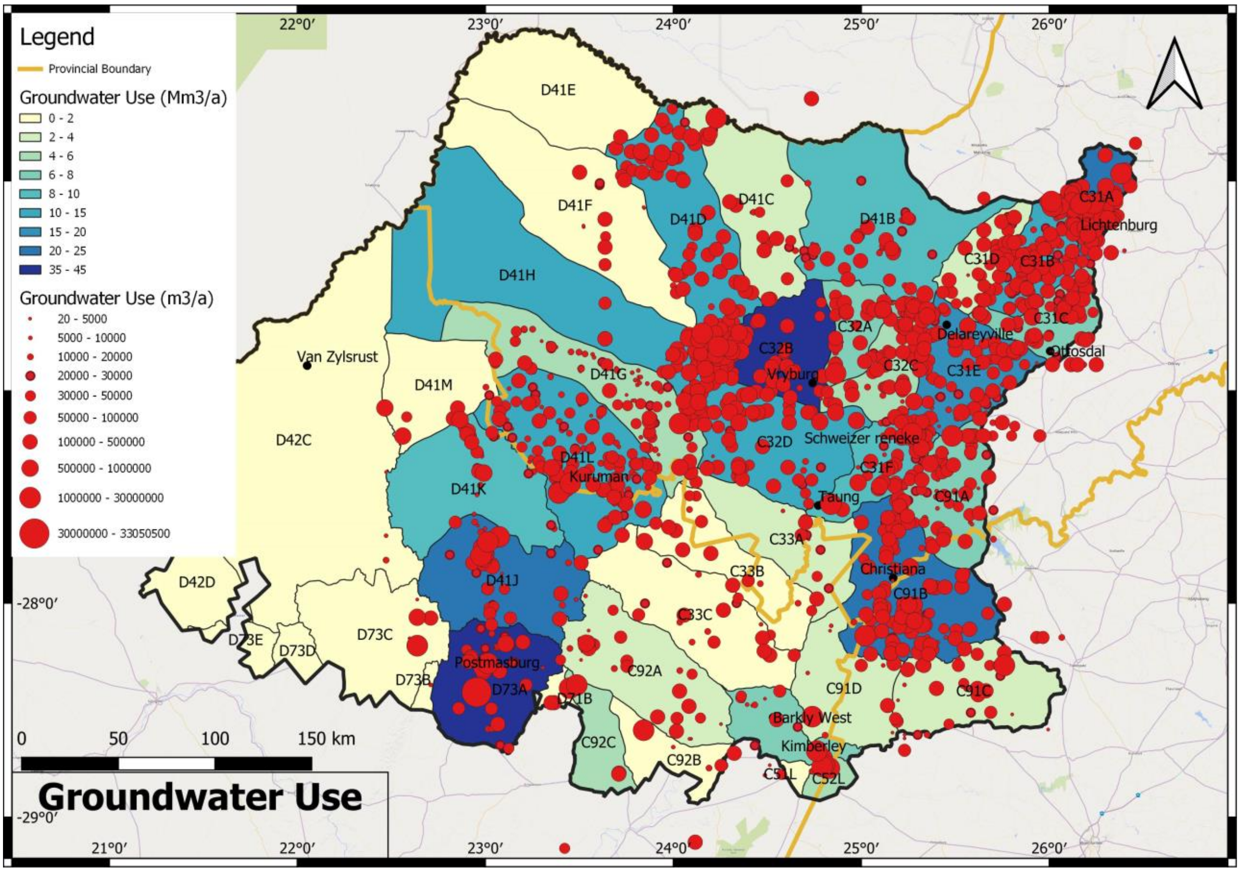

Figure 4-2 Groundwater use

4.3 Total water use

Total water use is shown in **Table 4-3.** Total lawful use is estimated at 1054 Mm^3/a, of which 759.9 Mm^3/a is from surface water. Registered water use for water supply in WARMS is less than estimated water supply in **Table 3-5.** Total water use for water supply equates to 121 l/c/d; hence it is likely that some of the water scheme water use is under-registered, or not registered.

Schedule 1 water use was calculated from Stats SA data of population in each Local Municipality dependant on boreholes and springs, and not receiving water from a water supply scheme. This was disaggregated by Quaternary catchment according to the area of the Municipality in each catchment. This segment of the population was assigned a use of 120 l/c/d.

Table 4-3 Total water use

	Population	Registered Groundwater Use (Mm³/a)				Registered Surface water Use (Mm³/a)				Total Registered Use (Mm³/a)	Schedule 1(Mm³/a)		Total Use (Mm³/a)
Quaternary		Agriculture	Industry	Mining	Water Supply	Agriculture	Industry	Mining	Water Supply		Use @ 120 l/c/d	Livestock	
C31A	43736	19.617	0.397	0.424	3.432	0.075	0.000	0.000	0.000	23.944	0.099	0.391	24.434
C31B	93307	12.296	0.144	1.200	0.003	0.006	0.000	0.042	0.000	13.691	0.400	0.549	14.641
C31C	120292	6.893	0.011	0.149	0.019	1.025	0.000	0.020	0.000	8.117	0.584	0.518	9.219
C31D	103381	3.227	0.005	0.024	0.004	0.000	0.000	0.000	0.000	3.260	0.511	0.156	3.927
C31E	147449	11.561	0.002	0.435	1.635	0.086	0.000	0.000	1.020	14.739	0.724	0.828	16.291
C31F	38381	6.047	0.000	1.061	0.255	0.000	0.000	0.000	0.000	7.364	0.077	0.263	7.704
C32A	18006	6.936	0.000	0.050	0.000	0.000	0.000	0.363	0.000	7.349	0.047	0.587	7.983
C32B	24488	33.429	0.000	0.000	3.081	0.000	0.000	0.000	0.000	36.510	0.081	1.872	38.463
C32C	46415	4.973	0.002	0.000	0.000	0.168	0.000	0.000	0.000	5.143	0.195	0.588	5.926
C32D	88631	7.987	0.000	0.133	5.005	0.000	0.000	0.000	0.000	13.125	0.187	1.673	14.985
C33A	125626	2.919	0.000	0.104	0.000	1.123	0.000	0.000	0.000	4.146	0.315	0.337	4.798
C33B	63119	1.416	0.000	0.000	0.000	0.041	0.000	0.000	0.000	1.457	0.139	0.267	1.862
C33C	36014	0.881	0.014	0.388	0.000	348.104	13.329	1.173	0.000	363.888	0.123	0.498	364.509
C91A	39561	4.354	0.004	0.635	0.000	18.969	1.600	0.000	1.173	26.735	0.065	0.666	27.466
C91B	49431	18.506	0.003	0.083	0.067	49.974	0.500	0.159	3.285	72.578	0.161	1.129	73.868
C91C	13763	2.016	0.000	0.000	0.000	0.453	0.000	0.000	0.000	2.470	0.126	1.037	3.633
C91D	48374	0.266	0.005	0.010	0.000	11.941	0.018	0.762	0.000	13.002	0.104	0.874	13.979
C91E	56848	0.285	0.034	0.103	0.011	30.476	1.191	5.113	28.105	65.319	0.047	0.253	65.618
C92A	49563	1.361	0.305	1.662	0.785	11.635	0.021	5.899	0.000	21.667	0.123	0.327	22.117
C92B	28328	0.365	0.000	0.002	0.000	120.980	0.000	1.502	0.000	122.848	0.031	0.285	123.165
C92C	4924	0.749	0.000	4.678	0.000	72.462	0.000	0.014	0.000	77.902	0.026	0.145	78.073
D41B	197899	6.251	0.000	0.759	0.000	0.000	0.000	0.000	0.000	7.010	0.777	0.132	7.918
D41C	21870	3.332	0.000	0.000	0.024	0.000	0.000	0.000	0.000	3.355	0.140	0.604	4.099
D41D	20502	13.627	0.005	0.000	0.103	0.000	0.000	0.000	0.000	13.735	0.154	0.554	14.444

D41E	21012	0.158	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.158	0.158	0.628	0.944
D41F	28039	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.004	0.210	0.214	0.428
D41G	42421	2.067	0.000	0.000	3.037	0.000	0.000	0.000	0.000	5.104	0.159	0.115	5.378
D41H	40288	9.176	0.006	0.000	0.884	0.000	0.000	0.000	0.000	10.066	0.284	0.375	10.724
D41J	52629	1.096	1.294	19.239	7.999	0.010	0.000	0.000	0.000	29.638	0.122	0.331	30.091
D41K	46410	0.139	0.088	2.451	5.025	0.000	0.000	0.007	0.000	7.711	0.145	0.328	8.184
D41L	67374	1.730	0.346	0.015	12.805	0.000	0.000	0.000	0.000	14.896	0.176	0.000	15.072
D41M	11355	0.000	0.000	1.595	0.000	0.000	0.000	0.000	0.000	1.595	0.079	0.244	1.918
D42C	60785	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.204	2.553	2.760
D42D	9014	0.009	0.000	0.569	0.000	0.000	0.000	0.000	0.000	0.578	0.003	0.456	1.036
D73A	7286										0.040	0.618	0.658
D73B	450										0.002		0.002
D73C	8738	0.000	0.000	0.000	0.000	27.084	0.000	0.000	0.000	27.084	0.045	0.568	27.696
Grand Total	1 909 926	183.670	2.664	35.770	44.179	694.612	16.658	15.054	33.583	1026.190	6.863	20.961	1054.014

5 WATER QUALITY

Water quality was obtained from the DWS Resources Quality Information Services.

5.1 Groundwater Quality

Groundwater quality is of Class 0 to 1, with an EC of less than 150 mS/m in the dolomitic aquifers of C31A around Lichtenburg and Kuruman in D41L (**Figure 5-1 and 5-2 and Table 5-1**). Only a few boreholes are of Class 2, indicative of very localised contamination. These boreholes are found at small communities like Tsineng, Ga Mopedi and Mothibistad or at farms.

Over most of the eastern portion of the study area groundwater is of Class 1 -2. Groundwater is elevated to Class 2 and 3 at Hartswater where irrigation from the Vaalharts occurs in C33A-C.

Groundwater of Class 3-4 occurs from Vryburg to Reivilo in C32B, D41G and C33B. These areas are associated with communities, irrigated lands, and extensive dryland farming, where vegetation removal results in leaching of nitrates to groundwater.

The presence of endoreic areas (**Figure 5-3)** in the drier western regions results in worsening groundwater quality to Class 3 and 4 since salts are not exported and accumulate in pans.

Linear trends of Class 0-1 groundwater occur along the Kuruman and Molopo rivers, indicative of flood waters and discharge from dolomite springs recharging the aquifer along the rivers. This can be noted along the Kuruman River to the confluence with the Molopo river as far as D41E.

The presence of endoreic salt pans northeast of Kimberley in C91D also results in elevated salinity.

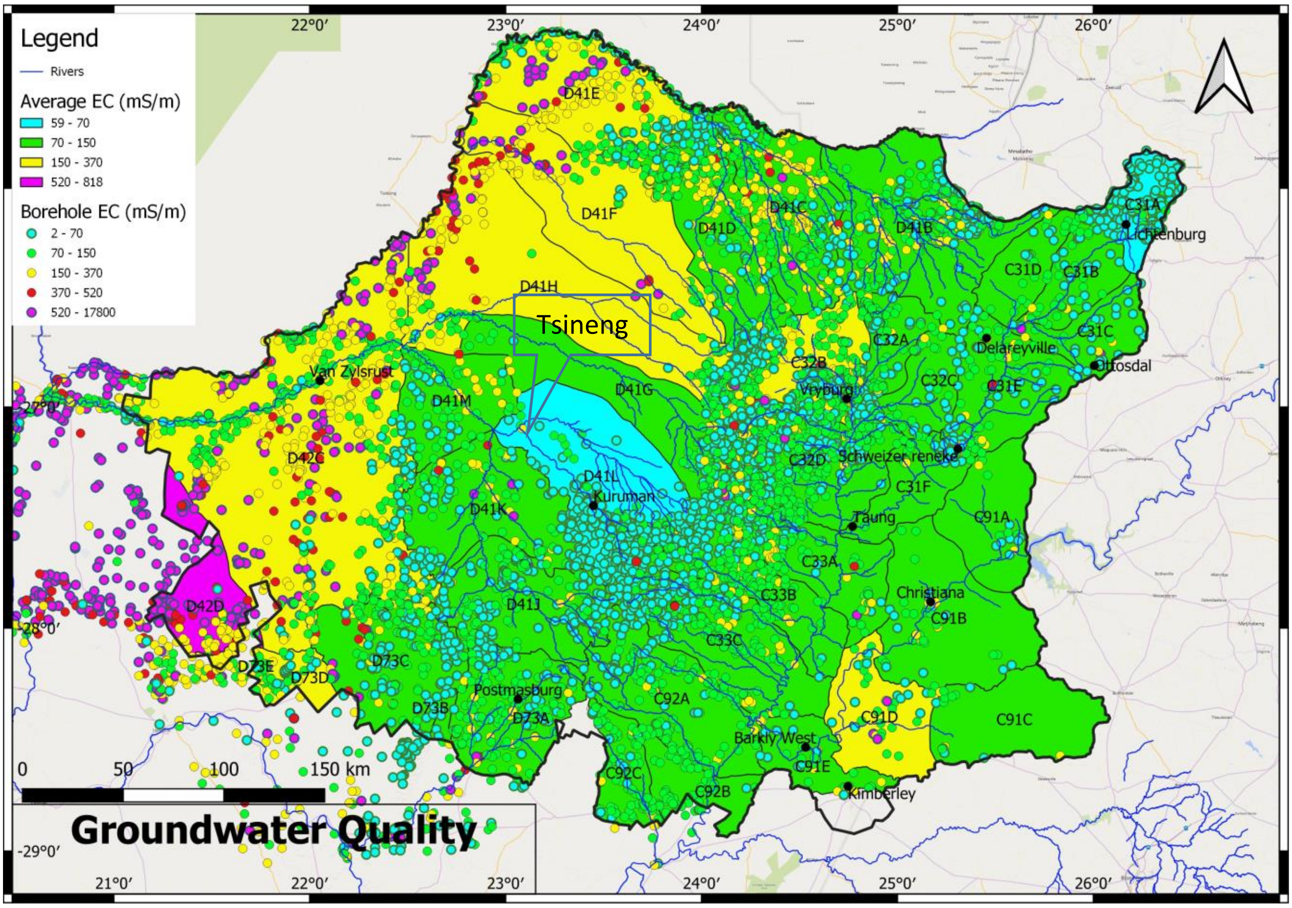

Figure 5-1 Groundwater Quality by Quaternary catchment

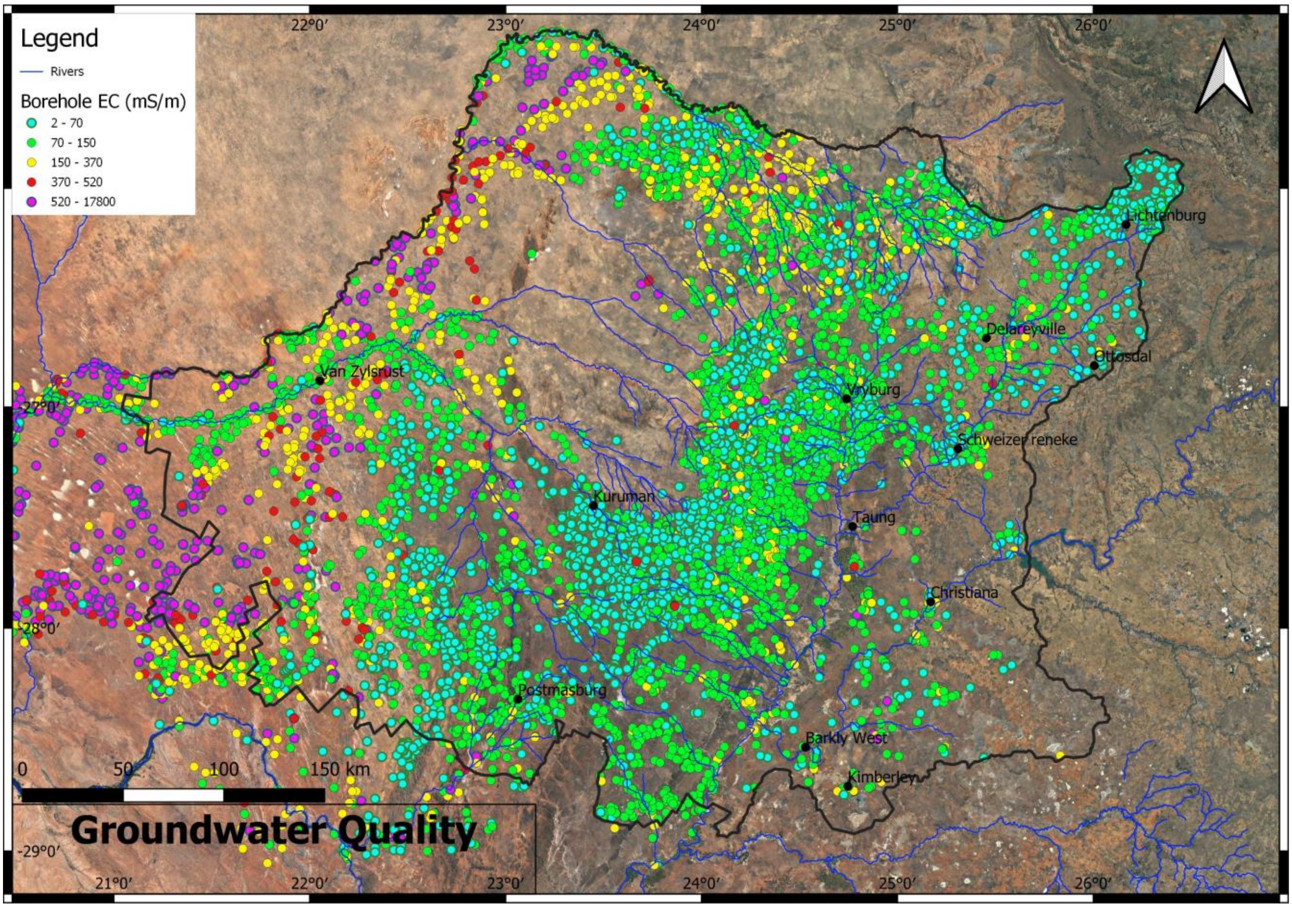

Figure 5-2 Borehole data for EC

Table 5-1 Average EC per Quaternary

Quaternary catchment	Average Electrical Conductivity (mS/m)
C31A	61
C31B	80
C31C	99
C31D	85
C31E	89
C31F	79
C32A	137
C32B	155
C32C	80
C32D	91
C33A	99
C33B	90
C33C	82
C91A	100

C91B	116
C91C	103
C91D	178
C91E	125
C92A	76
C92B	100
C92C	100
D41B	100
D41C	143
D41D	116
D41E	249
D41F	315
D41G	102
D41H	252
D41J	75
D41K	96
D41L	59
D41M	107
D42C	358
D42D	818
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D73B	108
D73C	119
D73D	191
D73E	206

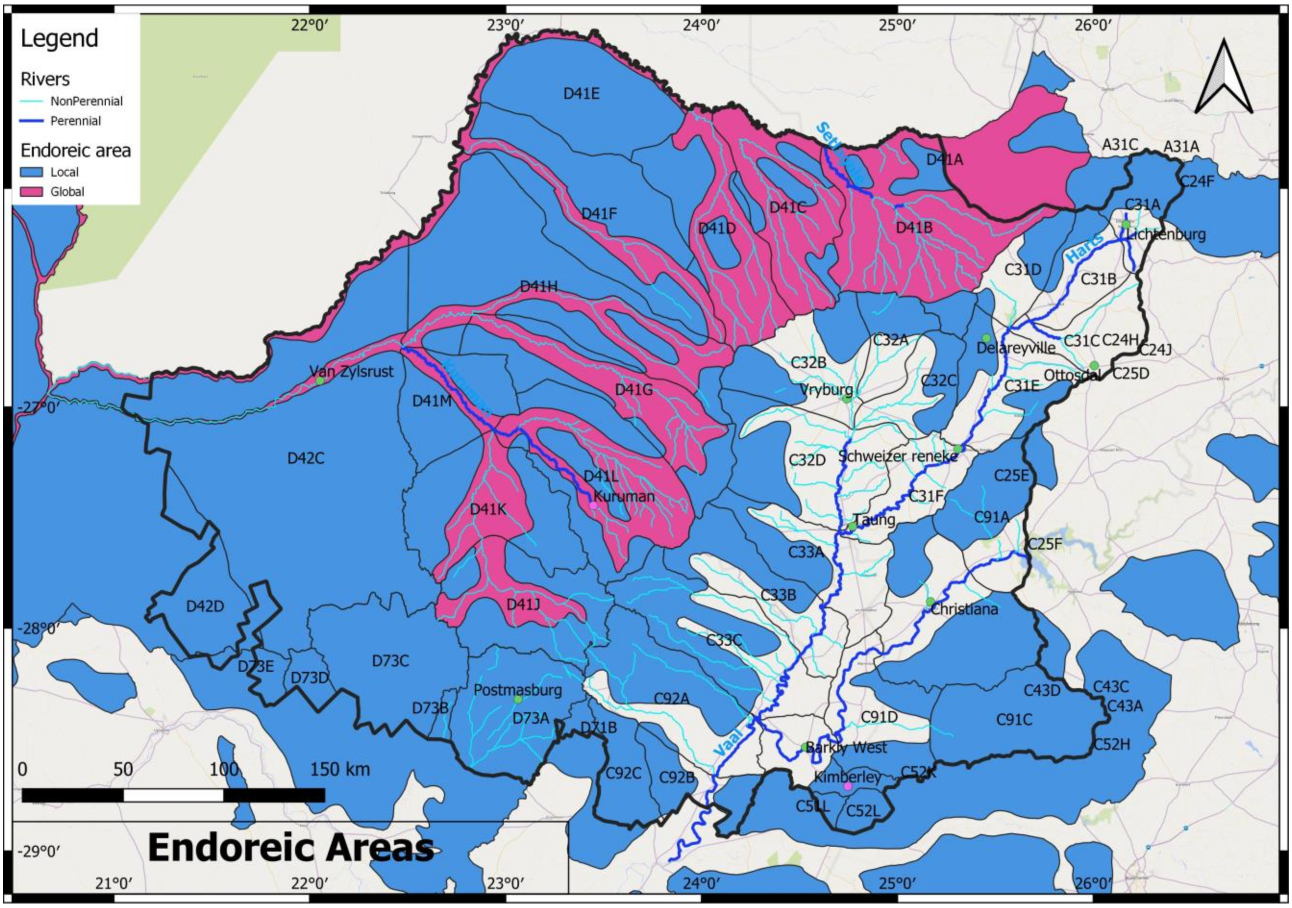

Figure 5-3 Endoreic areas

Groundwater quality in terms of nitrates is shown in **Figure 5-4.** No significant nitrification is evident in the Vaalharts area, although elevated nitrates occur in a band are of dryland agriculture between Vryburg and Lichtenburg, and east of Kimberley and Christiana. West of Kuruman natural dryland nitrates occur due to the absence of vegetation and organic material to uptake nitrates.

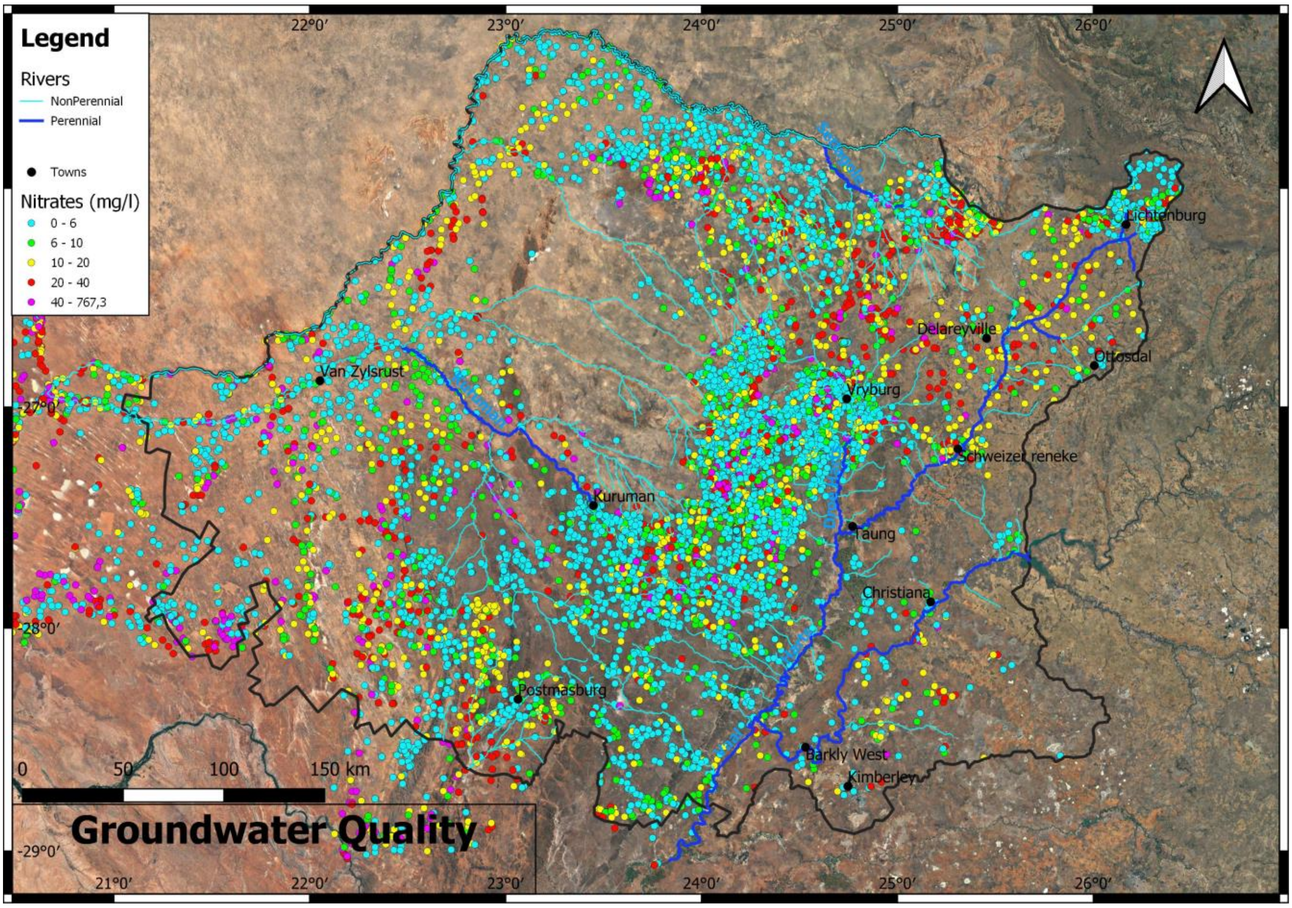

Figure 5-4 Borehole data for nitrates

The main mechanisms affecting groundwater quality can be summarised as:

- High recharge resulting in the Ideal to Good water quality in the dolomites
- Losses of streamflow to the aquifer ameliorating water quality in a linear pattern along the Kuruman and Molopo Rivers
- Endoreic areas exhibiting poorer water quality due to the lack of surface runoff to export salts and their accumulation in pans
- Localised contamination from irrigation, vegetation removal for dryland agriculture and possibly sanitation practices

5.2 Surface water quality

The surface water quality network is shown in **Figure 5-4.** The water quality results are shown in **Appendix 1.** In the Harts River, the most upstream gauge C3H6 has a water quality of 150 mS/m below Barberspan dam. This water quality is worse than that of the groundwater, suggesting that contamination from agriculture is taking place.

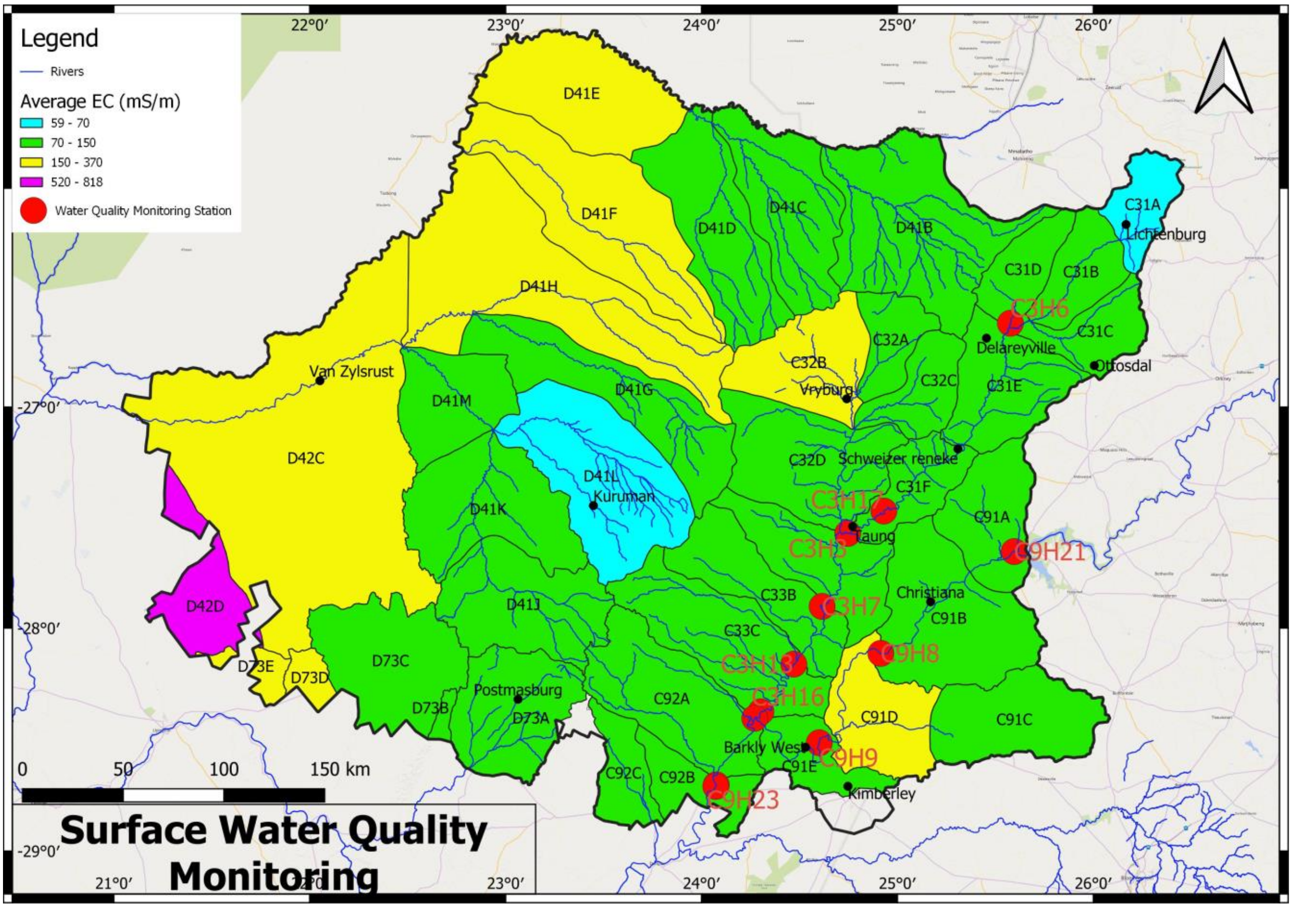

Figure 5-5 Surface water quality monitoring network and groundwater average EC

The EC downstream in C3H17, upstream of Vaalharts and Taung dam is approximately 40 mS/m. This declines to 60 mS/m at C3H3 downstream of Taung and within the Vaalharts irrigation area. There is a progressive decrease in water quality to 150 mS/m downstream of Vaalharts at C3H7 and C3H13 due to saline irrigation return flows. This poor water quality persists to the confluence with the Vaal at C3H16.

Waterlogging and salinisation have become a problem at Vaalharts and the water table has risen from 24 mbgl at the inception of the scheme to an average of 1.6 mbgl (WRC, 2011). An earlier investigation indicated that the macro salt input and output of the scheme is not in balance, with the result that the salt arriving at Spitskop dam downstream of Vaalharts, is lower than expected. The EC of the groundwater in the top 3.0 m for the four seasons were 160, 232, 190, and 183 mS/m, with an average of 191 mS/m. Since concentrations in river water downstream (C3H13 and C3H16) are now at 150 mS/m, an equilibrium seems to have been reached. The EC of water from Bloemhof dam used for irrigation is 60 mS/m implying a leaching fraction of about 0.3 in groundwater.

In the Vaal River, from the Bloefhof dam there is an increasing trend in EC from upstream activities.C9H21 and C9H8 below Bloemhof dam have an EC 60 mS/m and show trends of increasing salinity. Below the confluence with the Harts, water quality decreases to 80 mS/m at C9H10 due to the impact of saline Harts River water. This quality water persists to C9H23 and C9H24 near the confluence with the Riet.

The dominant trends in surface water quality are:

- increasing salinity in water from upstream in the Vaal
- the inflow of saline irrigation return flow the Harts from the Vaalharts irrigation scheme, which adds 20 mS/m to Vaal river water below the confluence with Harts.

6 WETLAND IDENTIFICATION

The wetlands identified are shown in **Figure 6-1.** These were identified from NFEPA 2011. Nearly 33000 wetlands exist. The types of wetlands are shown in **Table 6-1.** Most are depression wetlands and are the sinks for runoff in endoreic areas. The significance of these wetlands in terms of groundwater interactions are that:

- They contribute to groundwater recharge where surface runoff accumulates in pans
- A proportion of surface water runoff does not contribute to runoff in the main rivers, reducing flow accretion to the Vaal, Harts, Orange, Molopo and Kuruman Rivers
- The contribution of salts accumulated in pans from surface water runoff and subsequent evapconcentration results in the salinisation of groundwater

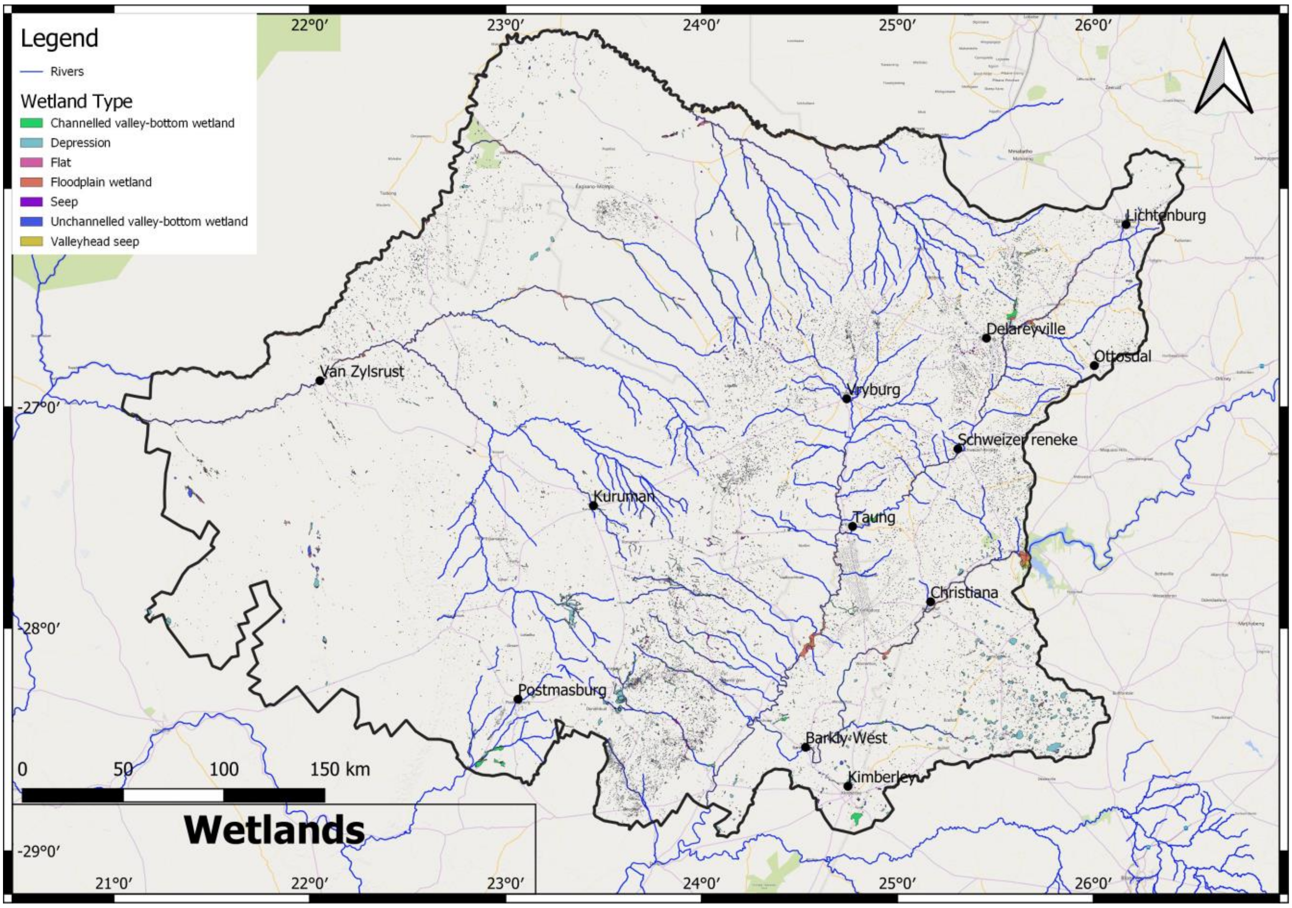

Figure 6-1 Wetlands

Table 6-1 Number of wetlands

Type of Wetland	Number	Relevance to surface-groundwater interactions
Channelled valley bottom	1966	Found in ephemeral channels and formed by seepage of surface runoff during storm events. They may recharge groundwater
Depression	13940	Form pans that recharge aquifers with saline water
Flat	5172	Form pans that recharge aquifers with saline water
Floodplain	840	Groundwater discharge zone

Seep	5848	Formed from the discharge of groundwater, which is subsequently lost by evapotranspiration
Unchanneled Valley bottom	3131	Formed from the discharge of groundwater, which is subsequently lost by evapotranspiration
Valleyhead seep	1997	Formed from the discharge of groundwater at impermeable layers, which is subsequently lost by evapotranspiration

7 CONCLUSION

Vaalharts Water is the largest water user in the study area and provides water for irrigation, industry and water supply from the Vaalharts canal and the Spitskop dam. 350 Mm^3/a is for irrigation and 13.328 allocated to industry. Actual use differs from the registered allocations. Present day use indicates only 26% of the water is utilised, with only 94.986 Mm^3/a released. Of this volume, 8.402 Mm^3/a is utilised for water supply to Phokwane, Dikgatlong and Magareng. However, releases to the canal at Warrention (C9H018), indicate that abstractions from the Vaal have been increasing over time and often exceed 400 Mm^3/a.

From the hydrocensus information and data collection, an estimate of water supply use was compiled by Local Municipality and water scheme. The total water use is 94.798 Mm^3/a, of which 48.179 is from surface water. Average per capita consumption is 145 l/c/d. It is possible some abstraction has been missed since the water use for Greater Taung, Tswaing and Ratlou seem low.

WARMS Registered water use data was obtained from DWS. The largest registered use is for the Vaal-Harts irrigation scheme at 270 Mm^3/a. Total use is 759.906 Mm^3/a. It is concentrated on the Vaal and Harts rivers. Registered surface water use for water supply is lower than the 48 Mm^3/a estimated.

Registered groundwater use in WARMS amounts to 266.28 Mm^3/a, excluding Schedule 1 domestic and livestock water use. 69% of this use is for irrigation.

Total lawful use is estimated at 1054 Mm^3/a. Total water use for water supply equates to 121 l/c/d, hence it is likely that some of the water scheme water use is under-registered, or not registered. Schedule 1 water use is 27.8 Mm^3/a.

Groundwater is of Class 0 to 1, with an EC of less than 150 in the dolomitic aquifers of C31A around Lichtenburg and Kuruman in D41L. Only a few boreholes in the dolomitic areas are of Class 2, indicative of very localised contamination. These boreholes are found at small communities like Tsineng, Ga Mopedi and Mothibistad or at farms. Over most of the eastern portion of the study area, groundwater is of Class 1 -2.

Groundwater is elevated to Class 2 and 3 at Hartswater where irrigation from the Vaalharts occurs in C33A-C. Groundwater of Class 3-4 occurs from Vryburg to Reivilo in C32B, D41G and C33B. These areas are associated with communities, irrigated lands, and extensive dryland farming.

The presence of endoreic area in the drier western regions results in worsening groundwater quality to Class 3 and 4, since salts accumulate in pans and are not exported. Linear trends of Class 0-1 groundwater occur along the Kuruman and Molopo rivers, indicative of flood waters and discharge from dolomite springs recharging the aquifer along the rivers. This can be noted along the Kuruman River to the confluence with the Molopo river as far as D41E. The presence of endoreic salt pans northeast of Kimberley in C91D also results in elevated salinity.

No significant nitrification is evident in the Vaalharts area, although elevated nitrates occur in a band of dryland agriculture between Vryburg and Lichtenburg, and east of Kimberley and Christiana. West of Kuruman natural dryland nitrates occur due to the absence of vegetation and organic material to uptake nitrates.

The main mechanisms affecting groundwater quality can be summarised as:

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- Localised contamination from irrigation, vegetation removal for dryland agriculture and possibly sanitation practices

In the Harts River, the most upstream gauge C3H6 has a water quality of 150 mS/m below Barberspan dam. This water quality is worse than that of the groundwater, suggesting that contamination from agriculture is taking place. The EC downstream in C3H17, upstream of Vaalharts and Taung dam is approximately 40 mS/m. This declines to 60 mS/m at C3H3 downstream of Taung and within the Vaalharts irrigation area. There is a progressive decrease in water quality to 150 mS/m downstream of Vaalharts at C3H7 and C3H13 due to saline irrigation return flows. This poor water quality persists to the confluence with the Vaal at C3H16.

In the Vaal River, from the Bloefhof dam there is an increasing trend in EC from upstream activities.C9H21 and C9H8 below Bloemhof dam have an EC 60 mS/m and show trends of increasing salinity. Below the confluence with the Harts, water quality decreases to 80 mS/m at C9H10 due to the impact of saline Harts River water. This quality water persists to C9H23 and C9H24 near the confluence with the Riet.

The dominant trends in surface water quality are:

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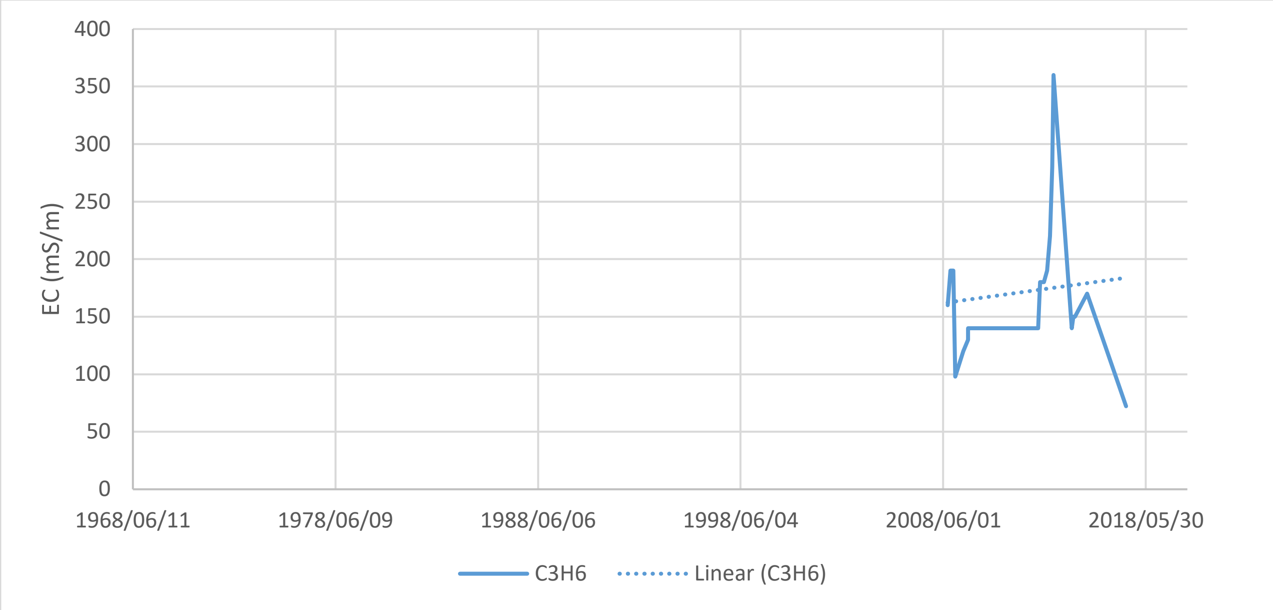
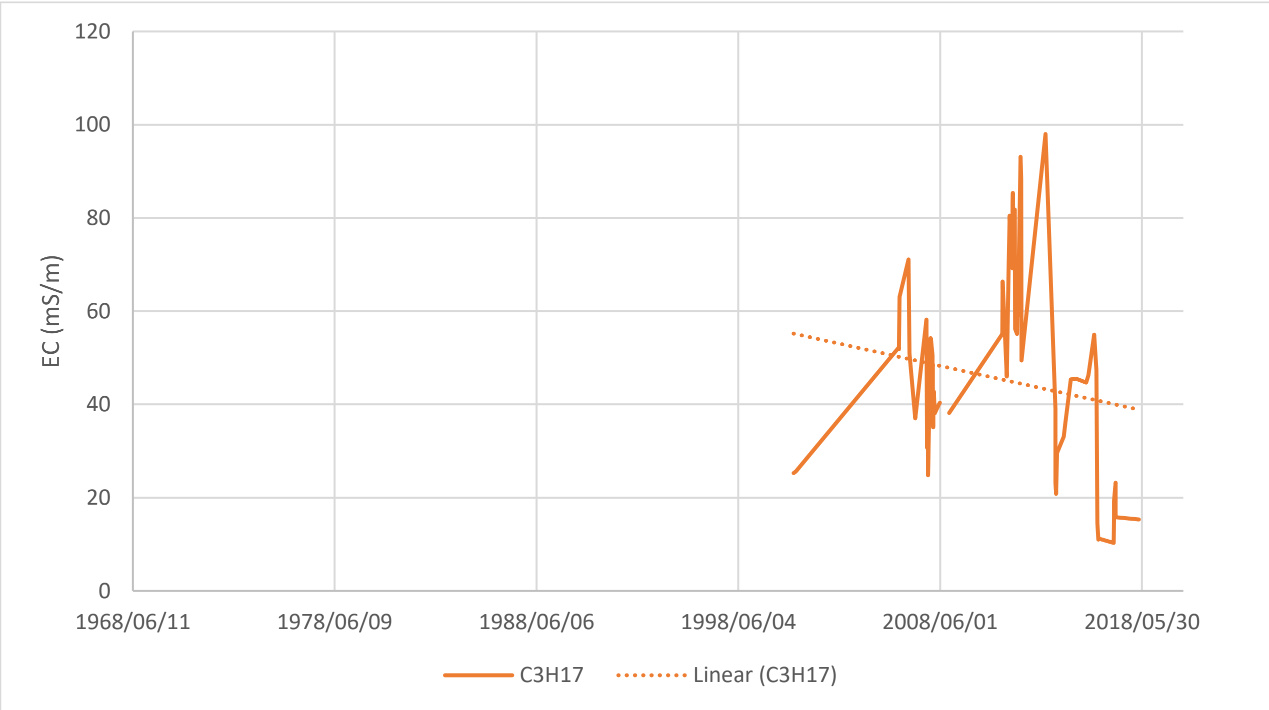
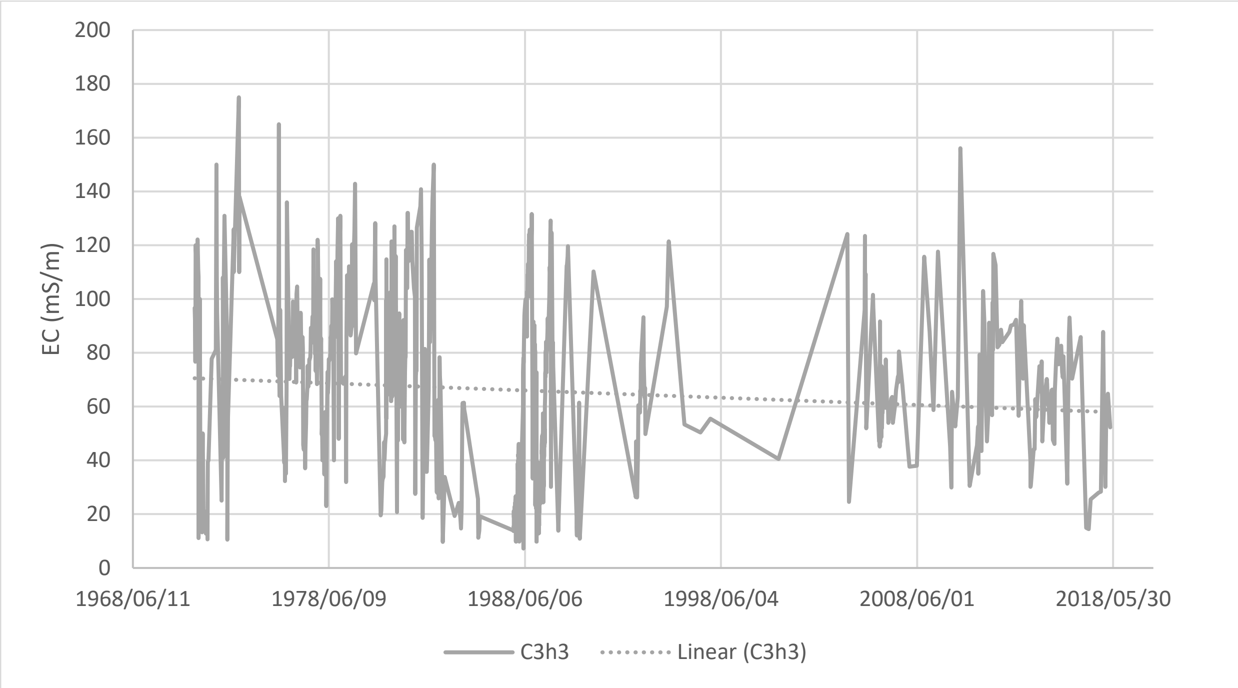
8 APPENDIX 1 – SURFACE WATER QUALITY



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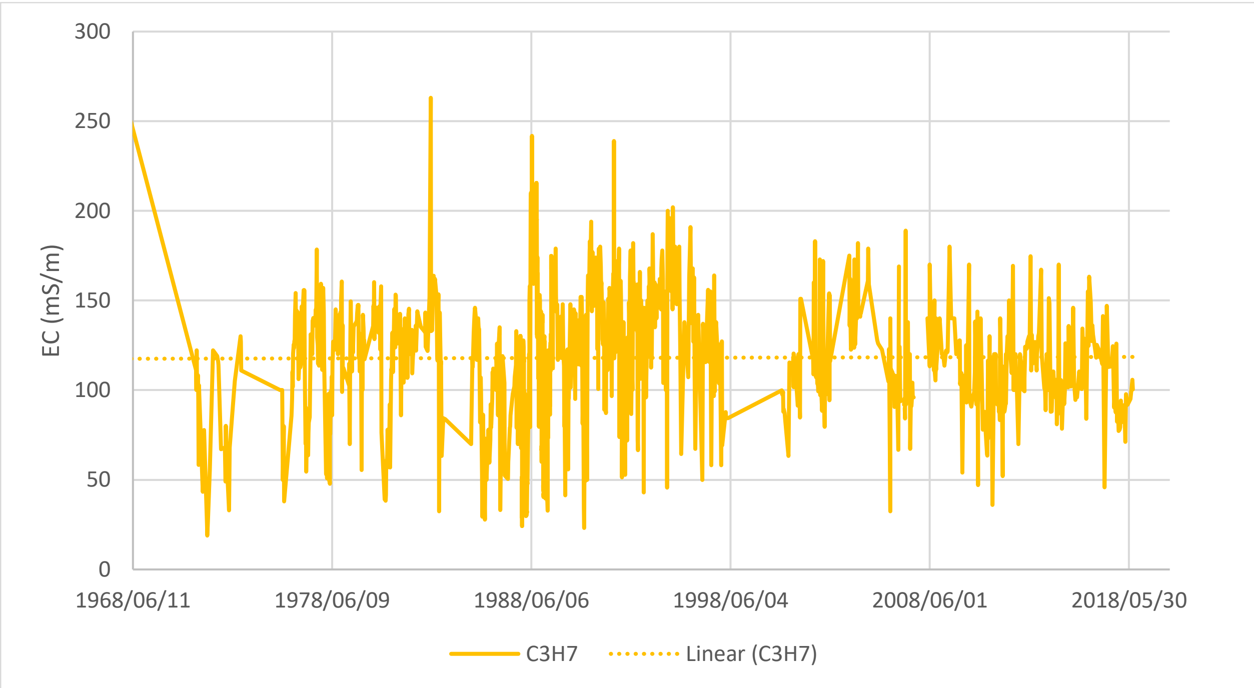
Linear (C3h3)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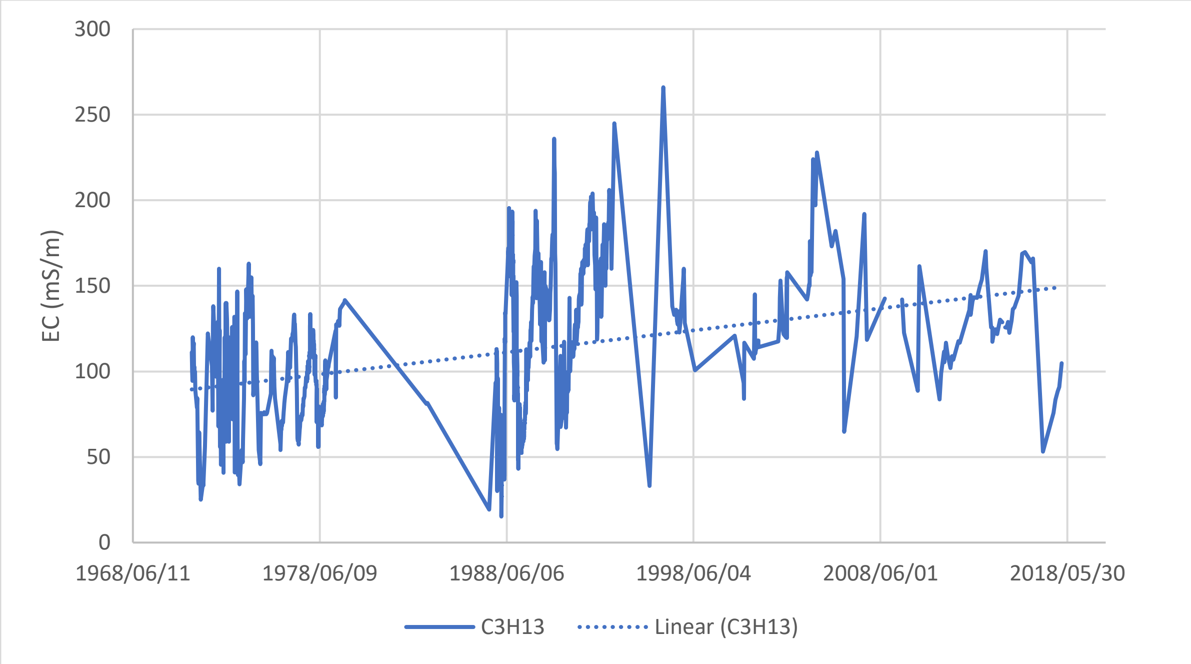
Linear (C3H7)



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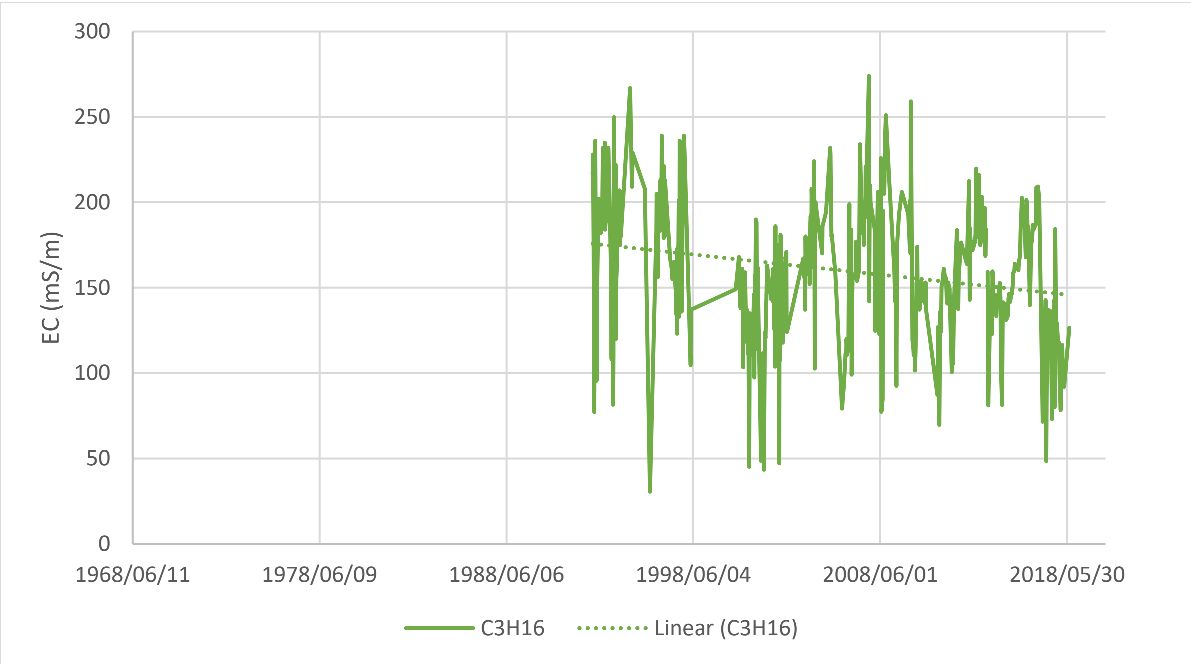

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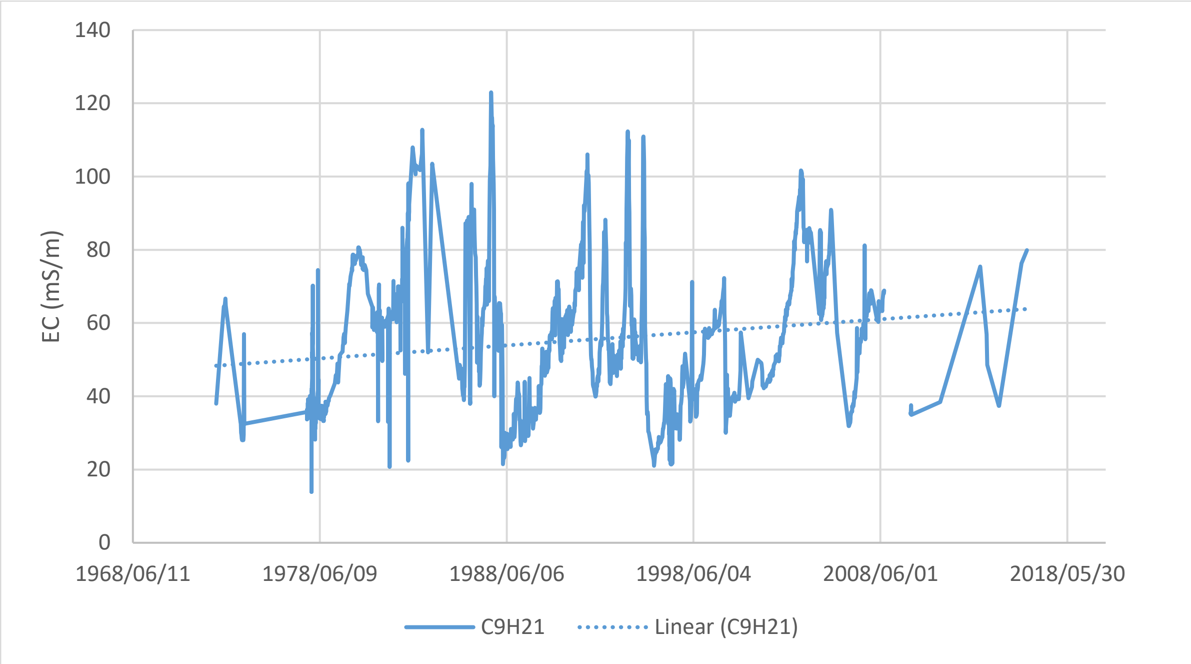

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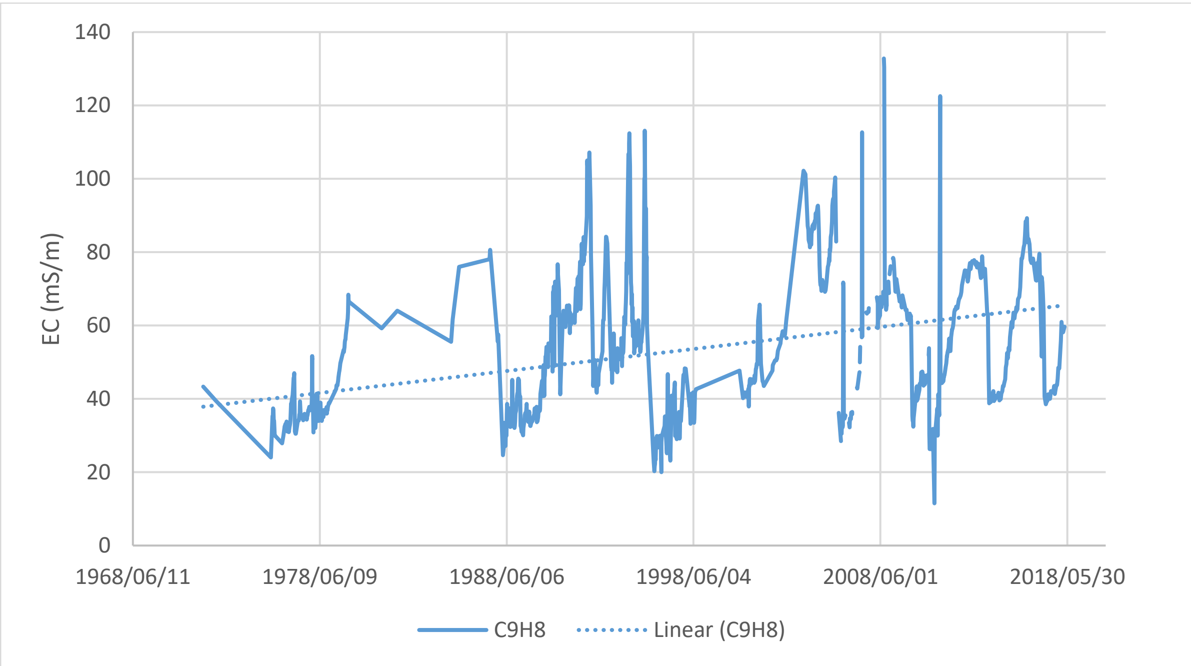

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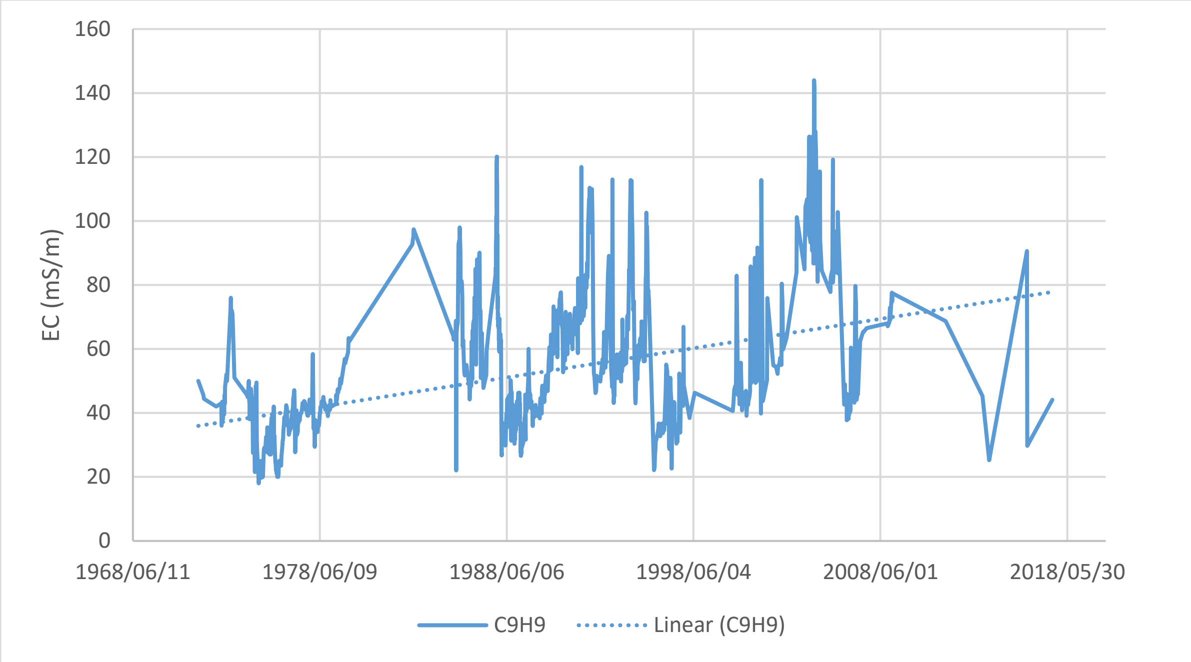

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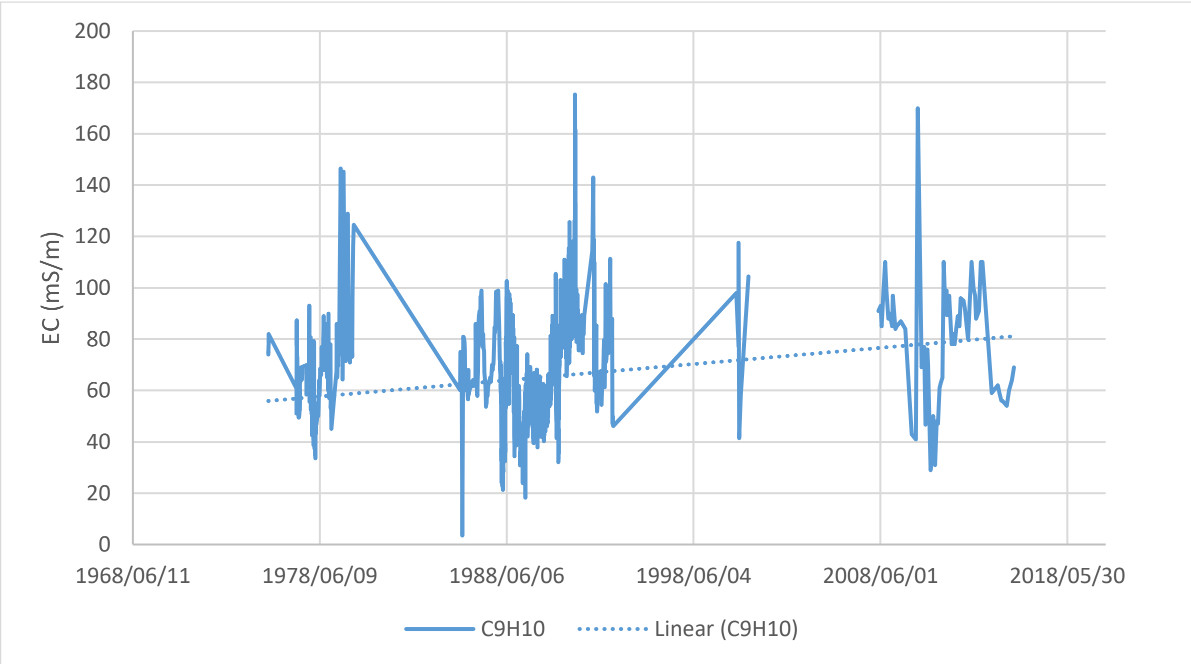

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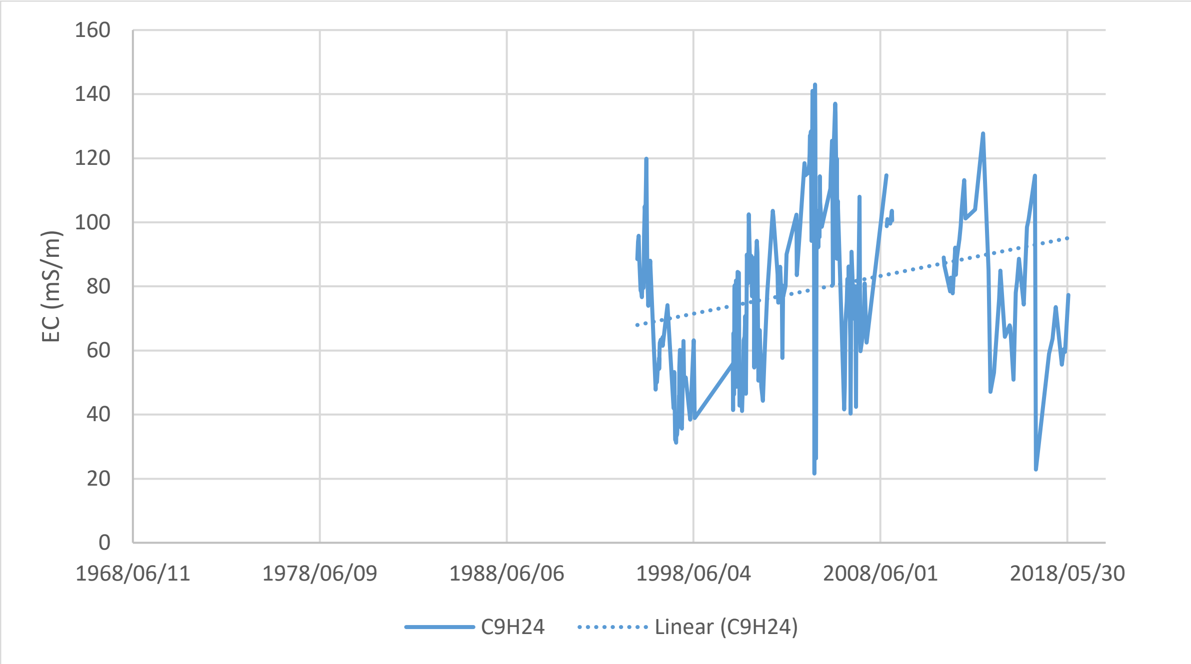
2008/06/01
2018/05/30
C9H10
Linear (C9H10)



160
140
120
100
80
60
40
20
0
EC (mS/m)
1968/06/11
1978/06/09
1988/06/06
1998/06/04
2008/06/01
2018/05/30
C9H24
Linear (C9H24)