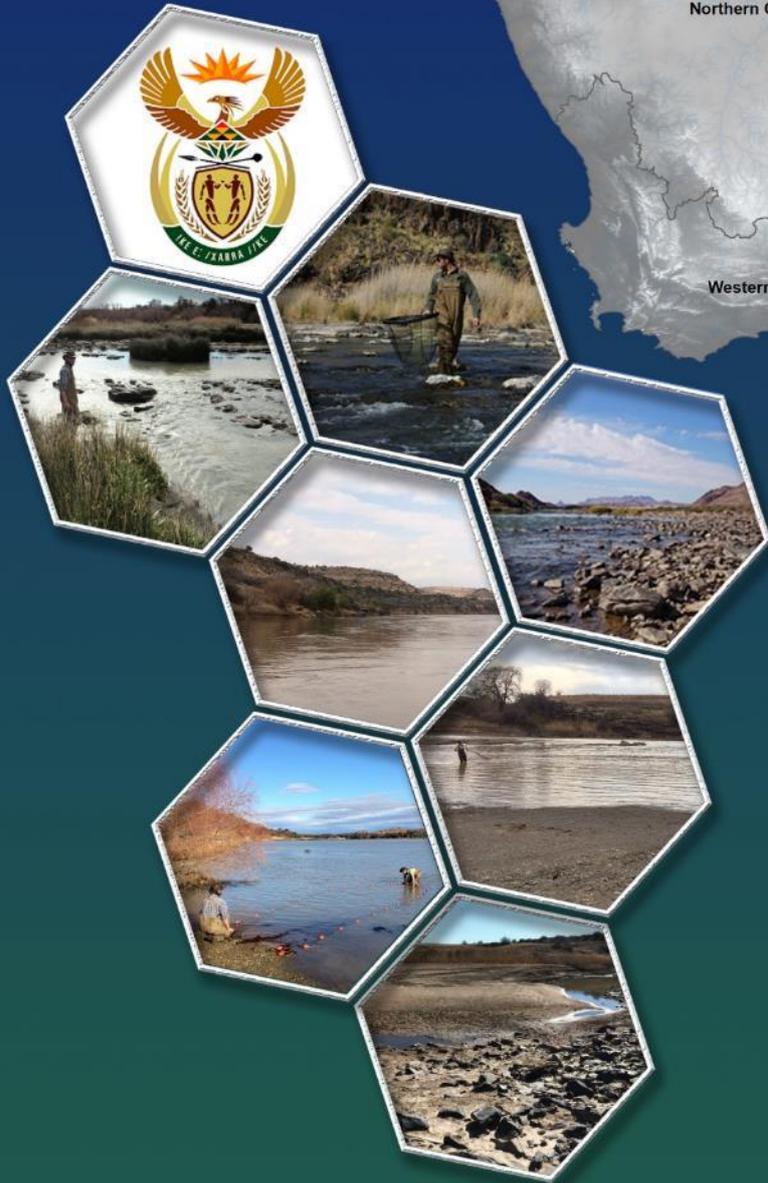
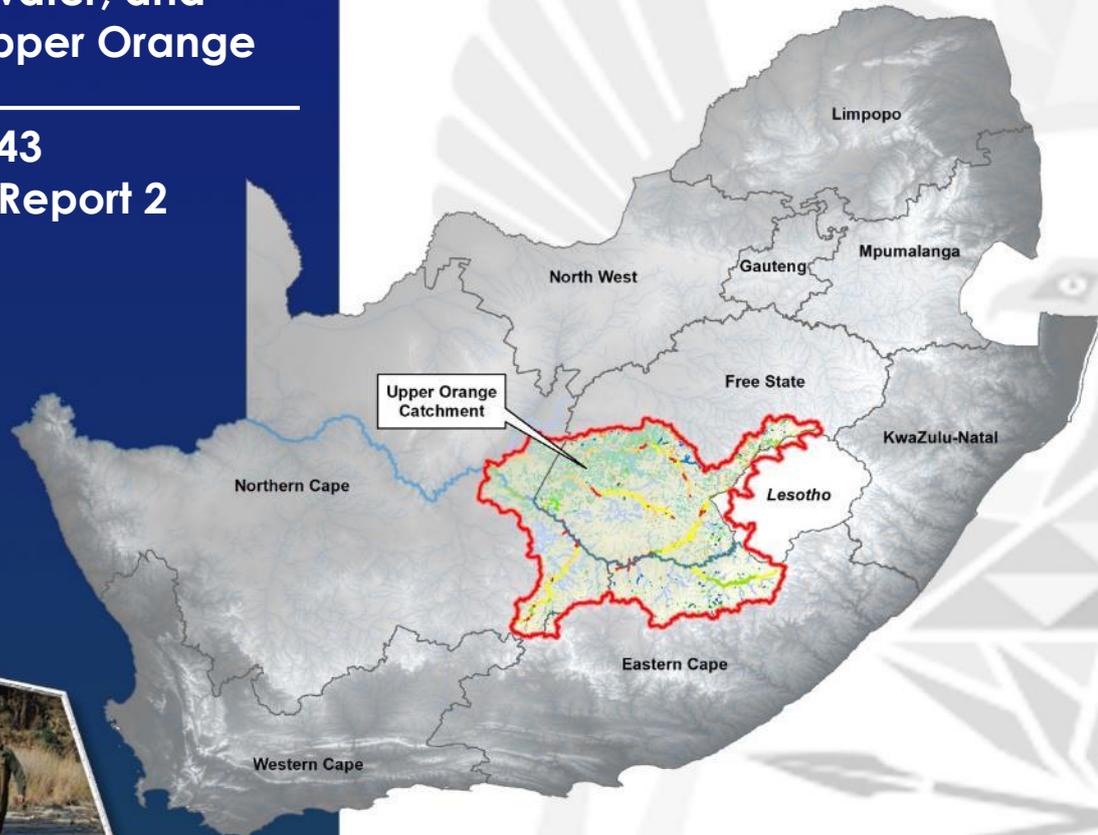


DEPARTMENT OF WATER AND SANITATION

A High Confidence Reserve Determination Study for Surface Water, Groundwater, and Wetlands in the Upper Orange

WP11343 River Survey Report 2



REPORT NO.:
RDM/WMA13/00/CON/COMP/1223

June 2023



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Kwazikwakhe Majola (Scientific Manager)

Date:

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Date

DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report

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LIST OF ACRONYMS

Acronym	Definition
CD:WEM	Chief Directorate: Water Ecosystems Management
DWS	Department of Water and Sanitation
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FRAI	Fish Response Assessment Index
FS	Fast Shallow
FD	Fast Deep
MIRAI	Macroinvertebrate Response Assessment Index
NWA	National Water Act
PES	Present Ecological State
RDM	Resource Directed Measures
RU	Resource Unit
SD	Slow Deep
SS	Slow Shallow
SIC	Stones-In-Current
SOOC	Stones-Out-Of-Current
UO	Upper Orange
VEGRAI	Riparian Vegetation Response Assessment Index
WWTW	Wastewater Treatment Works
WMA	Water Management Area
WRCS	Water Resource Classification System

1. INTRODUCTION

The National Water Act (No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without seriously affecting the functioning of water resource systems. To achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of Resource Directed Measures (RDM). As part of the RDM, a Reserve must be determined for a significant water resource, as a means to ensure a desired level of protection.

The Reserve (quantity and quality) is defined in terms of the Ecological Water Requirements (EWR), ensuring the water required to protect aquatic systems (water quality, habitat, and biota) of the water resource are provided for; and Basic Human Needs (BHN), ensuring that the essential needs of individuals served by the water resource in question are provided for. These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources, while allowing economic development.

The Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS) is tasked with the responsibility of co-ordinating all Reserve Determination studies in terms of the Water Resource Classification System (WRCS). These studies include the surface water (rivers, wetlands and estuaries) and groundwater components of water resources. The Reserve has priority over other water use in terms of the NWA, and should be determined before license applications are processed, particularly in stressed and over utilised catchments.

Consequently, the CD: WEM have identified the need to determine the Reserve for the Upper Orange catchment (rivers, wetlands and groundwater) forming part of the Orange Water Management Area (WMA6) in accordance with the WRCS. This report serves as a summary of the river fieldwork component of the study.

2. METHODOLOGY

The following section provides a repeat of the methodology adopted during the first river field survey which was undertaken in July 2022. It should be noted that this is the second river field survey report, which should be read in conjunction with the first river survey report (RDM/WMA13/00/CON/COMP/OP/0422).

The second river field survey entailed the undertaking of only the intermediate Reserve sites whereby the following was re-assessed:

- (i) Fish (modelled with the Fish Response Assessment Index – FRAI);
- (ii) Macroinvertebrates (modelled with the Macroinvertebrate Response Assessment Index – MIRAI)
- (iii) Riparian vegetation (using the Riparian Vegetation Response Assessment Index (VEGRAI);
- (iv) Hydraulics; and

- (v) Water quality;

2.1 Site visit

The first post-wet season river survey was conducted from the 4 to 15 July 2022 (first river survey) whereby the specialist team conducted all three Reserve level assessments (intermediate, Rapid Level 3 and field verification) at the identified priority RUs throughout the Upper Orange catchment.

The post-dry season survey (2nd survey) (this report) was undertaken from 29 May to 4 June 2023, whereby only the intermediate Reserve sites were re-surveyed, including the Lower Orange just downstream of the Marksdrift Weir. This site was downgraded from the proposed Intermediate level to a Rapid 3 level, as during the first river survey, this reach could not be accessed owing to considerable high flows. During this recent survey, the flows were low enough to conduct a successful survey.

Refer to Appendix A for the river survey 2 programme that was followed.

3. INTERMEDIATE RESERVE LEVEL SITE ASSESSMENTS CONDUCTED DURING THE FIELD SURVEY

Refer to Table 3-1 and Figure 3-1 for the list of priority RUs identified in the Upper Orange catchment area for intermediate Reserve assessments conducted during the river survey 2 in May 2023.

Table 3-1: River survey sites per priority RU

Resource Unit	River	Quaternaries	Level
R_RU04	Middle Caledon	D22D	Intermediate
R_RU02	Upper Orange	D12F	Intermediate
R_RU01	Sterkspruit	D12B	Intermediate
R_RU03	Lower Kraai	D13M	Intermediate
R_RU05	Lower Caledon	D24J	Intermediate
R_RU06	Seekoei	D32J	Intermediate
R_RU08	Upper Riet	C51F	Intermediate
R_RU09	Middle Modder	C52G	Intermediate
R_RU07*	Lower Orange	D33K	Rapid3

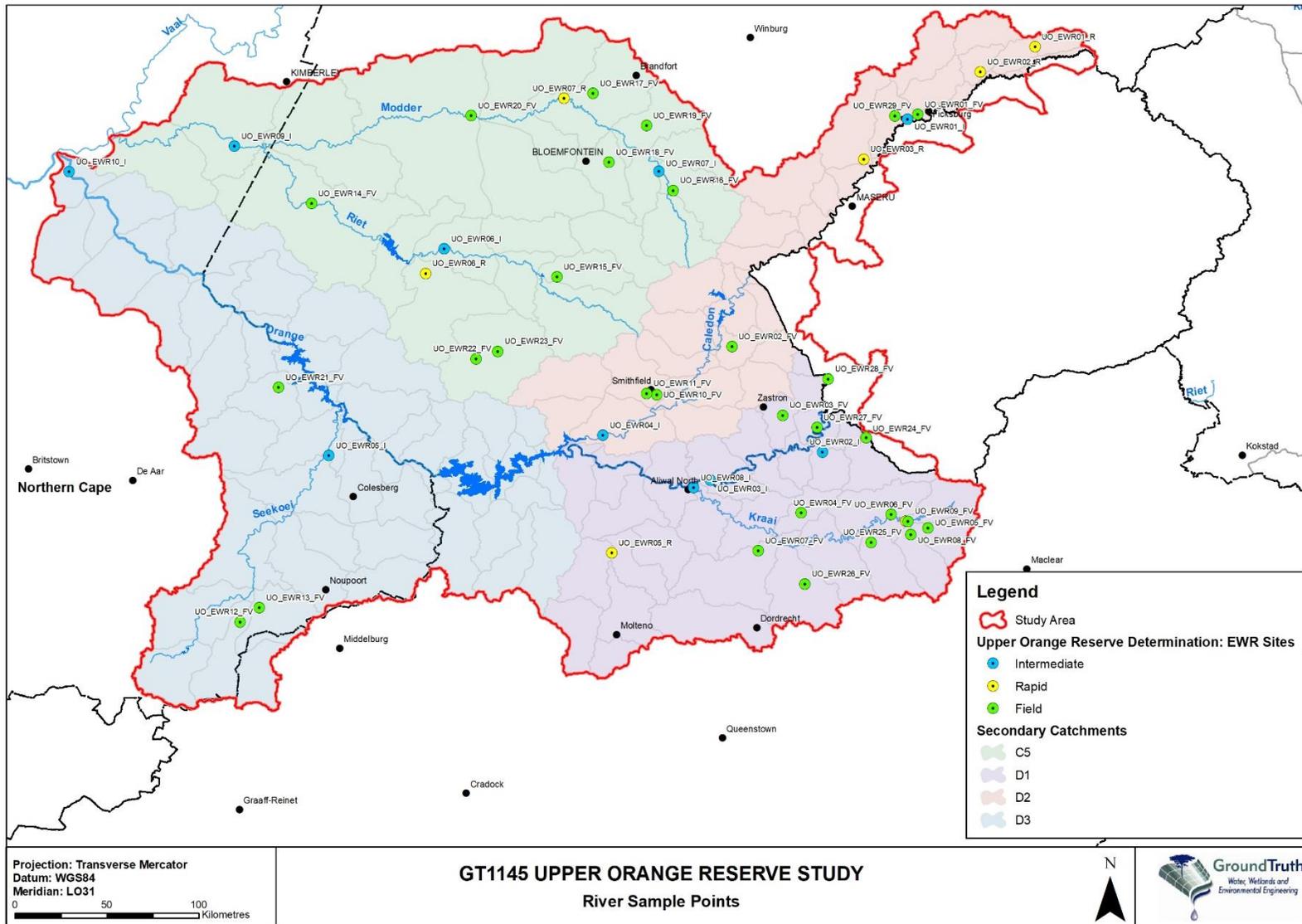


Figure 3-1: Map illustrating the various EWR sites for the study, of which all intermediate sites re-surveyed during the May 2023 second river survey

4. RIVER SURVEY TEAMS

The second river survey was once again well supported by DWS colleagues, who continued to learn and enhance their skills in the various Reserve determination components of their interest through this capacity building campaign. This survey further offered another opportunity for **citizen scientists** to also take part. Through citizen science, the PSP encourages the community involvement in water resource management, complement data collected, and upskill community members. Consequently, through these tools, it empowers local communities, and other government organisations, to engage with the Reserve processes and the importance of these communities in achieving some of the Sustainable Development Goals (SDG) targets, for example Target 6.b – Stakeholder participation - “Support and strengthen the participation of local communities in improving water and sanitation management” - 2030 Agenda for Sustainable Development (see <https://www.sdg6monitoring.org/indicators/target-6b/>). The Directorate: Water Use and Irrigation Development under the Department of Agriculture Land Reform and Rural Development were very much welcomed on the survey and who also learnt a great deal through this process.

Please refer to Table 4-1, which includes the list of 1. The specialist team who conducted the survey and built capacity, 2. DWS colleagues from both head office and the Bloemfontein regional offices and 3. The Citizen Scientists. For further information regarding the capacity building, please refer to Section 6.

Table 4-1: River survey teams

Specialist team	DWS team	Citizen Scientists
Trevor Pike	Tinyiko Mpete	The Directorate: Water Use and Irrigation Development under the Department of Agriculture Land Reform and Rural Development:
Khwezi Mncwabe	Rendani Mudzanani	● Mosibudi Sekgala
Byron Grant	Koleka Makanda	● Nomsa Masemola
Kylie Farrell	Nolusindiso Jafta	
Gary de Winnaar	Basetsana Mokonyama	
	Mawethu Ndiki	

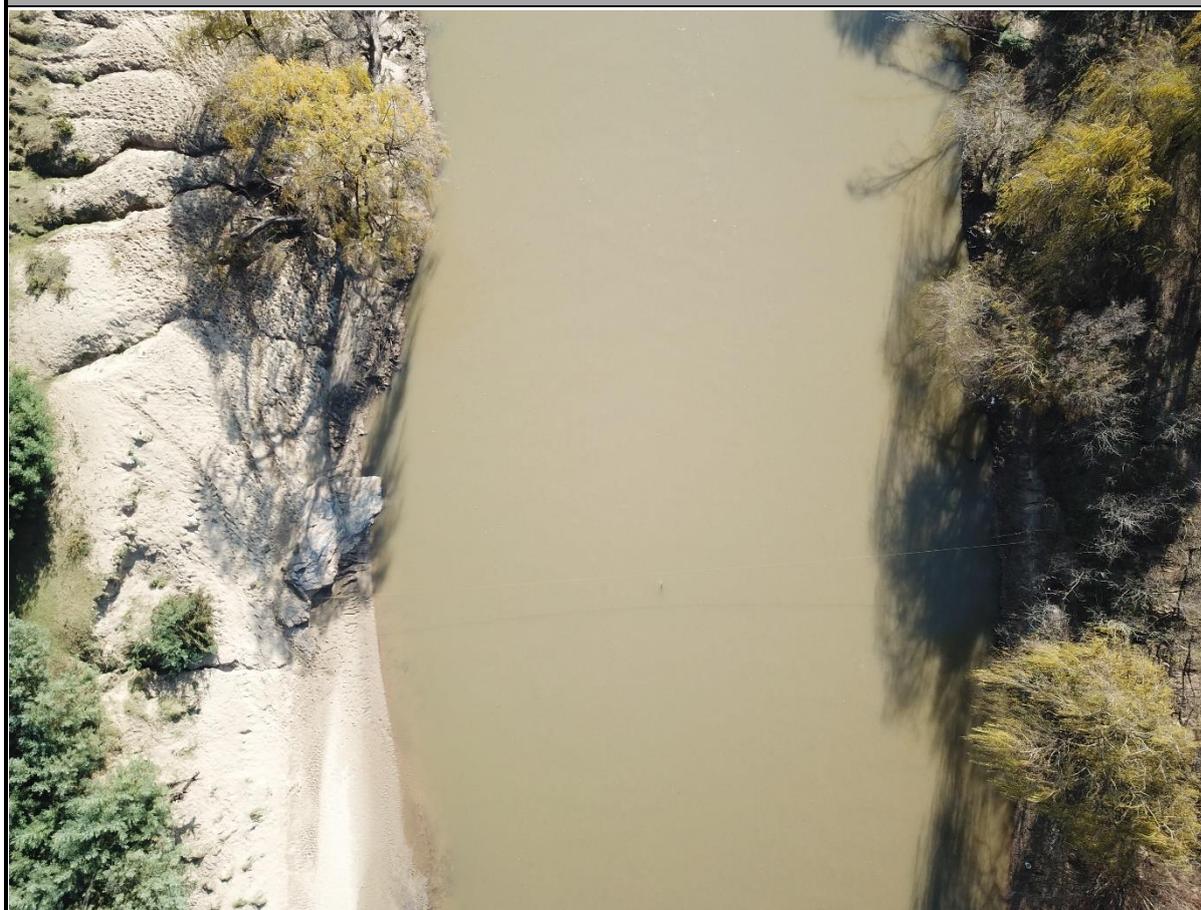
5. RIVER SURVEY SITE DETAILS: MAY 2023 SURVEY

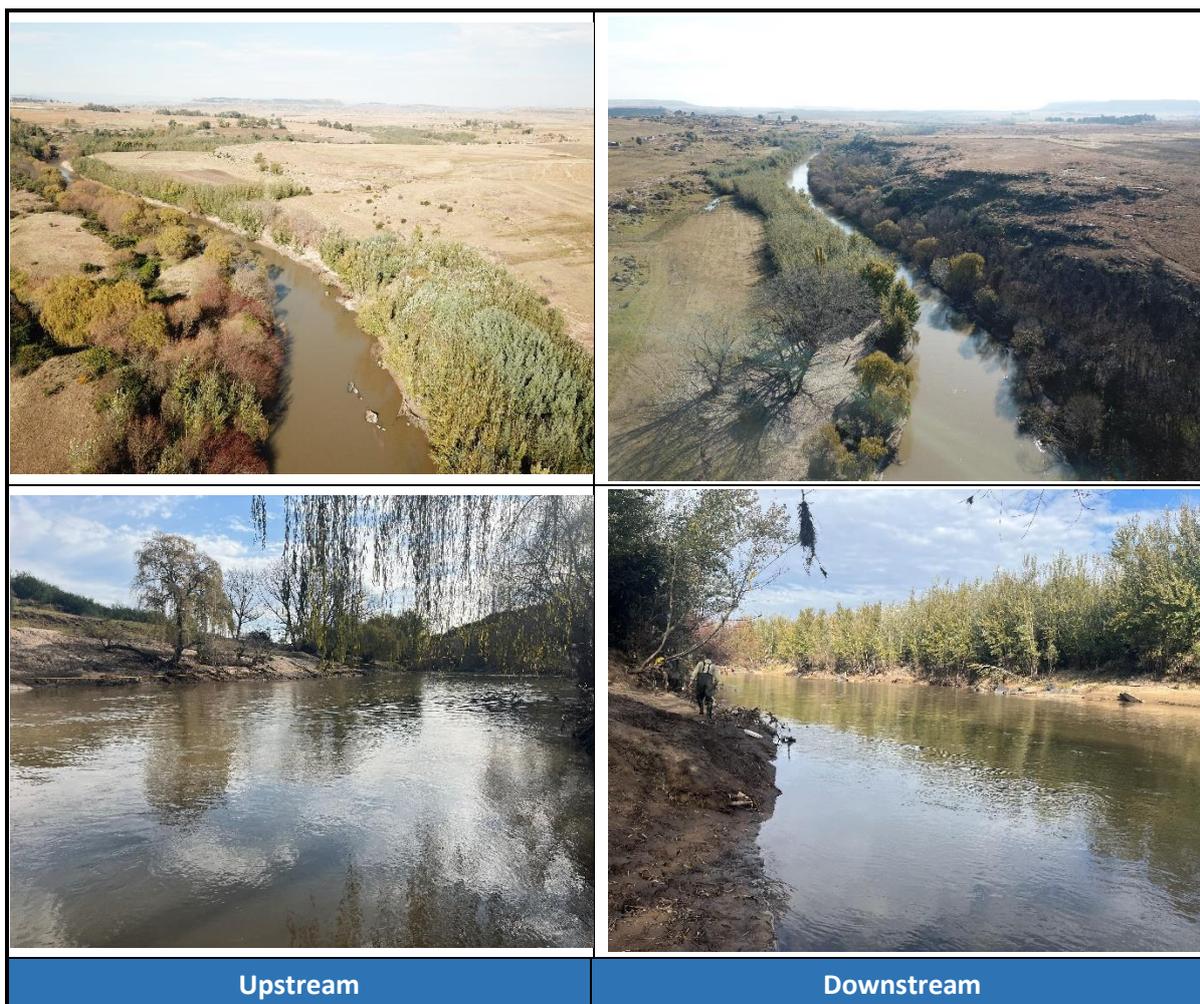
5.1 R_RU04: Middle Caledon

Sample Date	29 May 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR01_I	Prioritised RU	R_RU04
River	Middle Caledon	Altitude (m.a.s.l.)	1526
Longitude	26.653060	Latitude	-30.280115
Level 1 EcoRegion	Eastern Escarpment Mountains	Quaternary catchment/ SQ Reach	D22D D22D-03415
Level 2 EcoRegion	15.01	DWS, 2014 PES, EI, ES	C, Moderate, Moderate
Geomorphological zone	F (Lowland)		

Components sampled: Fish, aquatic macroinvertebrates, VEGRAI, *in situ* water quality, diatoms, water and slope measurements along cross-section and discharge

Site Photographs: Survey 2 (May 2023)





Upstream **Downstream**

Site Description:

This EWR site is located much further upstream from the previous Rapid 3 EWR site surveyed on the middle Caledon (UO_EWR01_R) in July 2022, just upstream and downstream of the confluence with the Rantsho and Meulspruit rivers respectively near Ficksburg.

The reach is partly confined with a deeply incised channel. The width is approximately 50m, homogenous with some inundated sandbars along the channel. The riverbed is very muddy and both banks are sandy, steep and highly erodible. Habitat availability for biota is poor and the water very turbid. The surrounding area is a mix of settlements, grazing areas and small-scale croplands. The Lesotho side is heavily overgrazed and eroded contributing to the already high fine sediment load and evidence of sediment deposition.

Biotopes available for macroinvertebrates was dominated by sand and silt, with small gravel deposits over the sandy substrate. Marginal vegetation was relatively absent owing to erosion of inset benches and lower banks along both banks. There are no Stones-in-Current (SIC) or Stones-Out-Of-Current (SOOC). For fish, the flow-depth velocity classes available were only Fast-Deep (FD) and Fast-Shallow (FS) habitats.

The riparian zone is defined by a deeply incised channel with steep banks that are infested by invasive alien trees (IAPs), notably Black Locust (*Robinia pseudoacacia*) on the right bank and Poplar (*Populus candescens*) and Wattle (*Acacia deacurrens*) on the left bank, interspersed by Weeping Willow (*Salix babylonica*). The marginal zone is inundated by high baseflows, and the

lower banks are devoid of vegetation. The riparian vegetation is also heavily impacted by bank erosion, footpaths and livestock trampling, and litter snagged in vegetation and scattered along the banks highlights a solid waste problem upstream.

Site impacts:

- Settlements
- Cattle grazing areas
- Small-scale croplands
- Alien invasives (*Salix sp.*, *Populus sp.*, *Gleditsia triacanthos*)
- Cultivation
- Vegetation removal
- Macropytes (plastics/litter) along both banks

Preliminary Results

***In situ* water quality:**

- pH: 8.0
- EC: 218.6 uS/cm
- TDS: 0.19 g/l
- DO: 9.1 mg/l
- DO%: 84.2%
- Clarity: 26cm
- Temperature: 11.7°C
- Salinity: 0.14

Discharge: 17.190 m³/s

5.2 R_RU01: Sterkspruit

Sample Date	30 May 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR02_I	Prioritised RU	R_RU01
River	Sterkspruit	Altitude (m.a.s.l.)	1429
Longitude	27.369058°	Latitude	-30.517806°
Level 1 EcoRegion	Eastern Escarpment Mountains	Quaternary catchment/ SQ Reach	D12B D12B-05232
Level 2 EcoRegion	15.01	DWS, 2014 PES, EI, ES	C, Moderate, High
Geomorphological zone	E (Lower Foothills)		

Components sampled: Fish, aquatic macroinvertebrates, VEGRAI, *in situ* water quality, diatoms, water and slope measurements along cross-section and discharge

Site Photographs: Survey 1 (July 2022)



Site Photographs: Survey 2 (May 2023)



★ Inlet into the Sterkspruit from the adjacent maturation pond



Upstream

Downstream

Site Description:

The site is located downstream from the town of Sterkspruit and Hershell, but just upstream of the Sterkspruit sewage maturation pond (see inlet and overflow into the Sterkspruit in the above image). The valley setting is confined, with cobbles, boulder and bedrock forming riffles and pools. The river is ~5m to 10m wide (macro channel 30m wide) with some bed and channel modifications, erosion on both banks, and cattle trampling and grazing. Biotopes available for macroinvertebrates included SIC, SOOC and slated/fractured bedrock, along with Gravel, Sand, Mud (GSM) and limited marginal vegetation, owing to undercut banks and vegetation die-back during both surveys. For fish there was Slow-Deep (SD), Slow-Shallow (SS) and FS. Various sections of riffles and runs present. Moderate algae content and very high macroplastics in-stream, including domestic plastic (nappies).

During the May 2023 survey, the water was considerably turbid, likely owing to recent rainfall events resulting in sediment loading downstream. Furthermore, there is much sand mining taking place, particularly at the EWR site itself, in-channel (Figure 1), and just above the site, mountain cutting activities are taking place to clear foundations for settlements (Figure 2). All having a detrimental impact on the functioning of this ecosystem.



Figure 1: Sand mining at the EWR site in-channel



Figure 2: Mountain cutting to create foundations for settlements

Both marginal and non-marginal zones have been severely impacted by sand mining operations at various points across the site, with additional impacts from rubbish dumping, livestock grazing/trampling, invasive alien plants (IAPs), bank erosion/collapse and sediment deposition. Nevertheless, the site retains reasonable riparian vegetation with some encroachment from terrestrial plant species. Areas not directly impacted by sand mining support good marginal vegetation dominated by *Cyperus marginatus*. The non-marginal zone is dominated by the grass

Cynodon dactylon and has a higher number of IAPs, notably Kikuyu (*Pennisetum clandestinum*), Tall Khaki Weed (*Tagetes minuta*) and Blackjack (*Bidens pilosa*).

Site impacts:

- Upstream construction and bridge collapse
- Dams (in upper catchment the Jozana Dam for water supply to the towns and villages)
- Localised sand mining
- Upstream sand mining
- The town of Sterkspruit and Hershell (possible water quality impacts)
- Possible impacts from local hospital and other businesses
- Cattle trampling and grazing
- Macroplastics

Preliminary Results

***In situ* water quality:**

Parameter	Survey 1 (July 2022)	Survey 2 (May 2023) at EWR site	Survey 2 (May 2023) downstream of maturation pond
pH	8.7	7.8	7.8
EC (uS/cm)	168	102.6	97.8
TDS (g/l)	0.138	0.09	0.08
DO (mg/l)	11.1	9.7	9.7
DO% (%)	108.7	102.6	88.1
Clarity (cm)	60	2.5	2.5
Temperature (°C)	14.2	10.9	10.9
Salinity (ppt)	0.10	0.07	0.06

	Survey 1 (July 2022)	Survey 2 (May 2023)
Discharge (m ³ /s)	0.618	0.996

5.3 R_RU02: Upper Orange

Sample Date	30 May 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR03_I	Prioritised RU	R_RU02
River	Upper Orange	Altitude (m.a.s.l.)	1302
Longitude	26.823213°	Latitude	-30.652793°
Level 1 EcoRegion	Nama Karoo	Quaternary catchment/ SQ Reach	D12F D12F-05348
Level 2 EcoRegion	26.03	DWS, 2014 PES, EI, ES	C, High, High
Geomorphological zone	F (Lowland)		

Components sampled: *in situ* water quality, diatoms, VEGRAI, water and slope measurements along cross-section and discharge

Site Photographs: Survey 1 (July 2022)



Site Photographs: Survey 2 (May 2023)

(Drone pics could not be taken owing to rainfall during the survey and lightning)



Upstream

Downstream

Site Description:

The site is located along a partly confined valley setting with terraces and narrow flood benches along both banks with an incised channel. The river is ~120m wide and homogenous sand bed channel with limited habitat diversity and exposed sand bars along the right bank. The site is located ~8 km upstream from the confluence of the Kraai River. The surrounding area is mostly agriculture with small-scale croplands and grazing areas. Intense in-stream sand mining both downstream and upstream of the site. The macrochannel is sandy and the steep fine sand and silt banks prove to be highly erodible. Both banks show recent erosion along the lower margins,

removing inset benches. Thickets of heavy infestation of *Salix sp.* and *Populus sp.* on both sides of the riverbanks. However, it is likely these trees are aiding in stabilising the macro channel banks to limit lateral migration. The water is turbid, and the riverbed is dominated by a featureless sand bed.

Biotopes available for macroinvertebrates was only sand and mud, there was no gravel or any stones biotope. Marginal vegetation comprised fallen down tree debris. Banks are undercut and eroded, owing to previous floods with limited inset bench development or marginal vegetation establishment. For fish there was FD and SS habitats.

The incised Orange River Channel has formed steep banks with a relatively narrow band of riparian vegetation, which is infested by Polular (*Populus candescens*), particularly of the right bank, as well as Weeping Willow (*Salix babylonica*), Tall Fleabane (*Conyza sumatrensis*), Tall Khaki Weed (*Tagetes minuta*) and Blackjack (*Bidens pilosa*). The marginal zone is inundated by high baseflows, and the lower banks are devoid of vegetation with bare, exposed soils beneath a largely woody canopy. The upper banks also include some indigenous thicket dominated by Wild Olive (*Olea europaeae*), Common Currant (*Searsia pyroides*), Star Apple (*Diospyros lycioides*) and *Lycium hirsutum*.

Site impacts:

- Upstream intense sand mining
- Future influence: proposed dam upstream (Verbeeldingskraal Dam)
- Small-scale croplands
- Cattle grazing and trampling

Preliminary Results

***In situ* water quality:**

Parameter	Survey 1 (July 2022)	Survey 2 (May 2023)
pH	8.8	8.3
EC (uS/cm)	155	139.4
TDS (g/l)	0.15	0.12
DO (mg/l)	10.7	8.9
DO% (%)	93.0	82.1
Clarity (cm)	27	12
Temperature (°C)	9.0	11.7
Salinity (ppt)	0.11	0.09
	Survey 1 (July 2022)	Survey 2 (May 2023)
Discharge (m ³ /s)	41.000	81.596

5.4 R_RU05: Lower Caledon

Sample Date	31 May 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR04_I	Prioritised RU	R_RU05
River	Lower Caledon	Altitude (m.a.s.l.)	1277
Longitude	26.299258°	Latitude	-30.436136°
Level 1 EcoRegion	Nama Karoo	Quaternary catchment/ SQ Reach	D24G D24G-04958
Level 2 EcoRegion	26.03	DWS, 2014 PES, EI, ES	C, High, High
Geomorphological zone	F (Lowland)		

Components sampled: Fish, aquatic macroinvertebrates, VEGRAI, *in situ* water quality, diatoms, water and slope measurements along cross-section and discharge

Site Photographs: Survey 1 (July 2022)



Site Photographs: Survey 2 (May 2023)





Upstream

Downstream

Site Description:

Just downstream of the N6 road bridge between Rouxville and Smithfield. The water transfer from the Caledon River to the Knellpoort Dam and the Welbedacht Dam are ~100km upstream. The surrounding land use is extensive sheep farming with localised irrigation of lucerne from the Caledon River. High silt loads in this river, abstracted for irrigation, are causing significant problems for local farmers with “fines” clogging the soil pores and preventing water penetration. The site is located along an unconfined low gradient reach. The channel is relatively straight, incised into the surrounding landscape with narrow flood features. The banks are steep and lined with invasive trees and annuals. Salix and Populus trees dot the riverbanks from the waterline to ~10 m from the water. The river at this site is ~50-70m wide and defined by a couple of strong basaltic intrusions diagonally across the river defining a narrow (~5m wide) resistant bedrock shelf and providing the key geomorphic structure to this reach of the river. Coarse material (boulder and cobble sized) has been introduced for the bridge construction. This has created a series of concrete shelves under the bridge and boulder and cobble shoots, runs and riffles directly downstream of the bridge. At the reach scale the system is dominated by the finer alluvial sands and silts from active upstream erosional processes. These sediments are regularly and extensively deposited onto the riverbanks and under lower flows defines a fine sediment dominated bed and braided main channel.

Biotores that were available for macroinvertebrates for both surveys were SIC and GSM. Limited SOOC and no marginal vegetation was present owing to undercut banks and vegetation die back and erosion. Flow-depth velocity classes available for the fish included FD, SD, SS and FS.

The marginal riparian zones are bare with emergent Salix mucronata trees (including some that are dead). This pattern extends into the lower portion of the lower zone. Beneath the bridge there is a broad area of exposed rocks and sand with very little vegetation cover. There is an abrupt increase in vegetation cover higher up the non-marginal zone which exists as a mosaic of woody and non-woody vegetation. A number of IAPs were recorded, namely *Cyperus eragrostis*, *Bidens pilosa*, *Gleditsia triacanthos*, *Persicaria lapathifolia*, *Populus nigra*, *Salix babylonica* and *Tagetes minuta*.

Site impacts:

- Agriculture
- Abstraction and irrigation
- Cattle grazing and trampling
- Local water pump just upstream of the bridge
- Artificial habitats (as a result of artificial construction material for the bridge which remain)

- Bank erosion
- Riparian alien invasives

Preliminary Results

***In situ* water quality:**

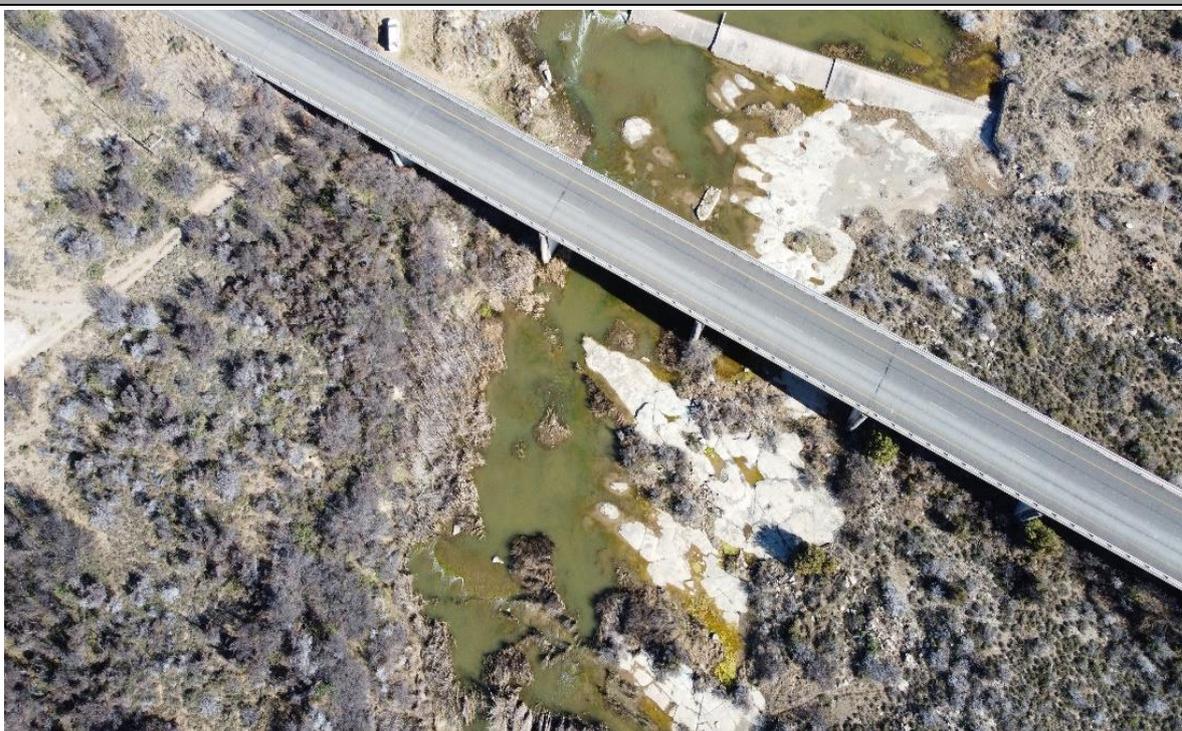
Parameter	Survey 1 (July 2022)	Survey 2 (May 2023)
pH	8.7	8.4
EC (uS/cm)	259.0	217.4
TDS (g/l)	0.2	0.2
DO (mg/l)	10.1	9.2
DO% (%)	87.9	83.5
Clarity (cm)	27	11.5
Temperature (°C)	9.2	10.8
Salinity (ppt)	0.18	0.14
	Survey 1 (July 2022)	Survey 2 (May 2023)
Discharge (m ³ /s)	14.190	38.451

5.5 R_RU06: Seekoei

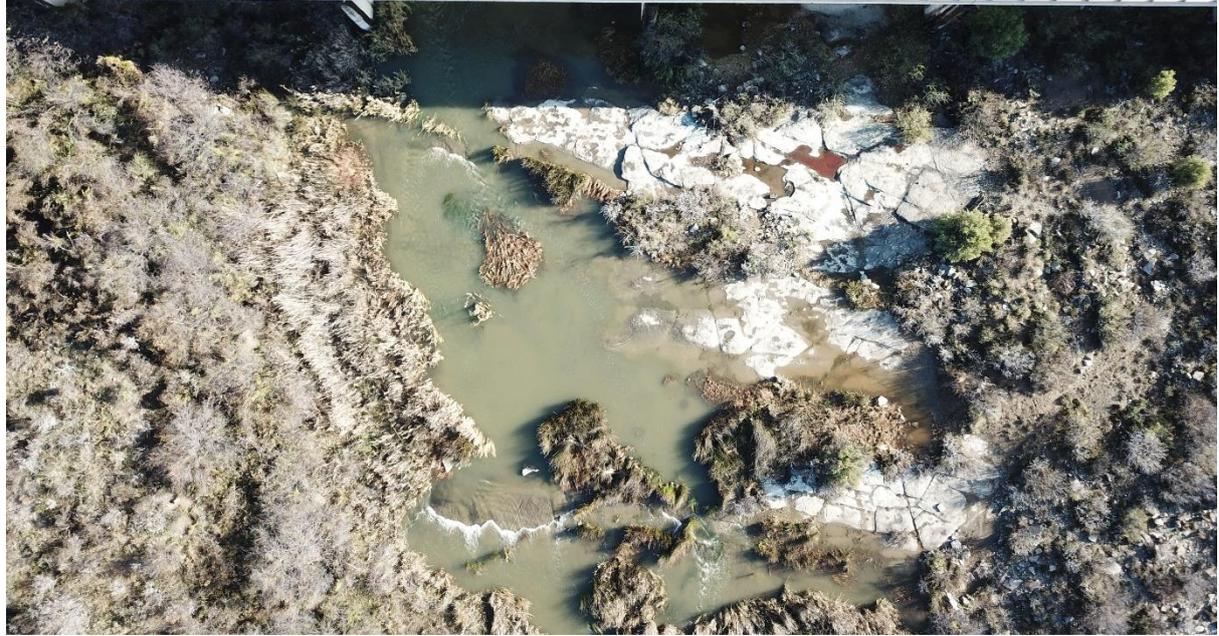
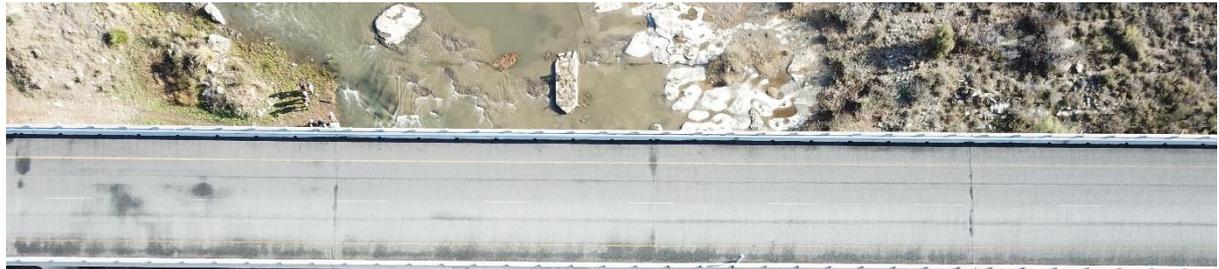
Sample Date	31 May 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR05_I	Prioritised RU	R_RU06
River	Seekoei	Altitude (m.a.s.l.)	1221
Longitude	24.962895°	Latitude	-30.534359°
Level 1 EcoRegion	Nama Karoo	Quaternary catchment/ SQ Reach	D32J D32J-05237
Level 2 EcoRegion	26.03	DWS, 2014 PES, EI, ES	D, Moderate, Moderate
Geomorphological zone	E (Lower Foothills)		

Components sampled: Fish, aquatic macroinvertebrates, VEGRAI, *in situ* water quality, diatoms, water and slope measurements along cross-section and discharge

Site Photographs: Survey 1 (July 2022)



Site Photographs: Survey 2 (May 2023)





Upstream

Downstream

Site Description:

The reach is relatively unconfined with the river incised into the valley floor. Flood features are narrow and the river pattern is straight to sinuous with bedrock, boulder, cobble and gravel and finer habitats available at the site. The site is located off a large cross over bridge off a district road R369, approximately 40km northwest from Colesburg and approximately 60km downstream of the Karoo Gariep Nature Reserve. The site continues to have high baseflows following the recent floods. Various upstream dams and weirs along the river reach, with a gauging weir located just upstream of the site, resulting in inundation upstream, as well as sediment accretion resulting in various instream islands of *Phragmites sp.*, as well as along both banks. Downstream of the weir, the site is dominated primarily by metamorphic sandstone with igneous intrusions forming the bedrock layer along this reach, along with small pockets GSM. The bedrock was blanketed by algae and silt. Furthermore, both instream and marginal vegetation was present for sampling macroinvertebrates. Flow-depth velocity classes available for the fish included FD, SD, SS and FS.

The riparian zone is spread across a flattened valley bottom with the macro-channel extending up to 200m. The weir upstream of the EWR site has inundated sections of marginal habitat and portions of the lower zone, and resulted in an increase in reeds (*Phragmites australis*). Downstream of the weir are several areas of flat, bedrock, and the marginal zone dominated by reeds and sedges. The lower zone of the right bank is relatively steep with low thicket comprising *Searsia pyroides*, *Lycium hirsuta*, *Heteromorpha arborescens* and *Vachellia karroo*, which flattens out into a broader upper zone with scattered tall shrubs interspersed by grasses, herbs and low shrubs. The left bank has a similar vegetation pattern, but is more sparse with more exposed alluvium.

Site impacts:

- Dams and weirs
- Irrigation
- Game farming
- Localised cultivation on terraces

Preliminary Results

In situ water quality:

Parameter	Survey 1 (July 2022)	Survey 2 (May 2023)
pH	8.8	8.5
EC (uS/cm)	695	580
TDS (g/l)	0.6	0.5
DO (mg/l)	11.1	10.0
DO% (%)	99.2	91.2

Clarity (cm)	30	25
Temperature (°C)	9.8	11
Salinity (ppt)	0.49	0.39
	Survey 1 (July 2022)	Survey 2 (May 2023)
Discharge (m ³ /s)	1.155	1.671

5.6 R_RU08: Upper Riet

Sample Date	1 June 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR06_I	Prioritised RU	R_RU08
River	Upper Riet	Altitude (m.a.s.l.)	1278
Longitude	25.524570°	Latitude	-29.535065°
Level 1 EcoRegion	Nama Karoo	Quaternary catchment/ SQ Reach	C51F C51F-04071
Level 2 EcoRegion	26.03	DWS, 2014 PES, EI, ES	C, High, Moderate
Geomorphological zone	E (Lower Foothills)		

Components sampled: Fish, aquatic macroinvertebrates, VEGRAI, *in situ* water quality, diatoms, water and slope measurements along cross-section and discharge

Site Photographs: Survey 1 (July 2022)



Site Photographs: Survey 2 (May 2023)



Upstream



Downstream

Site Description:

The reach is largely unconfined, with the macro channel incised into the gently sloping hillslopes. The river has a straight to sinuous macro channel pattern, with a braided low flow channel pattern. Bedrock, boulder, gravel and silt common sediment types at the site. This site is located in the upper reaches of the Riet River, upstream of the Kalkfontein Dam Nature Reserve and ~20km upstream of the confluence of the Kromellenboog. Upstream of this site is the DWS REMP site and previous JBS3 site C5RIET-IFR03 and 26_10 respectively. The Riet River is a main tributary of the Vaal River and flows in a western direction. The site is located just downstream of a low water cross-over bridge, where log jams have occurred upstream of the bridge, impeding the hydraulics of the river, as well as inundation of the system upstream.

The turbid channel is ~40m wide and braided downstream of the bridge owing to in-stream vegetated and gravel islands. The substrate at the site is dominated by gravel and cobbles, a section of bedrock along the left side of the channel. The forming braids have resulted in small streams running through the instream island with rocky habitat for macroinvertebrates and fish, sections of SOOC and mud forming allowing for instream vegetation. Small pools have formed as back eddies from the vegetated sedimentation which has formed. The increased flows have allowed aquatic grass to establish in the deep runs. Marginal vegetation was abundant and comprised reeds, grasses and sedges. Bank erosion from cattle trampling was evident, more so along the right bank, along with undercut banks.

The riparian zone is characterised by a fairly steep left bank with denser vegetation and a wider, flatter, more open right bank with areas of exposed bedrock and alluvium. The marginal zone is narrow and dominated by dense clumps of *Schoenoplectus* interspersed by the occasional woody shrub/tree (e.g. *Salix mucronata*), which leads into a grassy strip of tall/robust *Miscanthus capensis* defining the lower edge of the non-marginal, with a broader band of *Cynodon dactylon* and other grasses above extending across the upper zone into the terrestrial areas. The upper, left bank has numerous patches of low, dense thicket comprising *Lycium* and *Asparagus spp.* with several large, exotic trees (*Eucalyptus* and *Populus spp.*) scattered along the middle to upper bank. There are a number of islands and clumps of emergent *Schoenoplectus* with *Gomphostigma virgatum*. Impacts to the riparian zone are low to moderate and tend to be localised around the road crossing.

Site impacts:

- Rural development
- Cattle/game farming
- Cultivation
- Irrigation

Preliminary Results

In situ water quality:

Parameter	Survey 1 (July 2022)	Survey 2 (May 2023)
pH	8.8	8.34
EC (uS/cm)	486	557
TDS (g/l)	0.449	0.495
DO (mg/l)	9.9	8.98
DO% (%)	97.4	81.3
Clarity (cm)	22	13
Temperature (°C)	9.5	11.0
Salinity (ppt)	0.34	0.37

	Survey 1 (July 2022)	Survey 2 (May 2023)
Discharge (m ³ /s)	4.217	12.405

5.7 R_RU22: Upper Modder (Sannaspos)

Sample Date	2 June 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR07_I	Prioritised RU	R_RU22
River	Modder	Altitude (m.a.s.l.)	1333
Longitude	26.572492°	Latitude	-29.160017°
Level 1 EcoRegion	Highveld	Quaternary catchment/ SQ Reach	C52B C52B-03819
Level 2 EcoRegion	11.03	DWS, 2014 PES, EI, ES	D, High, High
Geomorphological zone	E (Lower Foothills)		

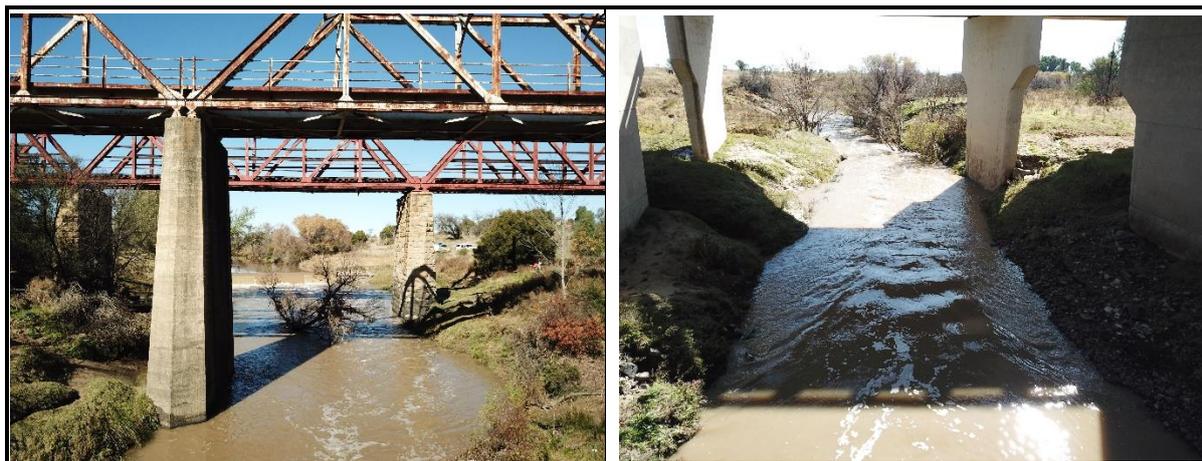
Components sampled: Fish, aquatic macroinvertebrates, VEGRAI, *in situ* water quality, diatoms, water and slope measurements along cross-section and discharge

Site Photographs: Survey 1 (July 2022)



Site Photographs: Survey 2 (May 2023)





Upstream

Downstream

Site Description:

The reach is largely unconfined, with gently sloping hillslopes and an incised channel with narrow flood features. The site is bedrock controlled with silty banks and introduced coarser bed material. Gravel and sand bars are present downstream of the site. The site along the upper reaches of the Modder River is located ~30km east of Bloemfontein off the N8, with its confluence downstream with the Riet River near the town of Ritchie. The site is situated approximately 13 km downstream of Rustfontein Dam. It is impeded by two (2) railway crossings and a large bridge. Furthermore, a gauging weir is located just upstream of the site. The river width varies from 3 m to 15 m in places with inundation taking place just upstream of the weir. Owing to these influences and impediments, much of the instream substrate, downstream of the weir comprises riffles with artificial loose SIC, and some SOOC. However, bedrock is the dominant substrate from the bridge and further downstream. There is relatively good GSM, but marginal vegetation, being grasses and sedges, was limited owing to undercut banks and vegetation die back (representative of the season). Sedimentation is present downstream of the weir forming a back eddie along the sandbank with algae on the rocks at the river's edge. Overall, considerable channel and bed modification is present at this site. Both banks are heavily eroded owing to recent flooding, flow modifications and cattle trampling.

The riparian zone has been affected by altered flows as a result of Rustfontein Dam located upstream, with localised impact caused by the bridge structures associated with the N8 and the railway line, as well as the gauging wier. The right bank, upstream of the wier has a dense stand of exotic Populus trees (*Populus canescens*). There has been an increase in woody vegetation, inclusive of IAPs and encroachment of terrestrial species such as *Vachellia karroo* and *Searsia lancea*. Erosion along the banks is exacerbated by runoff from the N8, as well as concentration of flows under the bridge. Various signs of impacts from cattle were also noted throughout the site.

Current land uses in the catchment include agricultural activities (primarily irrigated crops), urbanisation and industrial activities. The Modder River supplies water to several urban areas including Bloemfontein, Botshabelo (upstream) and Thabu Nchu although this is supplemented to a large degree by water from the Caledon River via the Caledon - Modder River Government Water Scheme (CMRGWS).

At the time of the May 2023 survey, the system was recovering from a recent flood event, which took place two days prior, measuring at approximately 60m³/s. This ultimately had an impact on the macroinvertebrate community and of which some of the biotopes could not be accessed namely the SIC during this recent survey.

Site impacts:

- Upstream dams
- Weirs
- WWTW works
- Agriculture
- Abstractions and irrigation
- Cattle trampling, grazing
- Industrial

Preliminary Results

In situ water quality:

Parameter	Survey 1 (July 2022)	Survey 2 (May 2023)
pH	8.4	7.96
EC (uS/cm)	459	155.7
TDS (g/l)	0.419	0.1404
DO (mg/l)	8.7	9.65
DO% (%)	76.6	86.2
Clarity (cm)	52	6.5
Temperature (°C)	9.9	10.4
Salinity (ppt)	0.32	0.10
	Survey 1 (July 2022)	Survey 2 (May 2023)
Discharge (m ³ /s)	0.673	9.180

5.8 R_RU03: Lower Kraai

Sample Date	30 May 2023	Reserve Level Assessment	Intermediate
Site Name	UO_EWR08_I	Prioritised RU	R_RU03
River	Lower Kraai	Altitude (m.a.s.l.)	1298
Longitude	26.74157°	Latitude	-30.69007°
Level 1 EcoRegion	Nama Karoo	Quaternary catchment/ SQ Reach	D13M D13M-05442
Level 2 EcoRegion	26.03	DWS, 2014 PES, EI, ES	C, High, High
Geomorphological zone	F (Lowland)		

Components sampled: VEGRAI, *in situ* water quality, diatoms, water and slope measurements along cross-section and discharge

Site Photographs: Survey 1 (July 2022)



Site Photographs: Survey 2 (May 2023)





Upstream

Downstream

Site Description:

This site is ORASECOM JBS3 site (26_11) and the DWS REMP site D1KRAA-ALIWA. The reach has a partly confined valley setting, straight to wandering channel form and pool-riffle sequences. The channel is incised with narrow flood features. The site is immediately downstream of a causeway/bridge which is frequently used by farmers. There is a sluice gate on the right end of the bridge – which can be closed in times of drought or should the Orange River dry up. This functions in pooling up the river upstream of the bridge for Basic Human Needs support. This river is a free flowing river, ~30 m wide and has a range of biotopes. There is a solid igneous bedrock base with riffles and runs below the causeway. Much filamentous algae coverage over the SIC biotopes. Most of the river in the area has deeper, slow flowing pools. The river comprises various sections of riffles and pools downstream of the bridge, providing a range of habitats. All biotopes for the macroinvertebrates are present, SIC, SOOC, GSM, although vegetation is limiting owing to undercut banks and vegetation die back/erosion. For fish, there are FD, SD, SS and FS habitats. During both the July and May 2022 survey, the baseflows were higher than expected for the time of year as a result of the high rainfall during the latter part of summer.

Left bank is dominated by non-woody vegetation, with several, large Poplar trees (*Populus canescens*) growing along the lower banks upstream of the weir. The site is spilt by the weir/causeway, which results in marginal zone being inundated. Downstream of the weir is a broad, flat bench of mostly bare/exposed alluvium with patches of raised alluvial mounds covered with *Cynodon dactylon* and a narrow strip of dense *Cyperus marginatus* growing along the marginal zone. The outer edge of the riparian is marked by a steep bank leading up into the terrestrial zone. The right bank has dense wooded vegetation comprising a mix of indigenous (e.g. *Celtis africana*, *Diospyros lyciodes*, *Lycium sp.*, *Salix mucronata* and *Searsia pyroides*) and IAPs (e.g. *Populus canescens* and *Salix babylonica*) which are sheltered from high velocities during flood events. There is a steep bank between the lower and upper zones. The riparian vegetation is mainly affected by vegetation removal due to roads, 4x4 tracks, footpaths, cultivation (right banks), as well as shading by IAPs. There is also serious erosion leading from the terrestrial areas into the riparian areas, especially on the left bank, as well as bank collapse and scour erosion.

The main land use in the area is agriculture with several centre pivot irrigation fields close to the river immediately upstream. *Salix sp.* line the banks both upstream and downstream. The flood debris line is ~3 m above the water level indicating large volumes passing through during flood events.

Site impacts:		
<ul style="list-style-type: none"> • Agriculture • Cattle activity • Irrigation 		
Preliminary Results		
<i>In situ</i> water quality:		
Parameter	Survey 1 (July 2022)	Survey 2 (May 2023)
pH	8.6	8.3
EC (uS/cm)	218	139.4
TDS (g/l)	0.2	0.1
DO (mg/l)	10.1	8.9
DO% (%)	87.7	82.1
Clarity (cm)	68	12
Temperature (°C)	9.1	11.7
Salinity (ppt)	0.15	0.09
	Survey 1 (July 2022)	Survey 2 (May 2023)
Discharge (m ³ /s)	17.300	19.030

5.9 R_RU07: Lower Orange

Sample Date	3 June 2023	Reserve Level Assessment	Rapid 3
Site Name	UO_EWR10_I	Prioritised RU	R_RU07
River	Lower Orange	Altitude (m.a.s.l.)	1000
Longitude	23.691236	Latitude	-29.144832
Level 1 EcoRegion	Nama Karoo	Quaternary catchment-SQ Reach	D33K-03723
Level 2 EcoRegion	26.01	DWS, 2014 PES, EI, ES	C, High, Moderate
Geomorphological zone	F (0.001; Lowlands)		

Components sampled: Fish, aquatic macroinvertebrates, VEGRAI, *in situ* water quality, diatoms, cross-section and discharge

Site Photographs: Survey 2 (May 2023)





Upstream **Downstream**

Site Description:

This EWR site is located approximately 13km south-west of Douglas, 12km upstream of the confluence with the Vaal River and 2.5km downstream of Marksdrift weir. It is defined by an incised macro-channel of approximately 160m wide. The primary land-use is irrigated agriculture/cultivation, principally centre pivots and peacan nut orchids. Water is pumped from the Orange River at Marksdrift and transferred to Douglas Weir on the Vaal River, which is 23.5km upstream of the confluence. This water transfer scheme is used mainly for irrigation and to improve the water quality in the lower Vaal River. Vanderkloof Dam is located approximately 175km upstream, with Gariep Dam positioned further upstream (approximately 55km upstream of Vanderkloof).

Up until 2020, the site was characterised by several small to medium islands covered by dense reeds and sedges, with a braided network of pools and runs. These channel features have since become covered by sediments that have been deposited at the site during recent floods. The active channel is now more confined to the mainstem, with the exception of two side channels along the left bank, that provides some riffle habitat comprising boulder and some cobble substrate. Fine sediments, gravel and sand were confined. The aquatic macroinvertebrate biotopes included SIC, SOOC and GSM. Owing to various flood events in this system, all marginal vegetation has been removed, although evidence of pockets of reeds beginning to establish. The different flow-depth-velocity classes present for fish included FS, SD (dominance), SS and some FD.

The riparian zone associated with the EWR site is characterized by short, steep banks that flattens out into the surrounding savanna (left bank) and agricultural lands (right bank). The marginal zone is made up of bare sand/alluvium with some exposed bedrock and occasional overhanging trees on the left bank. The lower portion of the lower zone is also sandy with scattered dead trees and shrubs, becoming more vegetated further up the banks with patches of *Cynodon dactylon* and riparian thickets of *Acacia karoo*, *Diospyros lyciodes*, *Lycium hirsutum* and *Ziziphus maculata*. The lower zone of the right bank is wider than the left bank and has a raised sand bar with a band of bare sand, leading into a grassy strip of *Cynodon dactylon*, then low thicket (mostly dead *Lycium* shrubs, with some *Salix mucronata* and *Ziziphus maculata*). Beyond the sand bar the bank drops into a depression, which becomes a side channel activated during high flows. From here the bank rises steeply into the densely wooded upper zone, with mature Buffalo Thorn (*Ziziphus maculata*) and Sweet Thorn (*Vachellia karoo*) trees. The riparian vegetation is primarily impacted by altered flows caused from Vanderkloof and Gariep Dams upstream, which affect the natural disturbance regime resulting in changes to riparian vegetation structure and composition.

Site impacts:

- Agriculture
- Cattle activity
- Irrigation
- Changed flow regime due to releases from upstream dams for water use in the lower Orange River and estuarine requirements

Preliminary Results

***In situ* water quality:**

- pH: 8.17
 - EC: 217.5 uS/cm
 - TDS: 0.1825 g/l
 - DO: 9.64 mg/l
 - DO%: 91.9%
 - Clarity: 24 cm
 - Temperature: 13.2°C
 - Salinity: 0.14
- Discharge: 63.71 m³/s

6. CAPACITY BUILDING

An important component of the river surveys was to share expert knowledge and river survey methodologies with members of the DWS (Table 4-1). As the DWS members took part in the first river survey in July 2022, they had a very good understanding of the methodology and approach involved in the intermediate river level approaches.

A second opportunity was provided to the DWS teams to accompany the river specialist team on the second river survey, which was undertaken from 26 May – 4 June 2023. Colleagues were again taken through the detail behind what is involved in intermediate and Rapid 3 river level approaches, and the various associated components. This second opportunity further included the riparian vegetation component at all intermediate studies, using the Riparian Vegetation Response Assessment Index (VEGRAI).



Discussions were had around the characteristics of each site and changes that had taken place since the July 2022 survey. Furthermore, the associated reach features namely, erosion, available biotopes/habits for the biota, flow velocities, algae/eutrophication, surrounding land use practices, sediment loading, hydraulic features, impediments amongst others. Vital components around how sites were selected to those that were not on the first river survey. It was reiterated that selected sites were those that would provide the information regarding the variety of conditions in a river reach related to the available habitats. Considerations were further discussed namely, their location within the identified priority RU (stressed areas, hotspots), whether there were upstream gauging weirs with good quality hydrological data, coupled with characteristics of tributaries.

From an ecological perspective, the Level II ecoregions was considered, geomorphological zones, habitat diversity for aquatic organisms, marginal and riparian vegetation, all critical for ecosystem functioning. Furthermore, suitability of the sites for accurate hydraulic modelling, where the range of possible flows, especially low flows, was considered. Each specialist then further took the members through their individual components (i.e. *in situ* water quality, diatoms, fish, aquatic macroinvertebrates, flow/discharge, cross-section and riparian vegetation) during the survey.





Overall, the enthusiasm and willingness to learn further yet again, and ask additional questions made for another positive learning experience for all involved. Thank you to those DWS members for your participation, involvement and more importantly, your support



7. APPENDICES

Appendix A: Field Survey 2 Programme

Upper Orange Post Dry Season Survey: 29 May - 4 June 2023						
Day	Date	Resource Unit	River	Quaternaries		Level
Monday	29-May-23		Middle Caledon	D22D	28.9089°, 27.7850°	Intermediate
Tuesday	30-May-23	R_RU01	Sterkspruit	D12B	27.369058°, -30.517806°	Intermediate
		R_RU02	Upper Orange (3)	D12F	26.823213°, -30.652793°	Intermediate
		R_RU03	Lower Kraai	D13M	26.74157°, -30.69007°	Intermediate
Wednesday	31-May-23	R_RU06	Seekoei	D32J	24.962895°, -30.534359°	Intermediate
		R_RU05	Lower Caledon	D24G	26.299258°, -30.436136°	Intermediate
Thursday	01-Jun-23	R_RU08	Upper Riet	C51F	25.524570°, -29.535065°	Intermediate
Friday	02-Jun-23	R_RU09	Modder (Sannapos)	C52G	26.572492°, -29.160017°	Intermediate
Saturday	03-Jun-23	R_RU07	Lower Orange (Marksdrift)*		23.659109, -29.087376	Rapid 3

