RESERVE DETERMINATION STUDY FOR SELECTED SURFACE WATER, GROUNDWATER, ESTUARIES AND WETLANDS IN THE F60 AND G30 CATCHMENTS WITHIN THE BERG-OLIFANTS WMA

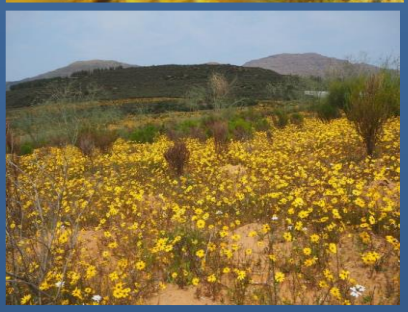
ECOLOGICAL WATER REQUIREMENTS REPORT

February 2023









Department of Water and Sanitation

Chief Directorate: Water Ecosystem Management

DEPARTMENT: WATER AND SANITATION

CHIEF DIRECTORATE: WATER ECOSYSTEM MANAGEMENT

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WP11340

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DOCUMENT INDEX

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ACRONYMS AND ABBREVIATIONS

AEC	Achievable Ecological Category
CSIR	Council for Scientific and Industrial Research
D:RDM	Directorate: Resource Directed Measures
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EcoStatus	Ecological Status
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FEPA	Freshwater Ecosystems Priority Areas
GIS	Geographic Information System
HGM	Hydrogeomorphic
IFR	Instream Flow Requirement
IHI	Index of Habitat Integrity
IUCN	International Union for Conservation of Nature
l/s	Litre per second
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MCM	Million Cubic Metres
NFEPA	National Freshwater Ecosystem Priority Area
NWA	National Water Act
NWM5	National Wetland Map 5
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category

RQO	Resource Quality Objective
RU	Resource Units
SANBI	South African National Biodiversity Institute
WCBSP	Western Cape Biodiversity Spatial Plan
WMA	Water Management Area
WR2012	Water Resources 2012
WRC	Water Research Commission

GLOSSARY

ABIOTIC	Without life, inanimate; physical environment like temperature, rainfall
ANTHROPOGENIC	Caused by human activity
AQUATIC	Relating to water
AQUIFER	Underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt)
ATTENUATION	To make something weaker or have less effect.
BASEFLOW	That part of stream flow contributed by groundwater and discharged gradually into the channel.
BENTHIC	Organisms that inhabit the shallow, bottom habitat of water.
BIOTA	The living organisms occupying a place together, e.g. plants, animals, bacteria, etc in the aquatic biota, or terrestrial biota.
CATCHMENT	The area from which any rainfall will drain into the watercourse or watercourses, through surface or subsurface flow.
DISTURBANCE REGIME	The pattern of natural variability of physical and biological processes, incorporating the return time to a stable condition from extreme conditions.
ECOCLASSIFICATION	The term used for Ecological Classification refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers compared to the natural or close to natural reference condition. The purpose of EcoClassification is to gain insights into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river. The EcoClassification process also supports a scenario-based approach where a range of ecological endpoints have to be considered.
ECOLOGICAL HEALTH	A descriptive non-specific term for the combination of all factors, biotic and abiotic, that make up a particular environment and its organisms

ECOREGIONS	Areas of similar ecological characteristics.
ECOSYSTEM	A community of animals, plants and bacteria with its physical and chemical environment.
EPHEMERAL	An ephemeral stream has flowing water only during, and for a short duration after, precipitation events in a typical year
ENVIRONMENT	All of the external factors, conditions, and influences that affect the growth, development, and survival of organisms or a community. This includes climate, physical, chemical, and biological factors, nutrients, and social and cultural conditions.
ESTUARY	A partially or fully enclosed body of water that is open to the sea permanently or periodically, and within which the sea water can be diluted, to a measurable extent, with fresh water drained from land.
FLOW REGIME	Recorded or historical sequence of flows used to create a hydrological profile of the water resource.
GEOMORPHOLOGY	The branch of geology that deals with, amongst other things, the form of the earth and the changes that take place in the process of development of landforms.
HABITAT	The environment or place where a plant or animal is most likely to occur naturally.
HYDRAULICS	Of, involving, moved by, or operated by a fluid, especially water, under pressure.
HYDROLOGY	The scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.
HYPERSALINE	An environment that has salinities greater than that of normal seawater
IMPACTS	The measurable effect of one thing on another.
IMPOUNDMENT	To retain water artificially by means of a weir or dam.
INDIGENOUS	Living or growing naturally in a particular area, but not naturally confined only to that area or any resource consisting of (a) any living or dead animal, plant or other organisms of an indigenous species, (b) any derivative of such animal, plant or other organisms; or (c) any genetic material of such animal, plant or other organisms.

INDIGENOUS SPECIES	A species that occurs, or has historically occurred, naturally in a free state, in nature within an ecologically similar area, but excludes a species that has been introduced from another area or continent as a result of human activity
INVERTEBRATE	Animal without a backbone
LEGISLATION	A law or a series of laws
MANDATE	The authority to do something, given to an organisation or government, by the people who support it.
MODIFIED	Changed, altered.
NUTRIENTS	Elements required for life processes: nitrogen, phosphorus and potassium are probably the most important nutrients.
POINT SOURCE	A definable or precise location or source e.g., of pollution
POLICY	A plan of action, statement of ideals, etc. proposed by an organization, government, etc.
PRISTINE	Remaining in a pure or natural state.
PREDATION	A predator is an animal that kills and eats other animals. Predation is the capturing of prey as a means of maintaining life.
PRESENT ECOLOGICAL STATE	The current state or condition of a resource in terms of its various components, i.e. drivers (physico-chemical, geomorphology, and hydrology) and biological response (fish, riparian vegetation and aquatic invertebrates). The prequel to recommended ecological category
QUATERNARY CATCHMENT	A fourth-order catchment in a hierarchical system in which the primary catchment is the major unit.
RIPARIAN	Of, on, or relating to the banks of a water course, including the physical structure and associated vegetation. The area of land adjacent to a stream or river that is influenced by stream-induced or related processes.
RIVER ESTUARY INTERFACE	That part of an estuary where the river and estuarine waters mix, and where the vertically integrated salinity is usually less than 10 ppt

SEDIMENTATION	The act or process of depositing sediment. Sediment comprises fragments of inorganic or organic material that are carried and deposited by water.
SPECIES	A kind of animal, plant or other organisms that does not normally interbreed with individuals of another kind, and includes any sub-species, cultivar, variety, geographic race, strain, hybrid or geographically separate population
TERTIARY CATCHMENT	A third-order catchment in a hierarchal classification system in which a primary catchment is a major unit.
SUBSTRATE	The surface to which a plant or animal is attached or on which it grows.
SURFACE WATER	All water that is exposed to the atmosphere, e.g., rivers, reservoirs, ponds, the sea, etc.
VARIABILITY	The tendency to vary i.e. to change.
WATERCOURSE	"A natural channel or depression in which water flows regularly or intermittently" (definition in the NWA)
WATER QUALITY	The value or usefulness of water, determined by the combined effects of its physical attributes and its chemical constituents and varying from user to user
WETLANDS	"Land which is transitional between terrestrial and aquatic systems where the water table is usually at, or near the surface or the land is periodically covered with shallow water and which land in normal circumstances supports, or would support vegetation typically adapted to life in saturated soil" (definition in the NWA)

1. INTRODUCTION

1.1 Background

The Chief Directorate: Water Ecosystems Management of the Department of Water and Sanitation (DWS) has embarked on a preliminary Reserve determination study for the G30 and F60 catchments (Figure 1). These are the two remaining Tertiary Catchments of the Berg Olifants Water Management Area (WMA) that still require a higher level of confidence Reserve determination. The Verlorevlei within the study area was designated as a Wetland of International Importance (Ramsar Site) on 28 June 1991 under the Ramsar Convention on Wetlands of International Importance, Especially as Waterfowl Habitat. In addition, peat wetlands have been identified to occur in the area that is associated with the Verlorevlei that provide important ecological services but are under severe threat and require urgent protection. It is therefore crucial that the Reserve calculations are revisited and the water resources with the Sandveld catchments addressed holistically, with a clear understanding of the surface and groundwater interactions and interdependencies being well researched and documented.

1.2 Objectives

This study aims to identify gaps in previous Reserve Determination Studies and to determine the Reserve at a high level of confidence to yield results that could be gazetted and provide legal protection specifications. The following objectives are listed:

1. Determination of the water quantity and quality for the protection of rivers at various Ecological Water Requirement (EWR) sites;
2. Determination of the water quantity and quality for the protection of priority wetlands, pans and lakes;
3. Determination of the water quantity and quality of estuarine freshwater requirements for the protection of various identified estuaries;
4. Determination of the groundwater quantity and quality requirements for the protection of groundwater resources; and
5. Determination of the quantity and quality of water required for the provision of Basic Human Needs.

1.3 Purpose of this Report

The purpose of this report is to quantify the Ecological Water Requirements (EWR) for the water resources in the G30 and F60 catchments (Figure 1) of the Olifants-Doorn Water Management Area. This task, therefore, describes the physical template and information for decision-making regarding the different levels of investigation for Reserve determination and guides the selection of where Ecological Water Requirements (EWRs) should be determined.

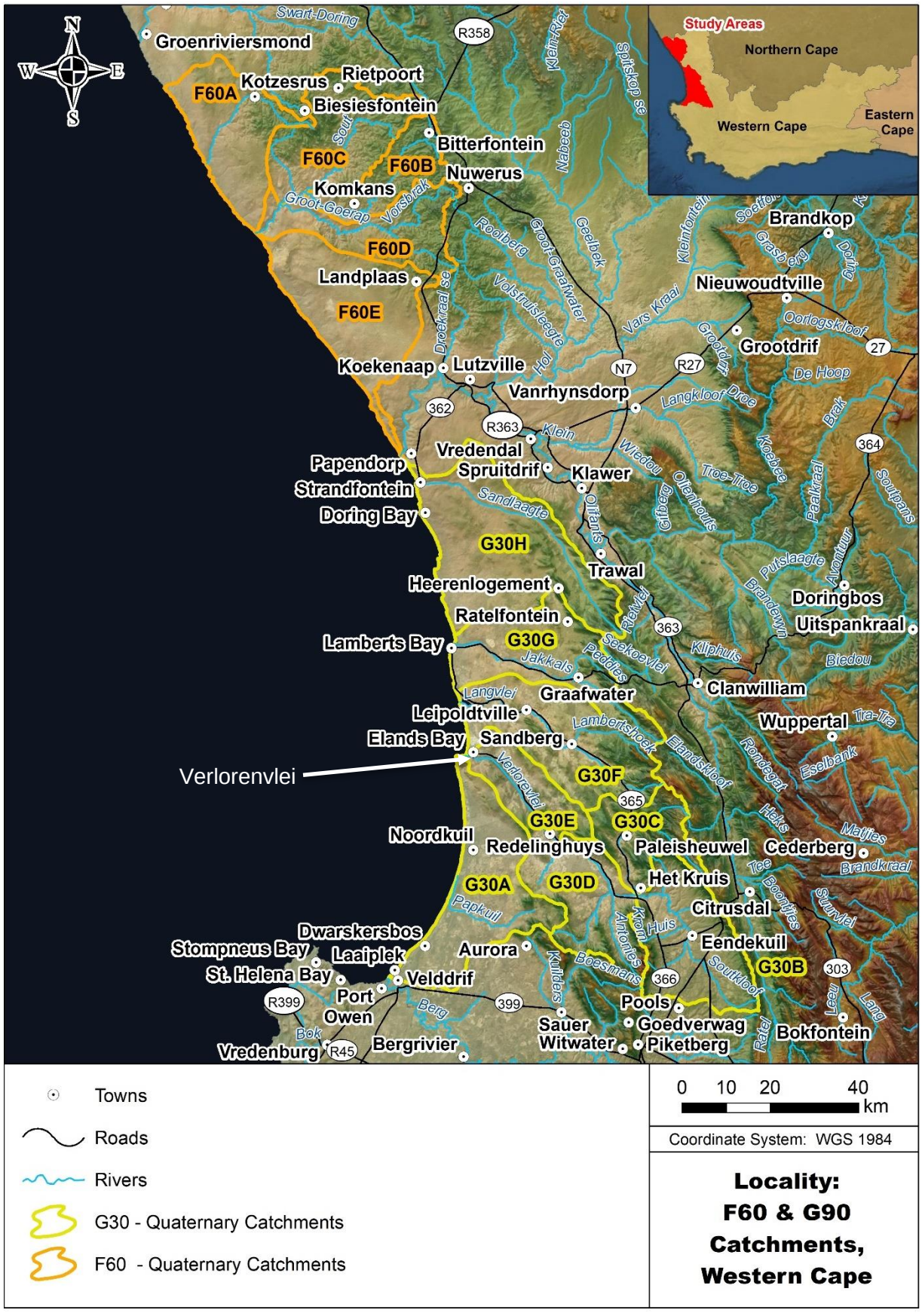


Figure 1: Map of the study area with the location of the G30 and F60 Catchments and main aquatic features shown

1.4. The Study Area

The study area comprises two Tertiary Catchments, the G30 (Sandveld) and the F60 (Knersvlakte) Catchments. The majority of the G30F60 Catchment Area falls within the Western Cape Province, with a small section of the most northerly section of the catchment falling within the Northern Cape Province.

The Sandveld consists of the coastal plain along the west coast of South Africa bordered by the Olifants River catchment in the north and east, the Berg River catchment in the south and the Atlantic Ocean coastline in the west. The area contains the following seasonal river and wetland systems:

- Verlorenvlei River System with its main tributaries, the Kruismans, Bergvlei, Krom Antonies and Hol Rivers, as well as the Verlorenvlei Estuary;
- Langvlei River with the Wadrif wetland and pan;
- Jakkals River and Jakkalsvlei Estuary;
- Sandlaagte River
- Rocherpan and Papkuil River; and
- Several smaller wetland areas along watercourses, coastline and on the hillslopes.

The Ramsar designated Verlorenvlei estuarine and wetland system is the best known of the systems. The Ramsar treaty falls under the aegis of the United Nations and the International Union for the Conservation of Nature (IUCN) and member nations - of which South Africa is one and thus has acceded to the Ramsar treaty with its clearly defined responsibility of actively conserving the unique wetland and the biological diversity that it supports.

The Groot Goerap/Sout and Brak River Catchments to the north of the Sandveld are in the even more arid Knersvlakte region. The area comprises ephemeral rivers and wetlands, including:

- Sout River System with its main tributaries, the Groot and Klein Goerap Rivers and the South Estuary;
- Brak River and Estuary; and
- Several mostly isolated depression wetlands.

Groundwater in the G30 (Sandveld) catchment enables extensive agricultural activity and is the sole source of freshwater for most of the towns and settlements within the catchments. Groundwater also plays a significant role in sustaining surface water ecosystems. The catchments contain both fractured and intergranular areas. Average yields range from very low (0.5 l/s) to high yielding (> 5 l/s), with identified paleochannels producing boreholes of a yield higher than 25 l/s. Groundwater quality is described as being good across the G30 catchments, however, where Malmesbury Group formations occur, the main aquifer can be identified as yielding groundwater of poor quality. The main recharge areas have been identified as the mountainous areas towards the east of the study area that form part of the Cederberg and Piketberg Mountain ranges.

Groundwater availability in the F60 catchments is much lower than in the G30 catchments. The geological setting of the area is also more complex. The area has been classified as containing both intergranular and fractured aquifers (DWAF 2005). The regional expected yields are very low (0.1 - 0.5 l/s) with higher-yielding boreholes (up to 2 l/s) at the most southern point of the F60 catchments. Groundwater quality across the catchment is generally categorised as being poor, with EC values of over 1000 mS/m.

Land use in the area consists largely of livestock farming (sheep and goats), with small areas being used for dryland farming. Intensive irrigation of citrus and potatoes is undertaken in the south. Urban and rural areas are small, with the main towns being Redelinghuys, Elands Bay, Eendekuil, Leipoldtville, Graafwater, Lamberts Bay, Strandfontein and Bitterfontein. Water abstraction from surface and groundwater in the southern portion of the study area has significantly modified the flow of the aquatic ecosystems, particularly in summer. Modified flows have reduced the habitat integrity and, consequently the goods and services provided by these ecosystems.

1.5. Study Methodology and Approach

The river, wetland, estuarine and groundwater components of the Reserve determinations will use the latest RDM recommended methodologies. While the standard methodologies for the determination of the Basic Human Needs and ecological Reserve will be followed in the study, recognition of the need for a slightly adapted approach for the Sandveld and Knersvlakte Rivers needs to be undertaken. This adapted approach is deemed to be necessary to address the following:

- Most of the surface water features within the study area are non-perennial with a hydrological regime that has high variability in flow both spatially and temporally with a highly unpredictable surface water flow.
- Surface water ecosystems in these systems are often confined to isolated pools that eventually dry up. The aquatic biota associated with these habitats comprises hardy species with low diversity, although both the habitat and biota may be of high ecological importance;
- The estuaries within the area comprise mostly coastal lakes or estuarine salt pans, with a low diversity of hardy species. These systems are mostly nearly permanently closed and also have very little freshwater inflow from their associated river systems. As a result, they tend to be hypersaline;
- Very close integration occurs between the surface water ecosystems (rivers, wetlands and estuarine habitats) as well as with the groundwater. Integration of these two specialist fields and the recommended ecological Reserve (quantity and quality) thus needs to take place; and
- The sequencing and interaction between the tasks and disciplines on this project are critical. The products from the groundwater specialists will provide an improved understanding of the surface water ecosystems and the delineation of the river reaches and wetland regions. Enough time must be set aside to allow for integration. The wetlands component will especially need to

provide inputs to and rely on inputs from the Rivers and Groundwater specialists. Once the priority wetlands have been determined, a key step will be to interact with the specialists to obtain assistance in determining EWRs. The River specialists would also need to have input into the wetland priorities chosen.

The revised generic procedure is provided in Figure 2 (DWAF, 2008), which shows the process for the determination of the Ecological Water Requirement in the context of the larger Resource Directed Measures process, with possible links to issues such as the stakeholder process, classification, implementation and operation, indicated as suggested ways to integrate the Reserve determination process.

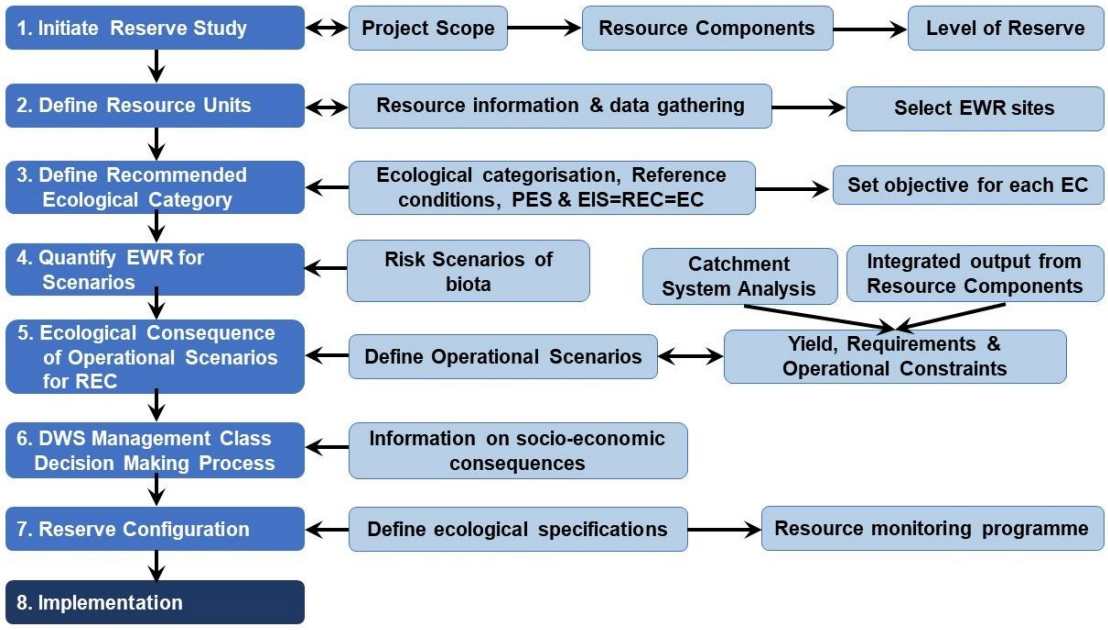


Figure 2: The Reserve Determination Process (adapted from DWAF, 2008)

This report documents the outcome of the first three steps of the above Reserve determination process. The river, wetland, estuarine and groundwater resource units have been defined and are summarised in the following section. Following this, EWR sites were identified and an Ecoclassification process was undertaken to determine the reference conditions, present ecological condition and ecological importance and ecological sensitivity of the resource unit at the EWR sites. The Ecoclassification is based on literature reviews, available data and a dry season (undertaken in April 2022) and wet season survey (September 2022) at the EWR sites. Based on these findings, Ecological Categories have been proposed.

2. EWR FROM PREVIOUS STUDIES

2.1. Sandveld 2006 Reserve Determination: Surface Water

Ecological Reserve (Rapid Level) specifications have been determined in the previous determination for surface waters for components of three river systems in the Sandveld as follows:

Langvlei River (G30F):

(i) Instream Flow Requirement (IFR) for the lowest reach;

(ii) Environmental Flow Requirement (EFR) for the Wadrif Wetland;

(iii) Environmental Flow Requirement (EFR) for the Wadrif Pan.

Jakkals River (G30G):

(i) Instream Flow Requirement (IFR) for the lowest reach;

(ii) Environmental Flow Requirement (EFR) for the Jakkalsvlei Pan.

Verlorenvlei River (G30B-E)

(i) Instream Flow Requirement (IFR) for the Kruismans River (upper mainstem, and the Verlorenvlei River – lowest reach of the mainstem);

(ii) Environmental Flow Requirement (Water Level Specification) for the Verlorenvlei Lake/Estuary, inclusive of provisional requirements for maintaining acceptable hydrodynamics for maintaining the seasonal connection to the sea.

The recommended Reserve specifications from the 2006 Sandveld Reserve determination are summarised in Table 1 and Table 2 on the following pages. The location of the sites is shown in Figure 3.

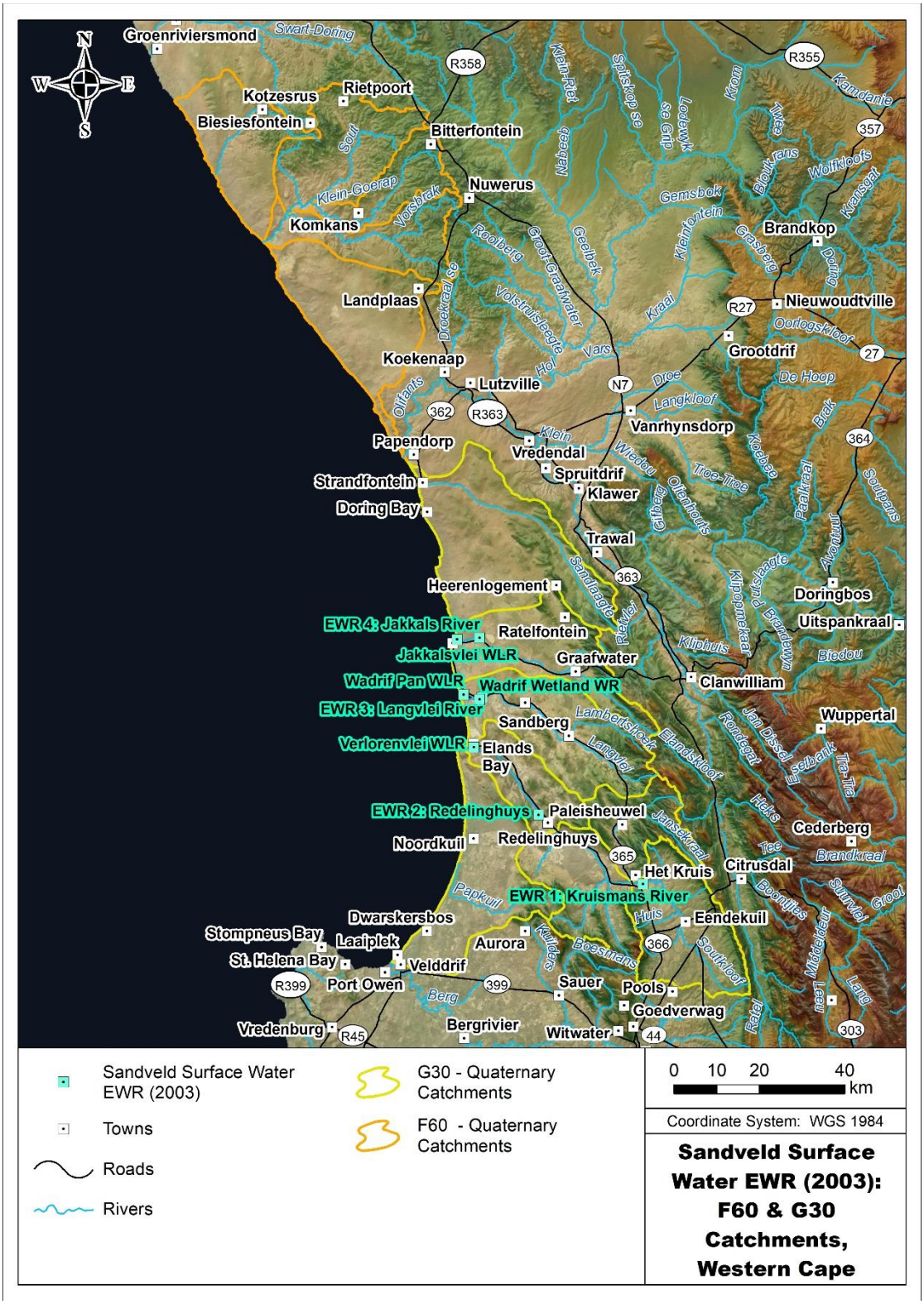


Figure 3. EWR sites selected in the previous Reserve study of 2006

Table 1. Surface water environmental water requirements (2006)

Surface water component	Location Lat/Long	Present Ecological State	Ecological Importance & Sensitivity	Recommended Ecological Management Category	Maintain low flow (Mm3/a)	Drought Low flow (Mm3/a)	Maintain High flow (Mm3/a)	Total IFR flow (Mm3/a)
Langvlei River	32°12' 37.8"S; 18°22' 41.7"E	E/F	C	C	0.520	0.000	1.437	1.957
Wadrif Wetland	32°12' 47.7"S; 18°22' 37.96"E	F	B	C	0.520	0.000	1.437	1.957
Wadrif Pan	32°12' 18.8"S; 18°20' 18.0"E	E	C	C	2.500	1.500	-	5.000
Jakkals River	32°5' 21.9"S; 18°21' 8.7"E	D	C	C	0.089	0.014	0.263	0.352
Jakkalsvlei	32°5' 15.9"S; 18°19' 17.5"E	E	C	C	0.250	-	-	0.500
Verlorenvlei (Duikerfontein)	32°36' 41.0"S; 18°46' 27.98"E	C	B	C	1.683	0.930	2.189	3.872
Verlorenvlei (Redelinghuys)	32°27' 56.0"S; 18°31' 0.0"E	C	B	B	4.537	0.623	8.739	13.276
Verlorenvlei Lake		C	B	B	Water level specification			

Table 2. Verlorenvlei Water Level Specification

Component	Requirement/Motivation
Frequency and duration of opening	Twice in any single year (autumn, early winter and spring), or alternatively; A single extended period from winter through into spring.
Mouth open conditions	"Semi-closed", i.e. continuous outflow with minimal seawater intrusion.
Water level (Mouth open)	2.20 m AMSL
Water level (Mouth closed)	1.95 m AMSL
Water level (Breaching)	Unknown but less than 2.5 m AMSL

The ecological categories and resource quality objectives per quaternary that formed part of the gazetted Proposed Classes and Resource Quality Objectives for the Catchments of the Olifants - Doorn in terms of Section 13(1)(a) and (b) of the National Water Act, 1998 (Act No. 36 of 1998) in Government Gazette No 39001, dated 17 July 2015, are provided in Table 3.

Table 3. Flow requirements calculated for each quaternary catchment (2015)

Catchment	River name	Mainstem Ecological Category	Tributary Ecological Category	Lowest flow month – mean flow (m^3/s)	Drought absolute minimum (m^3/s)	Flood in addition to Desktop	% nMAR
G30A*	Papkuils	C	C				
G30B	Kruismans	C	C				
G30C	Bergvallei	C	C				
G30D	Verlorenvlei	C	C				
G30E	Verlorenvlei	B	C				
G30E - Estuary	Verlorenvlei	C		March 0.29	0.04	>60% of natural floods for July, August & September	46
G30F	Langvlei and Wadrif wetland	C	C	March			14
G30F	Wadrif pan	C		March			37.7
G30G	Jakkals Jakkalsvlei	C	C	March 0.03	0.006		19.2
G30H*	Sandlaagte	C	C	March 0.02			12.8

3. EWR SITES SELECTED FOR THIS STUDY

3.1 Section of EWR Sites

3.1.1. Estuary EWR Sites

Estuary EWR determinations were conducted for the following estuaries within the study area:

1. **Verlorenvlei**, an Estuarine Lake, located in the Verlorenvlei Catchment in Quaternary Catchment G30E

Downstream boundary (estuary mouth):	32°18'58.34"S; 18°20'5.96"E
Upstream boundary:	32°25'55.82"S; 18°29'57.78"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Geographical boundaries of the Verlorenvlei Estuary

2. **Wadrift**, an Arid, Predominantly Closed estuary, located in the Langvlei Catchment in Quaternary Catchment G30F

Downstream boundary (estuary mouth):	32°12' 15.54"S; 18°19' 32.43"E
Upstream boundary:	32°12' 49.87"S; 18°22' 37.15"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Geographical boundaries of the Wadrift Estuary

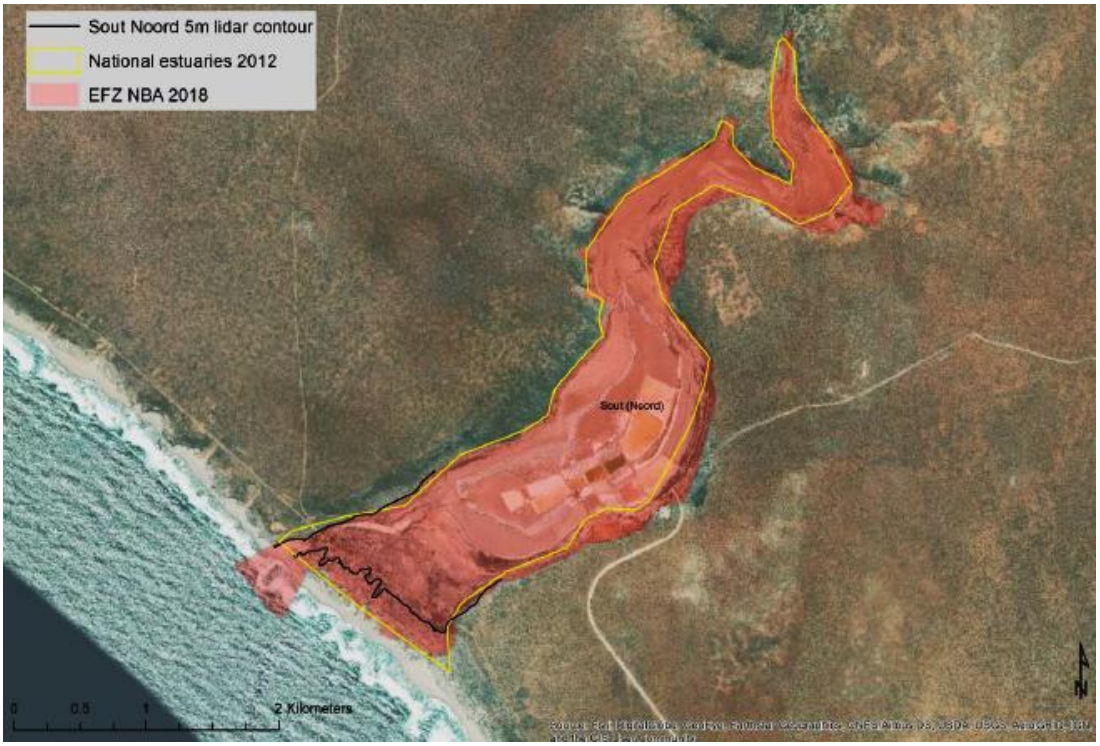
3. **Jakkalsvlei** of Jakkals Estuary, a Large, Temporarily Closed estuary, located in the Jakkalsvlei Catchment in Quaternary Catchment G30G

Downstream boundary (estuary mouth):	32° 5' 5.39"S; 18°18' 48.25"E
Upstream boundary:	32° 5' 26.89"S; 18°20' 1.32"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Geographical boundaries of the Jakkals Estuary

4. **Sout (Noord) Estuary**, an Arid, Predominantly Closed estuary, located in the Sout/Goerap Catchment in Quaternary Catchment F60D. This estuary was the subject of an EWR determination in 2017 as part of the Lower Orange Water Management Area EWR Study. The Recommendations of that EWR are included in this report for completeness' sake.

Downstream boundary (estuary mouth):	-31.247111° S; 17.853361° E
Upstream boundary:	-31.210076° S; 17.891072° E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank



Geographical boundaries of the Sout (Noord) Estuary, showing the 5 m topographical contour and the 2018 NBA (SANBI 2019) Estuarine Functional Zone (EFZ) boundary

3.1.2. River and Wetland EWR sites

The EWR sites for Rivers and Wetlands were selected within each of the identified River and Wetland Resource Units during the reconnaissance field survey undertaken in March 2022. Details of all the sites are provided in Table 4, together with the rationale for their selection. The locations are shown in Figure 4.

Table 4. List of River and Wetland EWR sites

EWR site No.	Description	Quaternary Catchment	Rationale for site selection
EWR1	Lower Brak River	F60A	Lower Brak River above the estuarine functional zone, relatively unimpacted within a more confined area and contains both river and wetland habitats; access is easy
EWR2, 4 &5	Isolated depression wetlands	F60A	One of the few FEPA depression wetlands in the NW Fynbos, Knersvlakte-Hardeveld and Sandveld Bioregions within Catchment F60; relatively accessible
EWR3	Lower Groot Goerap River	F60B	Lowest possible point on the system where access is possible and not impacted; the channel is also confined
EWR6	Lower Sandlaagte River	G30H	Lowest possible point on the system where access is possible and not impacted; channel also confined
EWR7	Lower Jakkals River	G30G	Lowest possible point on the system where access is possible and not impacted; channel also confined; near long term River Ecostatus monitoring site and near the previous IFR site
EWR8	Lower Langvlei River	G30F	Least impacted site on the lower Langvlei that is easily accessible; downstream of a long-term River Ecostatus monitoring site and near the previous IFR site

EWR9	Wadrif Wetland	G30F	This site was assessed during the previous EWR study in the region and should be re-visited, although the PES of the wetland has become severely degraded
EWR10	Lower Kruismans River	G30D	Least impacted site on the Verlorenvlei above the confluence with the Krom Antonies and below the confluence of the Kruismans and Bergvallei that is easily accessible and where the channel is relatively confined; downstream of a long-term River Ecostatus monitoring site and near the previous IFR site
EWR11	Lower Krom Antonies River	G30D	Least impacted site on the lower Krom Antonies that is easily accessible and where the channel is relatively confined
EWR12	Lower Verlorenvlei River	G30E	Least impacted site on the Verlorenvlei above the estuarine functional zone and below Redelinghuys that is easily accessible and where the channel is relatively confined downstream of a long-term River Ecostatus monitoring site and near the previous IFR site
EWR13	Isolated depression/ duneslack wetland	G30A	A relatively minimally impacted example of a dune slack wetland in the West Strandveld Bioregion, compared to most of the other dune slack wetlands in the region
EWR14	Rocherpan	G30A	A wetland of very high importance for wading birds and for eco-tourism, located within a nature reserve; very easy to access and safe to leave sampling equipment in place
EWR15	Lower Jakkals River	G30A	Least impacted site on the lower Papkuils River that is easily accessible and where the channel is relatively confined
EWR16	Papkuilsvlei	G30A	One of the most extensive seep wetlands (assumed to be of importance for streamflow regulation) in the entire study area, which is of particular significance for sustained water supply to the rest of the Papkuils system

Of the above sites, six sites were assessed in more detail as combined river and wetland sites, with another three wetland sites also being assessed in more detail (i.e. at an Intermediate level). This rationalisation of the sites was based on the availability of data for the sites as well as the importance for the determination of EWRs. These EWR sites are provided in Table 5.

Table 5. List of EWR sites assessed at an Intermediate level.

EWR site No.	Description	Quaternary Catchment	Lat/long
EWR7	Lower Jakkals River	G30G	32° 4'59.30"S; 18°22'20.10"E
EWR8	Lower Langvlei River	G30F	32°12'5.82"S; 18°23'54.02"E
EWR10	Lower Kruismans River	G30D	32°36'0.58"S; 18°41'34.83"E
EWR11	Lower Krom Antonies River	G30D	32°36'4.02"S; 18°41'28.52"E
EWR12	Lower Verlorenvlei River	G30E	32°27'29.91"S; 18°31'2.19"E
EWR13	Isolated depression/duneslack wetland	G30A	32°22'39.14"S; 18°19'48.28"E
EWR14	Rocherpan	G30A	32°36'49.34"S; 18°17'55.89"E
EWR15	Lower Papkuils River	G30A	32°37'53.62"S; 18°18'46.32"E
EWR16	Papkuilsvlei	G30A	32°38'1.26"S; 18°29'56.29"E

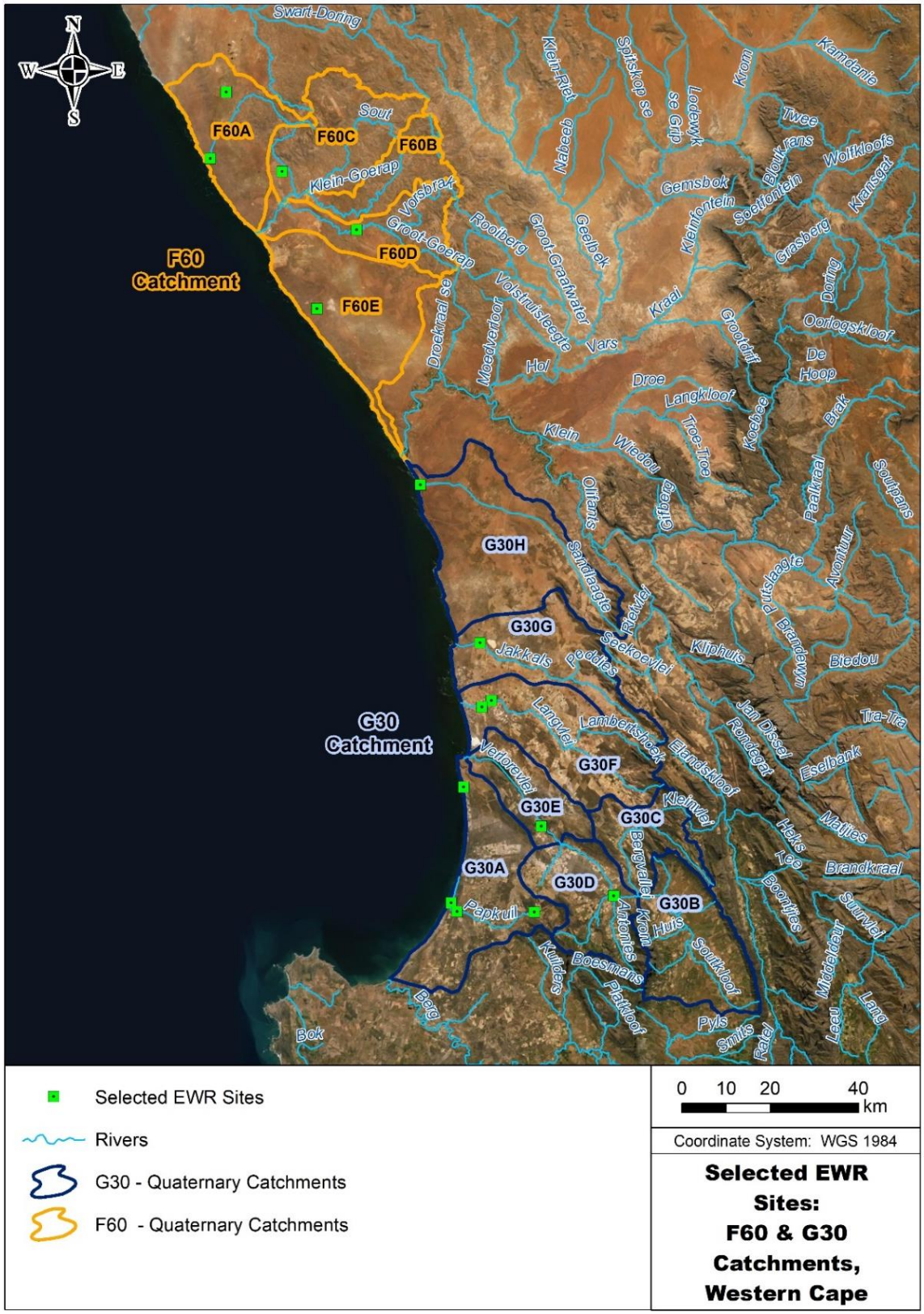


Figure 4. Map of the proposed EWR sites for rivers and wetlands in the F60 and G30 Catchments

3.2 Description of EWR sites

A description of the EWR sites assessed in more detail (listed in Table 5) is provided below.

Table 6. Characteristics and view of EWR 7

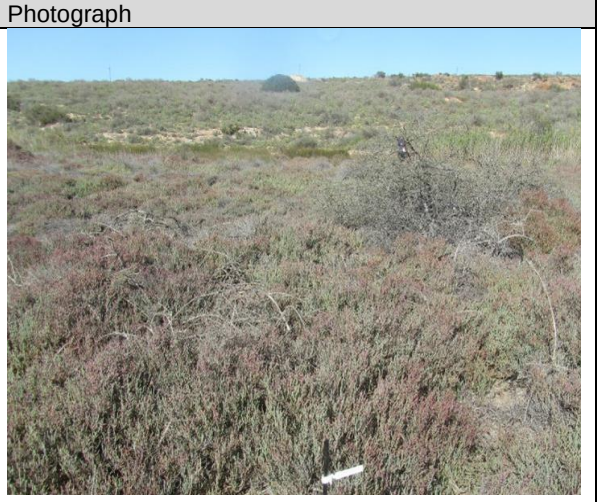
Site information		Photograph
EWR site	EWR 7	
Name	Lower Jakkals	
Description	Combined river and wetland site immediately upstream of the estuarine functional zone of the Jakkals River	
River	Jakkals	
Quaternary	G30G	
Resource Unit (RU)	Jakkals River Jakkals River RU; Lower Jakkals River VB Wetland RU U; Lower Jakkals Valley Bottom (VB) Wetland RU	
Coordinates	32° 4'59.30"S; 18°22'20.10"E	
Ecological Importance	Moderate; FEPA and NWM5 Mapped wetland	
Level of assessment	Site survey with cross-section, wetland, river, vegetation, water quality	

Table 7. Characteristics and view of EWR 8

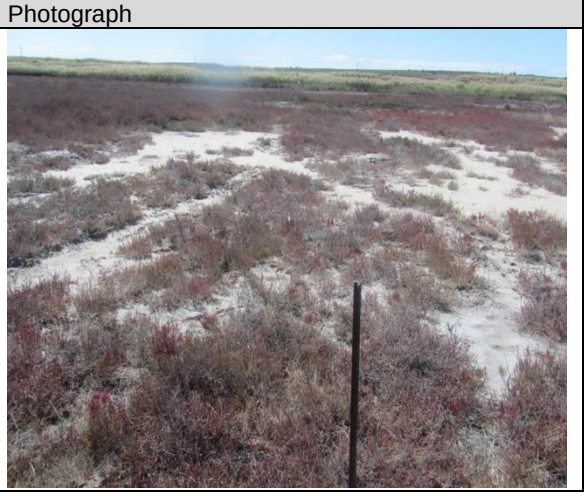
Site information		Photograph
EWR site	EWR 8	
Name	Lower Langvlei	
Description	Combined river and wetland site immediately upstream of the Wadrif Wetland and Wadrif Pan	
River	Langvlei	
Quaternary	G30F	
Resource Unit (RU)	Langvlei River RU; Lower Langvlei VB Wetland RU	
Coordinates	32°12'5.82"S; 18°23'54.02"E	
Ecological Importance	Moderate; FEPA and NWM5 Mapped wetland	
Level of assessment	Site survey with cross-section, wetland, river, vegetation, water quality	

Table 8. Characteristics and view of EWR 10

Site information		Photograph
EWR site	EWR 10	
Name	Lower Kruismans	
Description	Combined river and wetland site immediately upstream of the confluence of the Kruismans with the Krom Antonies River	
River	Kruismans	
Quaternary	G30D	
Resource Unit (RU)	Lower Kruismans River RU; Lower Kruismans River VB Wetland RU	
Coordinates	32°36'0.58"S; 18°41'34.83"E	
Ecological Importance	High; FEPA and NWM5 Mapped wetland; upstream Ramsar site	
Level of assessment	Site survey with cross-section, wetland, river, vegetation, water quality	

Table 9. Characteristics and view of EWR 11

Site information		Photograph
EWR site	EWR 11	
Name	Lower Krom Antonies	
Description	Combined river and wetland site immediately upstream of the confluence of the Krom Antonies with the Kruismans River	
River	Krom Antonies	
Quaternary	G30D	
Resource Unit (RU)	Krom Antonies River RU; Krom-Antonies River Floodplain (FP) Wetland RU	
Coordinates	32°36'4.02"S; 18°41'28.52"E	
Ecological Importance	High; FEPA and NWM5 Mapped wetland; upstream Ramsar site	
Level of assessment	Site survey with cross-section, wetland, river, vegetation, water quality	

Table 10. Characteristics and view of EWR 12

Site information		Photograph
EWR site	EWR 12	
Name	Lower Verlorenvlei	
Description	Combined river and wetland site immediately upstream of the estuarine functional zone of the Verlorenvlei	
River	Verlorenvlei	
Quaternary	G30E	
Resource Unit (RU)	Lower Verlorenvlei River RU; Lower Verlorenvlei River FP Wetland RU	
Coordinates	32°27'29.91"S; 18°31'2.19"E	
Ecological Importance	High; FEPA and NWM5 Mapped wetland; upstream Ramsar site	
Level of assessment	Site survey with cross-section, wetland, river, vegetation, water quality	

Table 11. Characteristics and view of EWR 13

Site information		Photograph
EWR site	EWR 13	
Name	G30A duneslack wetland	
Description	Isolated duneslack/depression wetland	
River	-	
Quaternary	G30A	
Resource Unit (RU)	West Strandveld dune slack Wetland RU	
Coordinates	32°22'39.14"S; 18°19'48.28"E	
Ecological Importance	Moderate; FEPA and NWM5 Mapped wetland	
Level of assessment	Brief site assessment with wetland, vegetation	

Table 12. Characteristics and view of EWR 14

Site information		Photograph
EWR site	EWR 14	
Name	Rocherpan	
Description	Isolated depression/duneslack wetland that is fed from groundwater and two minor streams	
River	Vlei	
Quaternary	G30A	
Resource Unit (RU)	Rocherpan Wetland RU	
Coordinates	32°36'49.34"S; 18°17'55.89"E	
Ecological Importance	High; FEPA and NWM5 Mapped wetland; Wetland of high importance for wading birds and eco-tourism, located in a nature reserve	
Level of assessment	Brief site assessment with wetland, vegetation	

Table 13. Characteristics and view of EWR 15

Site information		Photograph
EWR site	EWR 15	
Name	Lower Papkuils	
Description	Combined river and wetland site in the lower Papkuils River	
River	Papkuils	
Quaternary	G30A	
Resource Unit (RU)	Papkuils River RU; Lower Papkuils FP Wetland RU	
Coordinates	32°37'53.62"S; 18°18'46.32"E	
Ecological Importance	Moderate; FEPA and NWM5 Mapped wetland	
Level of assessment	Brief site assessment with wetland, vegetation	

Table 14. Characteristics and view of EWR 16

Site information		Photograph
EWR site	EWR 16	
Name	Papkuilsvlei	
Description	Wetland site in the upper Papkuils River	
River	Papkuils	
Quaternary	G30A	
Resource Unit (RU)	Upper Papkuils FP Wetland RU	
Coordinates	32°38'1.26"S; 18°29'56.29"E	
Ecological Importance	High; FEPA and NWM5 Mapped wetland; upstream Ramsar site	
Level of assessment	Brief site assessment with wetland, vegetation	

4. ECOCLASSIFICATION RESULTS

The EcoClassification results include the Ecological Importance and Sensitivity (EIS), Present Ecological Status (PES), Recommended Ecological Category (REC) and the Achievable Ecological Category (AEC) after considering the impacts and trends at the sites.

4.1. Estuary Ecoclassification

4.1.1. Verlorenvlei

Table 15. Estuarine Health Score (EHI) for the Verlorenvlei Estuary

Variable	Present (2022)	Present (Sim)	Present (Sim) without non-flow related impacts	Confidence
Hydrology	42	67	67	Very Low
Hydrodynamics and mouth condition	0	53	62	Medium
Water quality	22	43	43	Low
Physical habitat alteration	30	65	72	Medium
Habitat health score	24	57	61	
Microalgae	23	43	43	Low
Macrophytes	45	55	61	Medium
Invertebrates	10	50	53	Low
Fish	5	30	44	Medium
Birds	30	40	44	High
Biotic health score	23	44	49	
ESTUARY HEALTH SCORE	23	50	55	
PRESENT ECOLOGICAL STATUS	E	D	D	
OVERALL CONFIDENCE	Medium	Low	Low	

The EHI score for the estuary in the observed Present (2022) was estimated to be 23 (PES = E Category) due to the extended drought, which together with the abstraction of water, caused persistent long-term exposure of the lake margins and bed (very low water levels). Assuming that recovery is possible after lake levels increase again, an evaluation of the 101-year Present simulation scenario indicated an EHI score of 50 (PES = Category D).

The functional importance of the estuary was deemed to be high (80%), because of the system's importance as a roosting and foraging area for marine and coastal birds.

Table 16. Estimation of the functional importance score of the Verlorenvlei Estuary

Functional importance score	Score
a. Estuary: Input of detritus and nutrients generated in estuary	40
b. Nursery function for marine-living fish and crustaceans	60
c. Movement corridor for river invertebrates and fish breeding in sea	40
d. Roosting and foraging area for marine or coastal birds	80
e. Catchment detritus, nutrients and sediments to sea	20
Functional importance score - Max (a to e)	80

The EIS for Verlorenvlei Estuary, based on its present state, was therefore estimated to be 74, i.e., the estuary is rated as “Important” the estuary is rated as “Important”. It is a Ramsar site and a desired protected area in the Biodiversity Plan for the National Biodiversity Assessment

Table 17. Importance scores (EIS) for the Verlorenvlei Estuary

Criterion	Weight	Score
Estuary Size	15	70
Zonal Rarity Type	10	60
Habitat Diversity	25	70
Biodiversity Importance	25	82
Functional Importance	25	80
Weighted Estuary Importance Score		74

The Recommended Ecological Category for the estuary is its “Best Attainable State” i.e. a B Category. The existing Verlorenvlei Estuary Management Plan recommends at a minimum a B/C Category.

4.1.3. Wadrift

The EHI score for the estuary is estimated to be 46 (PES = D category) due to significant changes in the hydrology, mouth status, water quality, microalgae and bird fauna.

Table 18. Estuarine Health Score (EHI) for the Wadrift Estuary

Variable	Health score/100	Health score net of non-flow related impacts	Confidence
Hydrology	50	50	Low
Hydrodynamics and mouth condition	62	62	Low
Water quality	44	77	Low
Physical habitat alteration	50	90	Low
Habitat health score	52	70	Low
Microalgae	56	60	Low
Macrophytes	40	64	Medium
Invertebrates	40	58	Low
Fish	25	48	Low
Birds	45	48	High
Biotic health score	41	55	Low
ESTUARY HEALTH SCORE	46	63	Low
PRESENT ECOLOGICAL STATUS	D	C/D	
OVERALL CONFIDENCE	Low	Low	

The system's functional importance was deemed to be 70, because of its importance as a roosting foraging and/or nesting area for marine and coastal birds.

Table 19. Estimation of the functional importance score of the Wadrift estuary

Functional importance	Score
a) Export of organic material generated in the estuary (regional scale)	10
b) Nursery function for fish and crustaceans (marine /riverine)	10
c) Movement corridor for river invertebrates and fish breeding in sea	10
d) Roosting, foraging and/or nesting area for marine and coastal birds	70
e) Catchment detritus, nutrients and sediments to sea	10
Functional importance score - Max (a to e)	70

The EIS for the estuary, based on its present state, was therefore estimated to be 61, i.e., the estuary is rated as “Important”.

Table 20. Importance scores (EIS) for the Wadrift estuary

Criterion	Weight	Score
Estuary Size	15	70
Zonal Rarity Type	10	30
Habitat Diversity	25	60
Biodiversity Importance	25	60
Functional Importance	25	70
Weighted Estuary Importance Score		61

The REC for the estuary is a “C” Category or “Best attainable State” (BAS). The estuary does not have any statutory protection and is not included in the subset of estuaries identified as requiring protection to conserve South Africa’s estuarine biodiversity estate. However, the NBA 2018 Ecosystem Threat Status Assessment lists the system’s ecosystem type as “Endangered’ (Van Niekerk et al., 2019).

4.1.3. Jakkals Estuary

The EHI score for the estuary in its present state was estimated to be 53 (PES = D category) due to significant changes in the hydrology, mouth status, water quality, microalgae and bird fauna.

Table 21. Estuarine Health Score (EHI) for the Jakkals Estuary.

Variable	Health score/100	Health score net of non-flow related impacts	Confidence
Hydrology	44	44	Very Low
Hydrodynamics and mouth condition	49	49	Low
Water quality	56	72	Low
Physical habitat alteration	60	72	Low
Habitat health score	52	59	
Microalgae	49	49	Low
Macrophytes	60	64	Medium
Invertebrates	50	53	Low
Fish	50	60	Medium
Birds	55	60	Medium
Biotic health score	53	57	
ESTUARY HEALTH SCORE	53	58	
PRESENT ECOLOGICAL STATUS	D	C/D	
OVERALL CONFIDENCE	Low	Low	

The functional importance was deemed to be relatively high (40%), because of the estuary's relative importance as roosting, foraging and/or nesting area for marine and coastal birds.

Table 22. Estimation of the Functional importance score of the Jakkals Estuary

Functional importance	Score
a) Export of organic material generated in the estuary (regional scale)	20
b) Nursery function for fish and crustaceans (marine /riverine)	20
c) Movement corridor for river invertebrates and fish breeding in sea	20
d) Roosting, foraging and/or nesting area for marine and coastal birds	40
e) Catchment detritus, nutrients and sediments to sea	10
Functional importance score - Max (a to e)	40

The EIS for the Jakkals Estuary, based on its present state, was therefore estimated to be 29, i.e., the estuary is rated as of "Low to Average Importance".

Table 23. Importance scores (EIS) for the Jakkals Estuary

Criterion	Weight	Score
Estuary Size	15	20
Zonal Rarity Type	10	10
Habitat Diversity	25	30
Biodiversity Importance	25	30
Functional Importance	25	40
Weighted Estuary Importance Score		29

The Recommended Ecological Category for the Jakkals Estuary is thus a Category D (Largely modified) based on its importance. However, some efforts need to be made to prevent further trajectory downward and ensure the protection of ecosystem services, such as fish nursery function.

4.1.4. Sout (North) Estuary

The estuary was deemed to be highly degraded (PES = E category) due to road infrastructure, human disturbance and the salt works within the estuarine functional zone.

Table 24. Estuarine categories **for the** Sout **Estuary.**

Variable	Ecological Category
Hydrology	D/E
Hydrodynamics	E/F
Water quality	D
Physical habitat alteration	E
Habitat health	D/E
Microalgae	E
Macrophytes	E/F
Invertebrates	E
Fish	E/F
Birds	E
Biotic health	E
PRESENT ECOLOGICAL STATUS	E
OVERALL CONFIDENCE	Low

The functional importance was deemed to be important (60%).

Table 25. Estimation of the Functional importance score of the Sout **Estuary**

Functional importance	Score
Estuary derived detritus and nutrients to the sea	20
Nursery function for marine-living fish	0
Movement corridor for river invertebrates and fish breeding in sea	0
Contribute to a very limited wetland type habitat for estuarine and coastal birds along arid coast	60
Catchment sediments provided to the sea	20
Coastal connectivity (way point) for fish	0
Movement corridor for mammals (mongoose and otters)	20
Functional importance score - Max (a to g)	60

The EIS for the estuary, based on its present state, was therefore estimated to be 43, i.e., the estuary is rated as of “Average Importance”.

Table 26. Importance scores (EIS) for the Sout Estuary

Criterion	Weight	Score
Estuary Size	25	100
Zonal Rarity Type	25	30
Habitat Diversity	25	30
Biodiversity Importance	25	10
Functional Importance	25	60
Estuary Importance Score (Average)		43

The Recommended Ecological Category for the Sout Estuary is thus a Category D (Largely modified) based on its importance.

4.2. River and Wetland Ecoclassification

Below is a summary of the Ecoclassification results for the river and wetland EWR sites where the ecological categories and colour code shown below have been used:

Ecological Categories	Score (%)
Natural (A)	90-100
Largely Natural (B)	80-89
Moderately modified (C)	60-79
Largely modified (D)	40-59
Seriously modified (E)	20-39
Critically modified (F)	0-19

Table 27. Ecoclassification Results

EWR 7: Lower Jakkals

EIS: Moderate

PES: C/D Impacts due to abstraction of groundwater, agricultural and peri-urban activities. Impacts are largely flow related.

REC: B/C The EIS is moderate; therefore, the REC is an improvement of the PES. Need to restore some groundwater contribution to baseflow

AEC = C Better monitoring and management of groundwater use (particularly unauthorised use is required)

Site: Jakkals	
ECOSTATUS COMPONENT	**METRIC GROUP: CALCULATED RATING**
Hydrology	68.0
Water Quality	60.0
Geomorph	56.0
Driver score	**62.7**
Vegetation	55.0
Macroinvertebrates	37.0
Biotic Responses Score	**45.5**
Combined Ecostatus for Separate Component Assessments	**55.8**
River Habitat Integrity	**56.3**
Wetland Integrity	**62.0**
Overall Ecostatus Score	**58.0**
Overall Ecostatus Category	**C/D**
Trajectory of change	**Negative**
Confidence	**Medium/Low**

EWR 8: Lower Langvlei

EIS: Moderate

PES: E Impacts due to abstraction of groundwater, agricultural activities. Impacts are largely flow related.

REC: D The EIS is moderate; therefore, the REC is a slight improvement of the PES. Should be returned to a sustainable ecosystem functioning level. Need to restore the groundwater contribution to baseflow

AEC = REC Better monitoring and management of groundwater use (particularly unauthorised use is required)

Site:Langvlei	
ECOSTATUS COMPONENT	**METRIC GROUP: CALCULATED RATING**
Hydrology	36.0
Water Quality	45.0
Geomorph	42.0
Driver score	**39.8**
Vegetation	37.7
Macroinvertebrates	28.0
Fish	10.0
Biotic Responses Score	**27.5**
Combined Ecostatus for Separate Component Assessments	**34.9**
River Habitat Integrity	**41.5**
Wetland Integrity	**28.0**
Overall Ecostatus Score	**34.8**
Overall Ecostatus Category	**E**
Trajectory of change	**Negative**
Confidence	**Medium/Low**

EWR 10: Lower Kruismans

EIS: High due to downstream Ramsar site; refugia for endemic and endangered fishes

PES: D Impacts due to abstraction of groundwater, agricultural activities. Impacts are largely flow related.

REC: B/C The EIS is high; therefore, the REC is an improvement of the PES. Need to restore some groundwater contribution to baseflow as well as surface water runoff

AEC = C Better monitoring and management of water use (particularly unauthorised abstraction and storage use is required)

Site: Kruismans	
ECOSTATUS COMPONENT	**METRIC GROUP: CALCULATED RATING (%)**
Hydrology	39.0
Water Quality	50.0
Geomorph	63.0
Driver score	**48.5**
Vegetation	37.0
Macroinvertebrates	49.0
Fish	70.0
Biotic Responses Score	**49.3**
Combined Ecostatus for Separate Component Assessments	**48.8**
River Habitat Integrity	**54.5**
Wetland Integrity	**59.0**
Overall Ecostatus Score	**54.1**
Overall Ecostatus Category	**D**
Trajectory of change	**Negative**
Confidence	**Medium/Low**

EWR 11: Lower Krom Antonies

EIS: High due to downstream Ramsar site; refugia for endemic and endangered fishes

PES: C/D Impacts due to abstraction of groundwater, agricultural and peri-urban activities. Impacts are largely flow related.

REC: B/C The EIS is high; therefore, the REC is an improvement of the PES. Need to restore some groundwater contribution to baseflow

AEC = C Better monitoring and management of water use (particularly unauthorised abstraction and storage use is required)

Site: Krom Antonies	
ECOSTATUS COMPONENT	**METRIC GROUP: CALCULATED RATING**
Hydrology	55.0
Water Quality	60.0
Geomorph	56.8
Driver score	**56.7**
Vegetation	44.0
Macroinvertebrates	58.0
Fish	70.0
Biotic Responses Score	**54.8**
Combined Ecostatus for Separate Component Assessments	**55.9**
River Habitat Integrity	**58.1**
Wetland Integrity	**59.0**
Overall Ecostatus Score	**57.7**
Overall Ecostatus Category	**C/D**
Trajectory of change	**Negative**
Confidence	**Medium/Low**

EWR 12: Lower Verlorenvlei

EIS: High due to downstream Ramsar site; refugia for endemic and endangered fishes

PES: D Impacts due to abstraction of groundwater, agricultural activities. Impacts are largely flow related.

REC: B/C The EIS is high; therefore, the REC is an improvement of the PES. Need to restore some groundwater contribution to baseflow as well as surface water runoff

AEC = C Better monitoring and management of water use (particularly unauthorised abstraction and storage use is required)

Site: Verlorenvlei	
ECOSTATUS COMPONENT	**METRIC GROUP: CALCULATED RATING**
Hydrology	43.5
Water Quality	50.0
Geomorph	61.5
Driver score	**50.2**
Vegetation	57.8
Macroinvertebrates	44.0
Fish	70.0
Biotic Responses Score	**58.0**
Combined Ecostatus for Separate Component Assessments	**60.1**
River Habitat Integrity	**55.0**
Overall Ecostatus Score	**57.6**
Overall Ecostatus Category	**D**
Trajectory of change	**Negative**
Confidence	**Medium/Low**

EWR 15: Lower Papkuils

EIS: Moderate

PES: D Impacts due to abstraction of groundwater, agricultural activities. Impacts are largely flow related.

REC: C The EIS is moderate; therefore, the REC is a slight improvement of the PES. Need to restore some groundwater contribution to baseflow

AEC = REC Better monitoring and management of groundwater use (particularly unauthorised use is required)

Site: Papkuils	
ECOSTATUS COMPONENT	**METRIC GROUP: CALCULATED RATING**
Hydrology	57.0
Water Quality	70.0
Geomorph	37.0
Driver score	**54.4**
Vegetation	45.9
Fish	50.0
Biotic Responses Score	**43.0**
Combined Ecostatus for Separate Component Assessments	**49.8**
River Habitat Integrity	**56.4**
Wetland Integrity	**38.0**
Overall Ecostatus Score	**48.1**
Overall Ecostatus Category	**D**
Trajectory of change	**Negative**
Confidence	**Medium/Low**

Verlorenvlei Catchment

The combined EcoStatus for the Kruismans and downstream Verlorenvlei Rivers is a D Category (largely modified) while the integrity of the Krom Antonies River is slightly better and is a C/D Category (moderately to largely modified). The confidence in the results is medium to low due to a general shortage of data. All the rivers show a decreasing trend.

Langvlei Catchment

The combined EcoStatus for the Langvlei River is a D/E Category (largely to seriously modified). The confidence in the results is medium to low due to a general shortage of data. All the rivers show a decreasing trend.

Jakkals Catchment

The combined EcoStatus for the Jakkals River is a C/D Category (moderately to largely modified). The confidence in the results is medium to low due to a general shortage of data. All the rivers show a decreasing trend.

Papkuils Catchment

The combined EcoStatus for the Papkuils River is a C/D Category (moderately to largely modified). The confidence in the results is medium to low due to a general shortage of data. All the rivers show a decreasing trend.

Sandlaagte, Sout and Brak Rivers

River	Instream Integrity Score	Riparian Integrity Score	Ecostatus	Ecological Category
Brak	82	82	82	B
Klein Goerap	77	75	76	C
Groot Goerap	74	73	74	C
Sout	71	69	70	C
Sandlaagte	61	54	58	C/D

The rivers in the F60 Catchment are in a largely natural to moderately modified ecological condition, with mostly just localised impacts. There is, however, significant agricultural activity and groundwater use in the upper Sandlaagte River in G30H that has modified the river, particularly in its upper reaches.

MEDIUM to LOW levels of confidence in the EcoClassification results in the catchments was attributed to the lack of monitored flow and water quality data primarily. Due to the arid nature of the rivers in the area, there is also a high degree of variability, and the amount of biological data is also limited.

5. EWR RESULTS

5.1. Estuary EWRs

5.1.1. Verlorenvlei Estuary

The Best Attainable State for the Verlorenvlei Estuary without significant restoration interventions is a C Category. While this represents a significant improvement on the observed PES (2022), attaining the REC would require restoring flow to the system (82.6% to remain in the system) and improving the water quality, as well as addressing some of the existing non-flow related issues affecting the estuary.

Table 28. Summary of the monthly flow (distribution in Mm^3) for Verlorenvlei Estuary for REC=C Category

%ile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	10.52	5.70	2.19	0.66	0.47	0.62	7.55	26.54	63.09	75.00	44.29	25.86
95%	7.02	4.22	1.26	0.42	0.22	0.26	0.97	11.76	27.65	25.96	29.00	15.22
90%	6.07	3.67	1.02	0.37	0.17	0.15	0.47	7.92	19.63	17.19	23.22	12.42
80%	4.83	2.37	0.72	0.29	0.13	0.11	0.24	1.67	6.84	10.54	11.21	7.48
70%	4.09	2.12	0.61	0.25	0.11	0.08	0.18	1.03	5.36	6.79	8.79	6.56
60%	3.86	1.79	0.55	0.23	0.11	0.08	0.13	0.55	3.98	5.19	6.78	5.73
50%	3.41	1.65	0.49	0.21	0.09	0.06	0.10	0.47	2.75	4.51	5.85	5.15
40%	3.27	1.47	0.46	0.20	0.09	0.06	0.09	0.37	1.66	4.10	5.16	4.54
30%	2.79	1.27	0.40	0.18	0.08	0.05	0.07	0.23	1.29	3.22	4.54	4.20
20%	2.50	1.06	0.35	0.16	0.08	0.05	0.06	0.17	0.87	2.28	3.56	3.40

10%	1.93	0.82	0.27	0.13	0.06	0.04	0.05	0.13	0.61	1.72	2.93	2.80
5%	1.69	0.65	0.22	0.11	0.06	0.03	0.03	0.07	0.31	1.29	2.57	2.72
Min	0.85	0.37	0.13	0.09	0.05	0.03	0.02	0.04	0.17	0.44	1.02	1.27

5.1.2. Wadrift Estuary

The REC for the Wadrift Estuary is a C Category, representing a significant improvement on the PES. Attaining this state would require restoring a certain amount of flow to the system (77% to remain in the system) as well as addressing some of the existing non-flow related issues affecting the estuary.

Table 29. Summary of the monthly flow (distribution in Mm^3) for Wadrift Estuary for REC=C Category

%ile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	0.65	1.84	0.56	0.05	0.00	0.04	1.52	7.82	16.25	23.38	9.13	2.06
95%	0.20	0.01	0.00	0.00	0.00	0.00	0.13	2.56	5.41	4.40	2.63	0.87
90%	0.06	0.00	0.00	0.00	0.00	0.00	0.04	0.86	2.58	2.24	1.46	0.52
80%	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.66	1.17	0.75	0.23
70%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.76	0.71	0.46	0.14
60%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.56	0.55	0.28	0.09
50%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.33	0.21	0.05
40%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.24	0.14	0.02
30%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.13	0.08	0.00
20%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00
10%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00
5%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00

5.1.3. Jakkals Estuary

The REC for the Jakkals Estuary is a D Category, which requires the maintenance of its present state, i.e. PES D Category. Thus, it was agreed that the flow requirements for the estuary are the same as those described for the Present (57% to remain in the system).

Table 30. Summary of the monthly flow (distribution in Mm^3) for Jakkals Estuary for REC=D Category

%ile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Max	0.12	0.85	0.22	0	0	0	0.38	3.12	7.36	9.8	5.49	0.75	16.72
95%	0	0	0	0	0	0	0.08	0.85	2.01	1.59	0.99	0.42	4.45
90%	0	0	0	0	0	0	0	0.36	0.97	0.81	0.56	0.18	3.7
80%	0	0	0	0	0	0	0	0.05	0.57	0.45	0.17	0.02	1.73
70%	0	0	0	0	0	0	0	0	0.22	0.21	0.1	0	1.14
60%	0	0	0	0	0	0	0	0	0.13	0.12	0.03	0	0.7
50%	0	0	0	0	0	0	0	0	0.08	0.05	0	0	0.43
40%	0	0	0	0	0	0	0	0	0	0	0	0	0.25
30%	0	0	0	0	0	0	0	0	0	0	0	0	0.14
20%	0	0	0	0	0	0	0	0	0	0	0	0	0.06

10%	0	0	0	0	0	0	0	0	0	0	0	0	0
5%	0	0	0	0	0	0	0	0	0	0	0	0	0
Min	0	0	0	0	0	0	0	0	0	0	0	0	0

5.2. River and Wetland EWRs

The EWR results are provided for the rivers in the tables on the following pages. The EWR is expressed as both m^3/s (median value) and the depth at the EWR site due to the high level of uncertainty in the hydrology and the groundwater contribution to surface water flow, particularly during the low flow months (December to April).

Table 31. EWR 7 Lower Jakkals: EWR results for PES and REC

Month	PES (C/D)		REC (C)		AEC (D)	
	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)
October	0.000	0.000	0.017	0.350	0.009	0.350
November	0.000	0.000	0.026	0.360	0.015	0.350
December	0.000	0.000	0.021	0.360	0.012	0.350
January	0.000	0.000	0.015	0.350	0.008	0.350
February	0.000	0.000	0.015	0.350	0.008	0.350
March	0.000	0.000	0.015	0.350	0.008	0.350
April	0.000	0.000	0.034	0.360	0.021	0.360
May	0.000	0.000	0.067	0.370	0.034	0.360
June	0.031	0.360	0.104	0.380	0.065	0.370
July	0.019	0.350	0.399	0.420	0.271	0.400
August	0.000	0.000	0.181	0.390	0.12	0.380
September	0.000	0.000	0.067	0.370	0.043	0.360

Table 32. EWR 8 Lower Langvlei: EWR results for PES and REC

Month	PES (E)		REC & AEC (D)	
	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)
October	0.000	0.000	0.025	0.130
November	0.000	0.000	0.032	0.130
December	0.000	0.000	0.02	0.120
January	0.000	0.000	0.016	0.110
February	0.000	0.000	0.014	0.110
March	0.000	0.000	0.014	0.110
April	0.000	0.000	0.041	0.140
May	0.000	0.000	0.101	0.170
June	0.104	0.180	0.145	0.190
July	0.105	0.180	0.591	0.270
August	0.060	0.150	0.439	0.250
September	0.008	0.090	0.18	0.200

Table 33. EWR 10 Lower Kruismans: EWR results for PES and REC

Month	PES (D)		REC (B/C)		AEC (C)	
	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)
October	0.638	0.810	1.708	1.030	1.229	0.940
November	0.309	0.690	0.987	0.900	0.608	0.800
December	0.123	0.580	0.46	0.750	0.234	0.650
January	0.063	0.520	0.334	0.700	0.17	0.620
February	0.037	0.490	0.225	0.650	0.114	0.570
March	0.019	0.450	0.215	0.640	0.11	0.570
April	0.019	0.450	0.249	0.660	0.127	0.590
May	0.071	0.530	0.919	0.880	0.650	0.810
June	0.471	0.750	2.479	1.130	1.994	1.070
July	0.680	0.820	1.756	1.030	1.254	0.950
August	1.038	0.910	3.932	1.280	3.198	1.220
September	1.003	0.900	1.831	1.050	1.292	0.960

Table 34. EWR 11 Lower Krom Antonies: EWR results for PES and REC

Month	PES (C/D)		REC (B/C)		AEC (C)	
	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)
October	0.161	0.640	0.389	0.810	0.238	0.700
November	0.066	0.560	0.222	0.690	0.113	0.600
December	0.019	0.510	0.091	0.580	0.037	0.520
January	0.011	0.500	0.075	0.570	0.031	0.520
February	0.012	0.500	0.045	0.520	0.018	0.510
March	0.007	0.500	0.044	0.520	0.018	0.510
April	0.004	0.490	0.051	0.520	0.021	0.510
May	0.007	0.500	0.207	0.680	0.116	0.600
June	0.046	0.520	0.664	1.000	0.482	0.880
July	0.217	0.680	0.506	0.890	0.319	0.760
August	0.317	0.760	1.247	1.330	0.917	1.160
September	0.266	0.720	0.509	0.890	0.32	0.760

Table 35. EWR 12 Lower Verlorenvlei: EWR results for PES and REC

Month	PES (D)		REC (B/C)		AEC (C)	
	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)
October	1.094	1.060	2.915	1.280	1.905	1.180
November	0.637	0.950	1.353	1.100	0.819	1.000
December	0.183	0.750	0.474	0.900	0.242	0.790
January	0.078	0.640	0.352	0.850	0.175	0.740
February	0.037	0.550	0.24	0.790	0.115	0.690
March	0.022	0.500	0.23	0.780	0.109	0.680
April	0.039	0.560	0.263	0.800	0.127	0.700
May	0.175	0.740	2.424	1.240	0.794	1.140
June	1.061	1.050	5.187	1.430	3.528	1.330
July	1.684	1.150	3.141	1.300	2.053	1.200
August	2.184	1.210	8.538	1.580	5.839	1.470
September	1.987	1.190	3.193	1.300	2.081	1.200

Table 36. EWR 15 Lower Papkuils: EWR results for PES and REC

Month	PES (D)		REC (C)		AEC (D)	
	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)
October	0.000	0.350	0.033	0.500	0.021	0.510
November	0.000	0.350	0.031	0.510	0.021	0.510
December	0.000	0.350	0.030	0.510	0.020	0.500
January	0.000	0.350	0.025	0.480	0.016	0.480
February	0.000	0.350	0.025	0.480	0.016	0.480
March	0.000	0.350	0.025	0.480	0.016	0.480
April	0.000	0.350	0.065	0.560	0.051	0.540
May	0.007	0.520	0.073	0.660	0.071	0.620
June	0.035	0.640	0.562	0.800	0.489	0.730
July	0.037	0.650	0.211	0.680	0.165	0.650
August	0.019	0.580	0.332	0.760	0.279	0.710
September	0.008	0.520	0.139	0.650	0.112	0.610

EWR tables and rule files were then generated for each of the EWR river sites and are summarised in the table below.

Table 37. Summary of the EWRs at the EWR sites for the REC and AEC

Site	Natural	Present day		EWR						
	nMAR	MAR	PES	REC/ AEC	Low Flow EWR		High Flow EWR		Total EWR Flow	
	10^6 m^3	10 m^3			10^6 m^3	% MAR	10^6 m^3	% MAR	10^6 m^3	% MAR
EWR 7	2.315	1.24	C/D	C	0.269	11.63	0.780	33.68	1.049	45.32
				D	0.140	6.04	0.545	23.54	0.685	29.58
EWR 8	8.955	7.08	E	D	0.420	4.69	1.298	14.49	1.718	19.18
EWR 10	27.813	18.97	D	B/C	7.143	25.68	8.253	29.67	15.396	55.35
				C	3.638	13.08	7.641	27.47	11.279	40.55
EWR 11	7.318	5.14	C/D	B/C	1.749	23.90	2.400	32.80	4.149	56.70
				C	0.710	9.70	2.020	27.60	2.730	37.30
EWR 12	49.702	33.36	D	B/C	7.318	14.72	20.991	42.23	28.309	56.96
				C	3.789	7.62	14.828	29.83	18.617	37.46
EWR 15	1.378	1.19	D	C	0.196	14.2	0.289	20.97	0.485	35.18
				C/D	0.123	8.95	0.272	19.77	0.395	28.72

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