DEPARTMENT: WATER AFFAIRS
CHIEF DIRECTORATE: RESOURCE DIRECTED MEASURES

THE CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE OLIFANTS-DOORN WATER MANAGEMENT AREA (WMA 17)

DRAFT RECOMMENDED SCENARIO REPORT

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ACRONYMS

DSLF	Dry Season Low Flow
DSS	Decision Support System
DWA	Department of Water Affairs (previously DWAF)
EC	Ecological Category
EGSA	Ecosystem Goods, Services and Attributes
EIS	Ecological Importance and Sensitivity
EISC	Ecological Importance and Sensitivity Category
ESBC	Ecological Sustainability Base Configuration
EWR	Ecological/Environmental Water Requirements
I&AP	Interested and Affected Parties
IFR	Instream Flow Requirement
IUA	Integrated Units of Analysis
IWRM	Integrated Water Resource Management
MAR	Mean Annual Runoff
MC	Management Class
nMAR	Naturalised Mean Annual Runoff
NWA	National Water Act
PES	Present Ecological Status
PESC	Present Ecological Status Category
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RWQO	Resource Water Quality Objective
SANBI	South African National Biodiversity Institute
WMA	Water Management Area
WRCS	Water Resource Classification System

GLOSSARY

Catchment configuration: A set of ecological categories (ECs) within a catchment for each nodal reach representing a significant water resource.

Ecostatus: The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and it capacity to provide a variety of goods and services (Kleynhans *et al.* 2005).

Environmental Water Requirements: An allocation of water with a prescribed distribution in space and time, and of a specific quality, that is deliberately left in a river or released into it, to manage river health and the integrity of ecosystems and communities sustained by river flows.

Habitat Integrity: A measure of the extent or degree to which the integrated composition of physico-chemical and habitat characteristics is maintained on scale that is comparable with the characteristics under natural conditions. Habitat integrity can be used as a surrogate for Ecostatus (Kleynhans *et al.* 2005).

Integrated Unit of Analysis (IUA) class: The desired condition or characteristics of a resource and concomitantly, the degree to which it can be utilised. It may range from minimally to heavily used, depending on societal requirements. The IUA Class is a summary condition recommended for a configuration of water resources within an IUA and between IUAs in a catchment.

Nodes: These are modelling points representative of an upstream reach or area of an aquatic ecosystem (rivers, wetlands, estuaries and groundwater) for which a suite of relationships apply.

Nodal reaches: the upstream reach or area of an aquatic ecosystem as represented by nodes.

Present Ecological State: the current state or condition of a resource in terms of its various biophysical components, i.e. drivers (physico-chemical, geomorphology, and hydrology and biological responses (i.e. fish, riparian vegetation and aquatic invertebrates).

Reserve: The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water of 25 litres per person per day and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in the National Water Act (Act No. 36 of 1998).

Significant Water Resources: Water resources that are deemed to be significant from a water resource use perspective, and/or for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in their quality and quantity of water.

1. INTRODUCTION

This report is part of a project to classify the Water Resources of the Olifants Doorn Water Management Area. The Olifants/Doorn WMA is located on the west coast of South Africa, extending from about 100 km to 450 km north of Cape Town. The south-western portion mainly falls within the Western Cape Province, and the north-eastern portion falls within the Northern Cape Province. The WMA incorporates the E primary drainage region and components of the F and G drainage regions along the coastal plain, respectively north and south of the Olifants River estuary, covering a total area of 56 446 km^2. The major river in the WMA is the Olifants River, of which the Doring River (draining the Koue Bokkeveld and Doring area) and the Sout River (draining the Knersvlakte) are the main tributaries. The Olifants and Doring Rivers flow strongly during the winter months whilst flows only occur very occasionally in the Sout River. There are also a number of smaller coastal rivers and water courses which flow infrequently.

The Water Resource Classification System (WRCS) is used (via a described Classification Process) to define a set of categories that describe the condition of aquatic ecosystems. The classification process entails a seven step classification process (Figure 1.2) during which the social, economic and environmental implications of different class scenarios and a configuration in the catchment are investigated and the consequences communicated to the users and stakeholders in the catchment. The users and stakeholders are then consulted in terms of each of these scenarios in order to recommend a class configuration and scenario to the DWA delegated authority responsible for classification for approval.

The Management Class (MC) of an aquatic ecosystem will reflect the future desired condition or health of the system, and will be used to guide the amount and quality of water to be reserved for that ecosystem. Deciding on the MC of a system will involve consideration of a broad range of issues and a set of related processes that will include water resource planning, catchment management planning as well as the Classification Process itself. It is important to understand that the product of a Classification Process is the assignment of a management class to water resources within a catchment, i.e. rivers, wetlands, groundwater and estuary. This outcome may influence the water yield that can be utilised from the resources, and indirectly activities within the catchment, such as land use.

Table 1.1: Water resource management classes

Class I: Minimally used
The configuration of water resources within a catchment results in an overall water resource condition that is minimally altered from its pre-development condition.
Class II: Moderately used
The configuration of water resources within a catchment results in an overall water resource condition that is moderately altered from its pre-development condition.
Class III: Heavily used
The configuration of water resources within a catchment results in an overall water resource condition that is significantly altered from its pre-development condition.

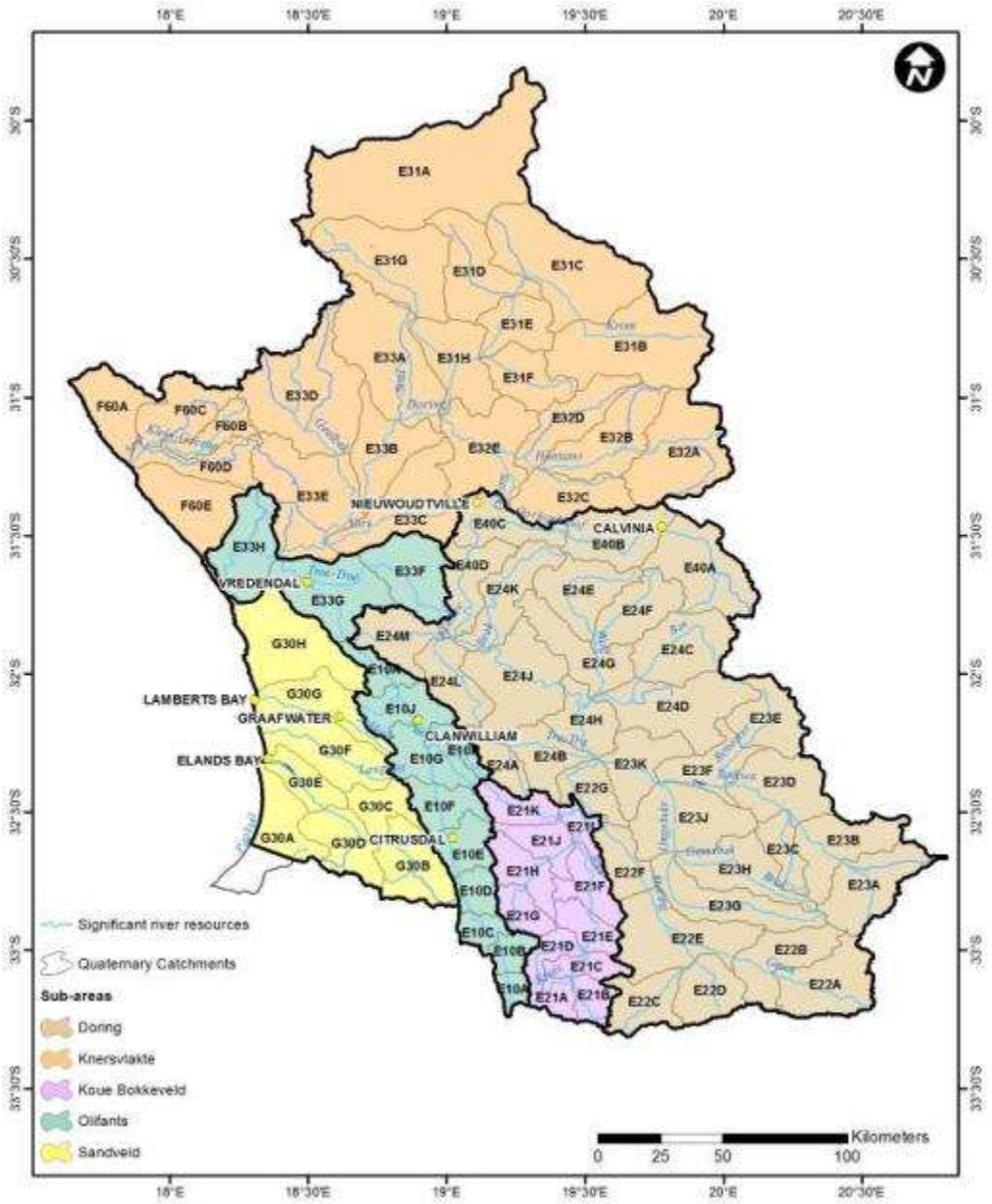

Figure 1.1: The Olifants/Doorn Water Management Area and Sub-areas

The report focuses on Step 4 of the Classification Process, that is, the testing of various catchment configuration scenarios, in terms of their hydrological feasibility in order to generate a recommended catchment configuration that can be evaluated in terms of its socio-economic and ecological implications as well as its acceptability to the stakeholders in the catchment. Step 4 includes the following:

a. Define non-negotiable constraints (national- and regional-level constraints and second-level constraints),
b. Screen catchment configurations for hydrological feasibility,
c. Describe the catchment sustainability baseline configuration scenario for catchment,
d. Discard/adjust non-feasible configurations, and
e. Group river nodes into IUA.

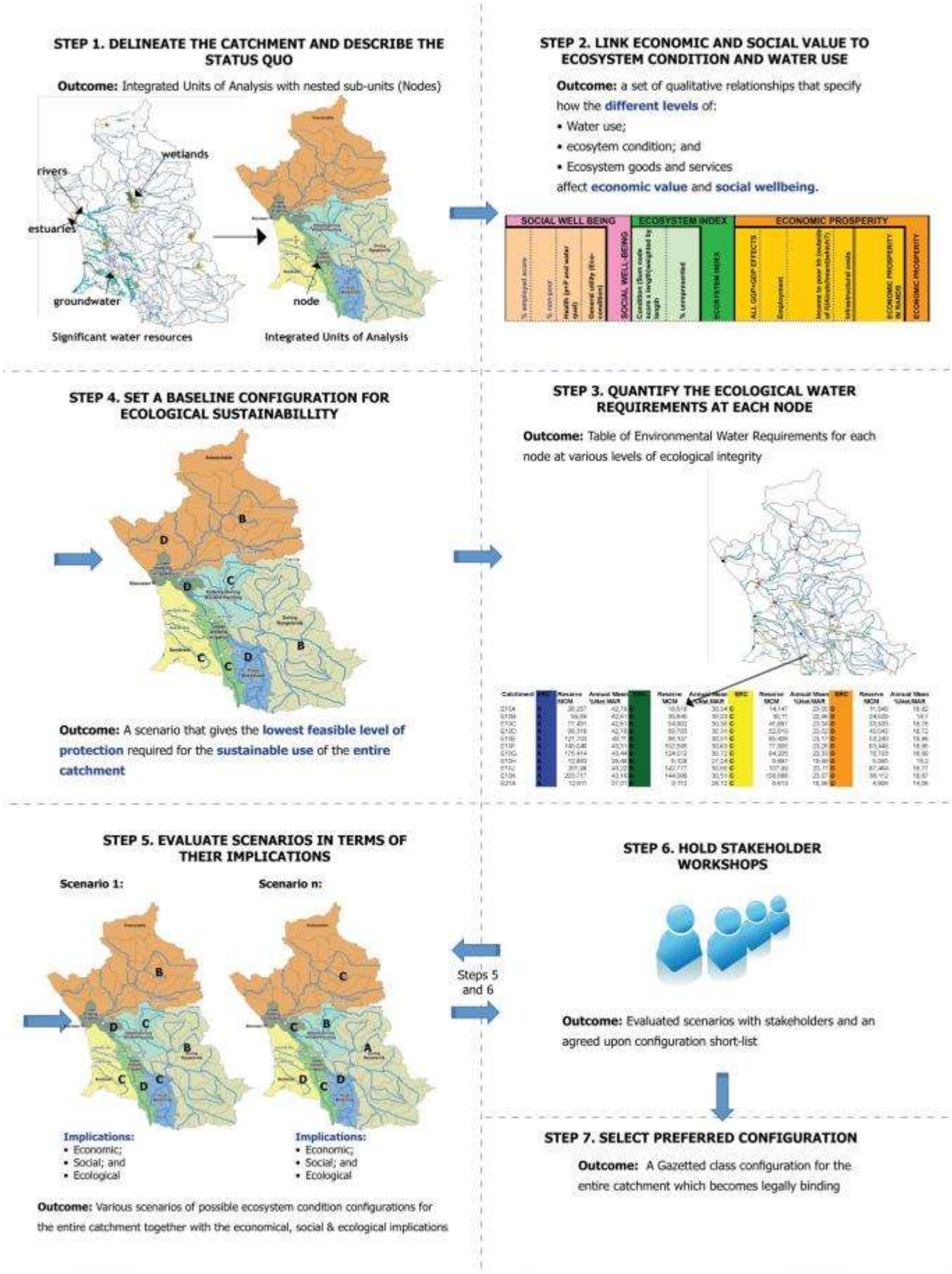

Figure 1.2: A simplified diagram of the seven-step procedure for recommending the Class of a water resource

2. RIVER NODES AND INTEGRATED UNITS OF ANALYSIS

A multi-tiered approach for establishing the location and number of the river nodes within a study catchment is recommended (Figure 2.1), as it allows for consideration of a suite of characteristics that dictate the ecological nature of rivers at different scales.

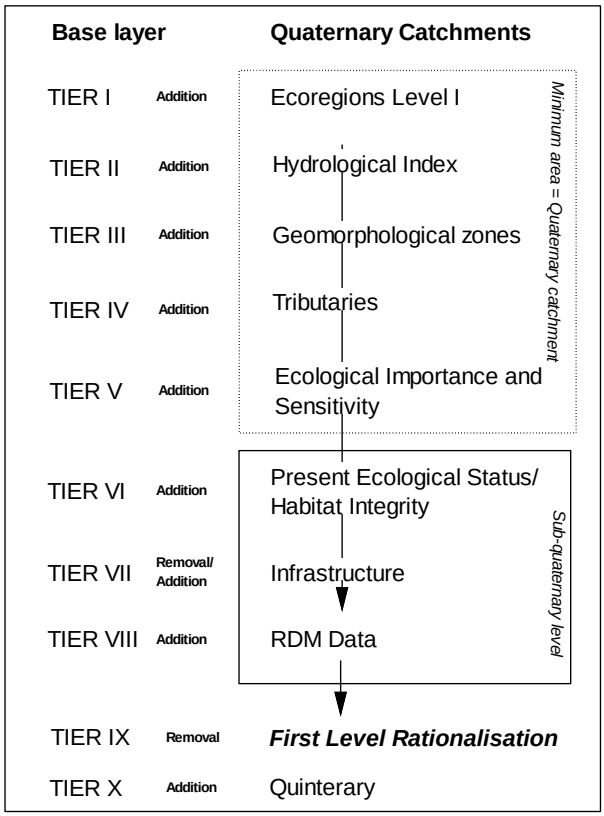

Figure 2.1: Summary of the procedure of river node establishment

The primary aim in defining the nodes is to delineate a network of significant resources that will form the basis of a classification procedure in a catchment. The nodes are located at the end-points of ecosystem reaches (normally at the exit point to a quaternary catchment) that will allow for various development or water use scenarios that can accommodate trade-offs between different parts of the catchment in terms of the quantity (volume and distribution) and quality of water that remains in the aquatic ecosystem(s) versus that which is available for use. A total of 55 river nodes (R1 to R58 were selected but 3 nodes were rationalised) were selected for the Olifants/Doring catchment (Figure 2.2). A summary of the river nodes is listed in Table 2.1.

Table 2.1 Final River nodes

QUAT	NODE	ECOREGION	HYDRO INDEX	GEOMORPHIC ZONE	ALTITUDE	RIVER	EISC	PESC	REC	RDM DATA	RESERVE REGION	SURFACE/WATER INTERACTION
E10A	R47	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	600-800	Olifants	High	C: Moderately Modified	Class C: Moderately Modified	Desktop	W Cape (wet)	High
E10B	R44	Western Folded Mountains	Perennial	Lower Foothill	400-600	Olifants	High	C: Moderately Modified	Class B: Largely Natural	Desktop	W Cape (wet)	High
E10C	R42	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	0-200	Olifants	Very High	B: Largely Natural	Class B: Largely Natural	Extrapolated	W Cape (wet)	Low
E10D	R40	Western Folded Mountains	Perennial	Lower Foothill	0-200	Olifants	Moderate	C: Moderately Modified	Class B: Largely Natural	Extrapolated	W Cape (wet)	High
E10E	R33	Western Folded Mountains	Perennial	Lower Foothill	0-200	Olifants	Moderate	D: Largely Modified	Class B: Largely Natural	EWR site 1	W Cape (wet)	High
E10G	R34	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	0-200	Rondegat	Moderate	B: Largely Natural	Class B: Largely Natural	EWR site 3	W Cape (wet)	Medium
E10H	R24	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	200-400	Jan Dissels	Moderate	D: Largely Modified	Class B: Largely Natural	Extrapolated	W Cape (dry)	High
E10J	R23	Western Folded Mountains	Perennial	Lower Foothill	0-200	Olifants	Moderate	D: Largely Modified	Class B: Largely Natural	Extrapolated	W Cape (wet)	High
E10K	R13	Western Folded Mountains	Perennial	Lower Foothill	0-200	Olifants	Moderate	E - F: Not Acceptable	Class E - F: Not An Acceptable Class	EWR site 2	W Cape (wet)	High
E21A	R48	Western Folded Mountains	Perennial	Lower Foothill	800-1000	Kruis	Low	E - F: Not Acceptable	Class C: Moderately Modified	Desktop	W Cape (dry)	High
E21B	R49	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	800-1000	Welgemoed	Low	E - F: Not Acceptable	Class B: Largely Natural	Desktop	W Cape (dry)	High
E21C	R46	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	800-1000	Winkelhaak	Low	E - F: Not Acceptable	Class C: Moderately Modified	Desktop	W Cape (dry)	High
E21D	R45	Western Folded Mountains	Perennial	Rejuvenated Floodplain	800-1000	Houdenbeks	Low	E - F: Not Acceptable	Class B: Largely Natural	Desktop	W Cape (dry)	High
E21E	R43	Western Folded Mountains	Perennial	Rejuvenated Floodplain	800-1000	Riet	Low	B: Largely Natural	Class B: Largely Natural	Desktop	W Cape (dry)	High
E21F	R39	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	400-600	Riet	Low	B: Largely Natural	Class B: Largely Natural	Extrapolated	W Cape (dry)	High
E21G	R41	Western Folded Mountains	Perennial	Lower Foothill	600-800	Leeu	Low	B: Largely Natural	Class B: Largely Natural	Desktop	W Cape (dry)	High
E21J	R38	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	400-600	Groot	Low	B: Largely Natural	Class B: Largely Natural	EWR site 6	W Cape (dry)	Low
E21L	R37	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	200-400	Groot	Low	B: Largely Natural	Class B: Largely Natural	Desktop	W Cape (dry)	Low
E22D	R50	Great Karoo	Ephemeral	Mnt Stream/Upper Foothill	400-600	no name	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	Low
E22F	R36	Great Karoo	Ephemeral	Lower Foothill	200-400	Doring	Low	B: Largely Natural	Class B: Largely Natural	Desktop	West Karoo	Low
E22G	R28	Western Folded Mountains	Seasonal	Lower Foothill	200-400	Doring	Very High	B: Largely Natural	Class B: Largely Natural	Extrapolated	W Cape (dry)	Low
E23D	R32	Great Karoo	Ephemeral	Lower Foothill	200-400	Tankwa	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	Low
E23E	R31	Great Karoo	Ephemeral	Mnt Stream/Upper Foothill	200-400	Renoster	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	High
E23F	R29	Great Karoo	Ephemeral	Lower Foothill	200-400	Tankwa	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	Low
E23J	R30	Great Karoo	Ephemeral	Lower Foothill	200-400	Ongeluks	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	Low
E23K	R27	Great Karoo	Ephemeral	Lower Foothill	0-200	Tankwa	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	Low

Table 2.1 *cont.:* Final River nodes

QUAT	NODE	ECOREGION	HYDRO INDEX	GEOMORPHIC ZONE	ALTITUDE	RIVER	EISC	PESC	REC	RDM DATA	RESERVE REGION	SURFACE/WATER INTERACTION
E24A	R25	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	400-600	Tra-Tra	Low	B: Largely Natural	Class B: Largely Natural	Desktop	West Karoo	High
E24B	R26	Western Folded Mountains	Seasonal	Mnt Stream/Upper Foothill	0-200	Tra-Tra	Low	B: Largely Natural	Class B: Largely Natural	Desktop	West Karoo	High
E24D	R21	Great Karoo	Ephemeral	Mnt Stream/Upper Foothill	0-200	Bos	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	High
E24G	R22	Great Karoo	Ephemeral	Mnt Stream/Upper Foothill	200-400	Wolf	Low	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	High
E24H	R20	Western Folded Mountains	Seasonal	Lower Foothill	0-200	Doring	High	B: Largely Natural	Class B: Largely Natural	Extrapolated	W Cape (dry)	High
E24J	R19	Western Folded Mountains	Seasonal	Lower Foothill	0-200	Doring	High	B: Largely Natural	Class B: Largely Natural	EWR site 4	W Cape (dry)	High
E24K	R16	Western Folded Mountains	Seasonal	Lower Foothill	0-200	Doring	High	C: Moderately Modified	Class B: Largely Natural	Extrapolated	W Cape (dry)	Medium
E24L	R15	Western Folded Mountains	Seasonal	Mnt Stream/Upper Foothill	0-200	Brandewyn	High	C: Moderately Modified	Class E - F: Not An Acceptable Class	EWR site 5	W Cape (dry)	Medium
E24M	R14	Western Folded Mountains	Seasonal	Lower Foothill	0-200	Doring	High	C: Moderately Modified	Class E - F: Not An Acceptable Class	Extrapolated	W Cape (dry)	Medium
E31E	R2	Nama Karoo	Ephemeral	Lower Foothill	400-600	Krom	Moderate	C: Moderately Modified	Class C: Moderately Modified	Desktop	West Karoo	High
E31G	R1	Nama Karoo	Ephemeral	Mnt Stream/Upper Foothill	600-800	Rooiwater Laagte	Moderate	C: Moderately Modified	Class C: Moderately Modified	Desktop	West Karoo	High
E32C	R4	Great Karoo	Seasonal	Mnt Stream/Upper Foothill	200-400	Hantams	Moderate	C: Moderately Modified	Class D: Largely Modified	Desktop	West Karoo	High
E32E	R3	Western Coastal Belt	Ephemeral	Lower Foothill	0-200	Doring	Moderate	C: Moderately Modified	Class A: Unmodified, Natural	Desktop	West Karoo	High
E33B	R5	Western Coastal Belt	Ephemeral	Lower Foothill	0-200	Sout	Moderate	C: Moderately Modified	Class D: Largely Modified	Desktop	West Karoo	High
E33E	R8	Western Coastal Belt	Ephemeral	Lower Foothill	0-200	Sout	Moderate	C: Moderately Modified	Class D: Largely Modified	Desktop	West Karoo	Low
E33G	R7	Western Coastal Belt	Perennial	Lower River	0-200	Olifants	Moderate	D: Largely Modified	Class D: Largely Modified	Desktop	W Cape (wet)	Low
E33H	R9	Western Coastal Belt	Perennial	Lower Foothill	0-200	Olifants	Moderate	D: Largely Modified	Class D: Largely Modified	Desktop	West Karoo	High
E40B	R12	Great Karoo	Ephemeral	Lower Foothill	600-800	Oorlogskloof	Moderate	C: Moderately Modified	Class E - F: Not An Acceptable Class	Desktop	West Karoo	High
E40C	R11	Western Folded Mountains	Ephemeral	Lower Foothill	0-200	Oorlogskloof	High	B: Largely Natural	Class D: Largely Modified	Desktop	West Karoo	High
E40D	R17	Western Folded Mountains	Ephemeral	Lower Foothill	0-200	Koebee	High	C: Moderately Modified	Class B: Largely Natural	Desktop	West Karoo	High
F60D	R 58	Western Coastal Belt	Ephemeral	Lower Foothill	0-200	Sout	Moderate	C: Moderately Modified	Class C: Moderately Modified	Desktop	West Karoo	Low
G30A	R 51	South Western Coastal Belt	Ephemeral	Lower Foothill	0-200	Papkuil	High	B: Largely Natural	Class B: Largely Natural	Desktop	West Karoo	Low
G30B	R 55	South Western Coastal Belt	Perennial	Mnt Stream/Upper Foothill	0-200	Kruismans	Moderate	C: Moderately Modified	Class C: Moderately Modified	EWR site	W Cape (dry)	High
G30C	R 54	Western Folded Mountains	Perennial	Mnt Stream/Upper Foothill	0-200	Bergvallei	Moderate	C: Moderately Modified	Class C: Moderately Modified	Desktop	W Cape (dry)	High
G30D	R 53	South Western Coastal Belt	Perennial	Upper Foothill	0-200	Verlorenvlei	Moderate	C: Moderately Modified	Class C: Moderately Modified	Desktop	W Cape (dry)	Low
G30E	R 52	Western Coastal Belt	Seasonal	Lower Foothill	0-200	Verlorenvlei	High	B: Largely Natural	Class C: Moderately Modified	EWR site	W Cape (dry)	Medium
G30F	R 56	South Western Coastal Belt	Ephemeral	Upper Foothill	0-200	Langvlei	High	B: Largely Natural	Class C: Moderately Modified	EWR site	West Karoo	Low
G30G	R 57	Western Coastal Belt	Ephemeral	Upper Foothill	0-200	Jakkals	Low	D: Largely Modified	Class C: Moderately Modified	EWR site	West Karoo	Low

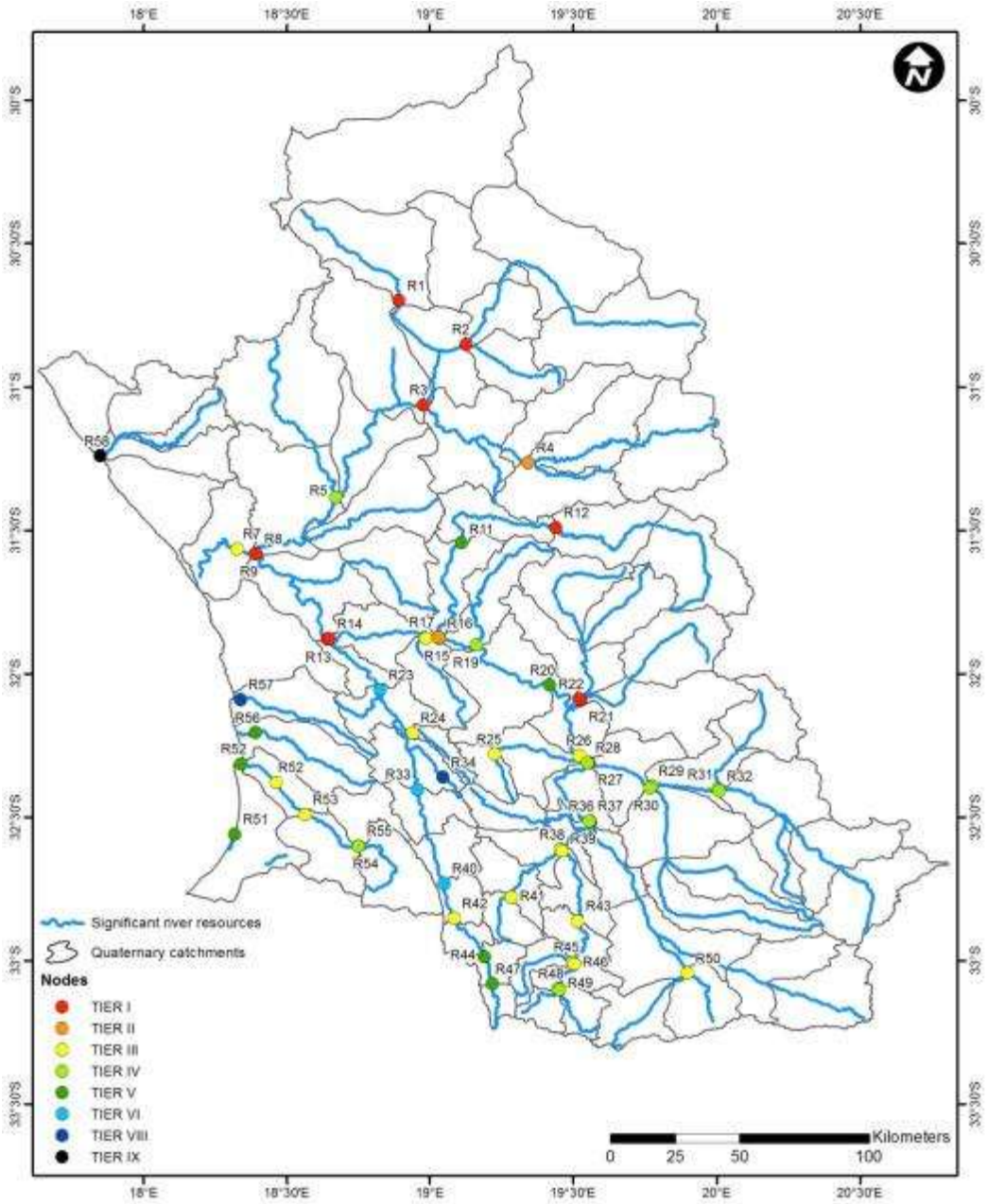

Figure 2.2: Final river nodes for the Olifants Doorn WMA

The Integrated Units of Analysis (IUAs) are a combination of the socio-economic zones and watershed boundaries, within which ecological information will be provided at a finer (node) scale Figure 2.3. The Olifants Doorn Water Management Area (WMA) has long been divided, from a water resources management point of view, into sub-areas that are based on considerations of land as well as water use. These sub-areas are also relatively homogenous socio-economic zones and represent similar aquatic ecological characteristics.

As the areas have been delimited to quaternary catchment boundaries and are at a sufficiently fine scale to approximate socio-economic zonal boundaries, they have the potential to facilitate the integration of ecological and socio-economic aspects that is required in the classification procedure. These areas have thus formed the basis in the delineation of Integrated Units of Analysis (IUAs) for the Olifants Doorn WMA classification procedure, where some of the original sub-areas (that is the Koue Bokkeveld, Doring Rangelands, Knersvlakte, Olifants and Sandveld) were further divided to further facilitate the classification procedure for the WMA.

The IUAs that have been identified through the classification procedure for the WMA consist of the following areas:

- The Koue Bokkeveld area consists of 11 quaternary catchments (E21A-L),
- The Doring Rangelands consists of 27 quaternary catchments (E22A-G, E23A-K, E24A-H, E40A-B),
- The Knersvlakte consists of 24 quaternary catchments (E31A-H, E32A-E, E33A-F, F60A-E),
- The Upper Olifants Irrigation area consists of ten quaternary catchments (E10A-K),
- The Olifants/Doring Dryland Farming area consists of seven quaternary catchments (E24J-M, E40C-D, E33F),
- The Lower Olifants Irrigation area consists of two quaternary catchments (E33G-H),
- The Olifants/Doring Estuary, and
- The Sandveld sub-area consists of 8 quaternary catchments (G30A-H).

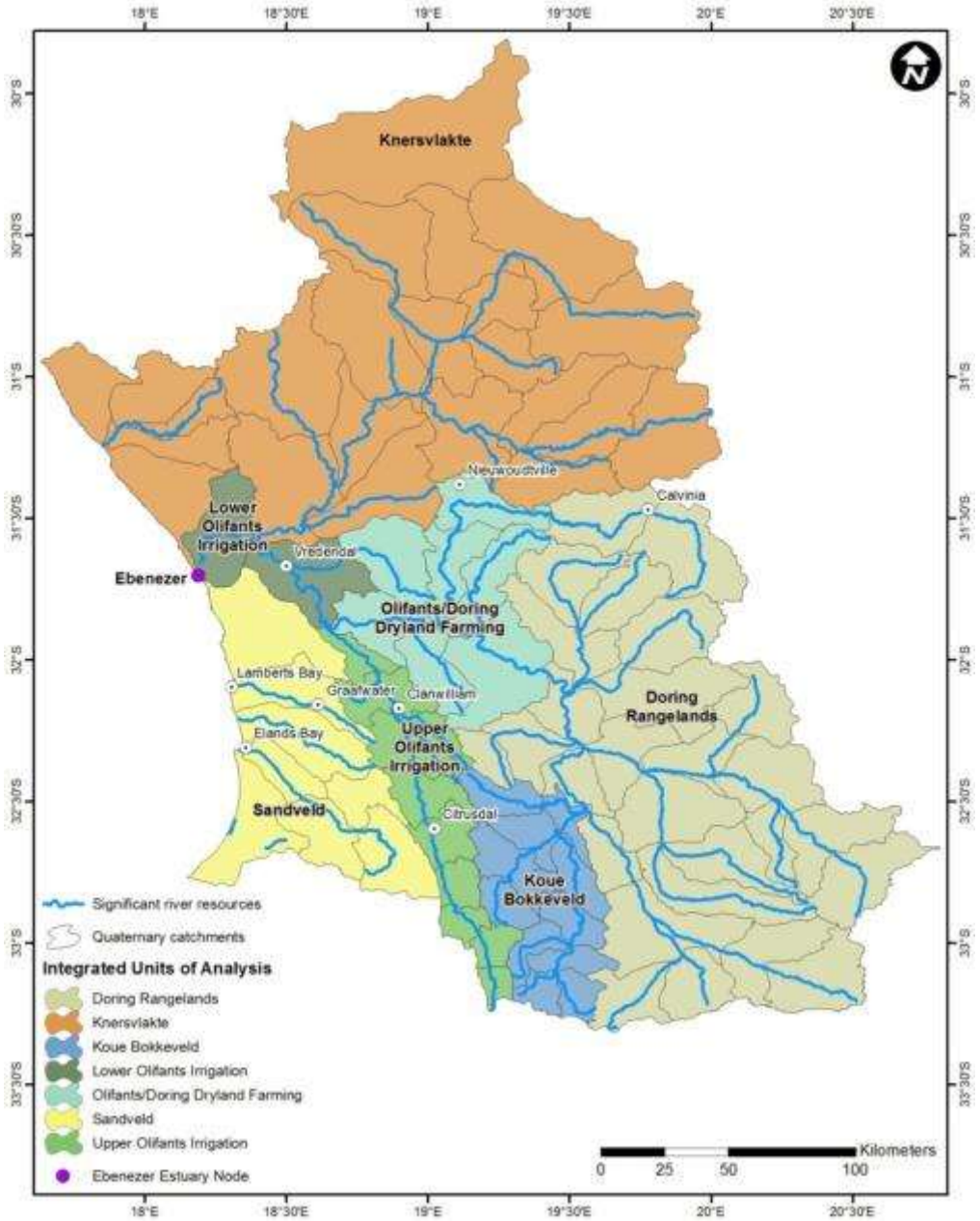

Figure 2.3. Integrated Units of Analysis for the Olifants Doorn WMA

3. STARTER CONFIGURATION SCENARIOS

There may be numerous possible ecological category configurations for a particular catchment, ranging from the catchment ecological sustainability baseline configuration (ESBC) which would permit maximum use scenario to a minimum use scenario, that is, the catchment is maintained in near-pristine (A/B-category) condition throughout.

To facilitate the decision making process, five representative catchment configuration scenarios have been selected and the resulting ecological flow balance generated for evaluation. These are:

- Scenario 1 - Ecological Sustainability Baseline Configuration (ESBC) scenario (which would permit maximum use);
- Scenario 2 - Present Ecological State (PES) scenario;
- Scenario 3 - RDM scenario (approved ecological Reserve);
- Scenario 4- ESBC with conservation targets; and
- Scenario 5 - PES with Conservation targets Scenario.

The five selected scenarios are discussed in greater detail in the following sections.

3.1. Environmental Water Requirements (EWR) Balance Sheet

In order to consider the various ecological category configurations within the WMA, one needs to specifically assess the water available to achieve the EWR for the desired ecological category at each river node. A hydrological model was not available for use in considering the various scenarios for the Olifants Doorn WMA. However as part of the pilot testing of the classification procedure in the Olifants Doring catchment, an EWR balance excel spread sheet was used which allows for a consideration of the compliance with the EWRs for each quaternary within the catchment (Figure 3.2). The spread sheet thus allows for the hydrological balance testing of the EWRs both the incremental and cumulative flows for each ecological category (A/B, B, C and D) throughout the catchment.

The spread sheet was updated with the most recent hydrology (a combination of the hydrology generated for consideration of the raising of Clanwilliam Dam and WR2005 hydrology for the remaining, drier areas of the WMA). The flow tree for the various catchments in the WMA is shown in Figure 3.1. Based on the updated hydrology, newly generated EWR values were incorporated into the spread sheet for the four ecological categories and the spread sheet was also expanded to include the G30 and F60 catchments.

The determination of the EWRs for the river nodes were divided into three groups:

- Nodes for which a high confidence EWR has already been determined (River nodes R33[EWR1], R13 [EWR2], R34 [EWR3], R20 [EWR4], R15 [EWR5] and R38 [EWR6] are all in quaternary catchments that have had a Comprehensive Reserve determined for them);
- Nodes for which extrapolation of high confidence EWRs could be undertaken (**R13**, R23, **R33** and R40 could be extrapolated from EWR 1 and 2; R24, **R34**, **R38**, R39, R42 and R44 could be extrapolated from EWR 3 and 6; and R14, R16, R19, **R20** and R28 could be extrapolated from EWR 4 and 5); and
- Non-extrapolation nodes for the remainder of the river nodes.

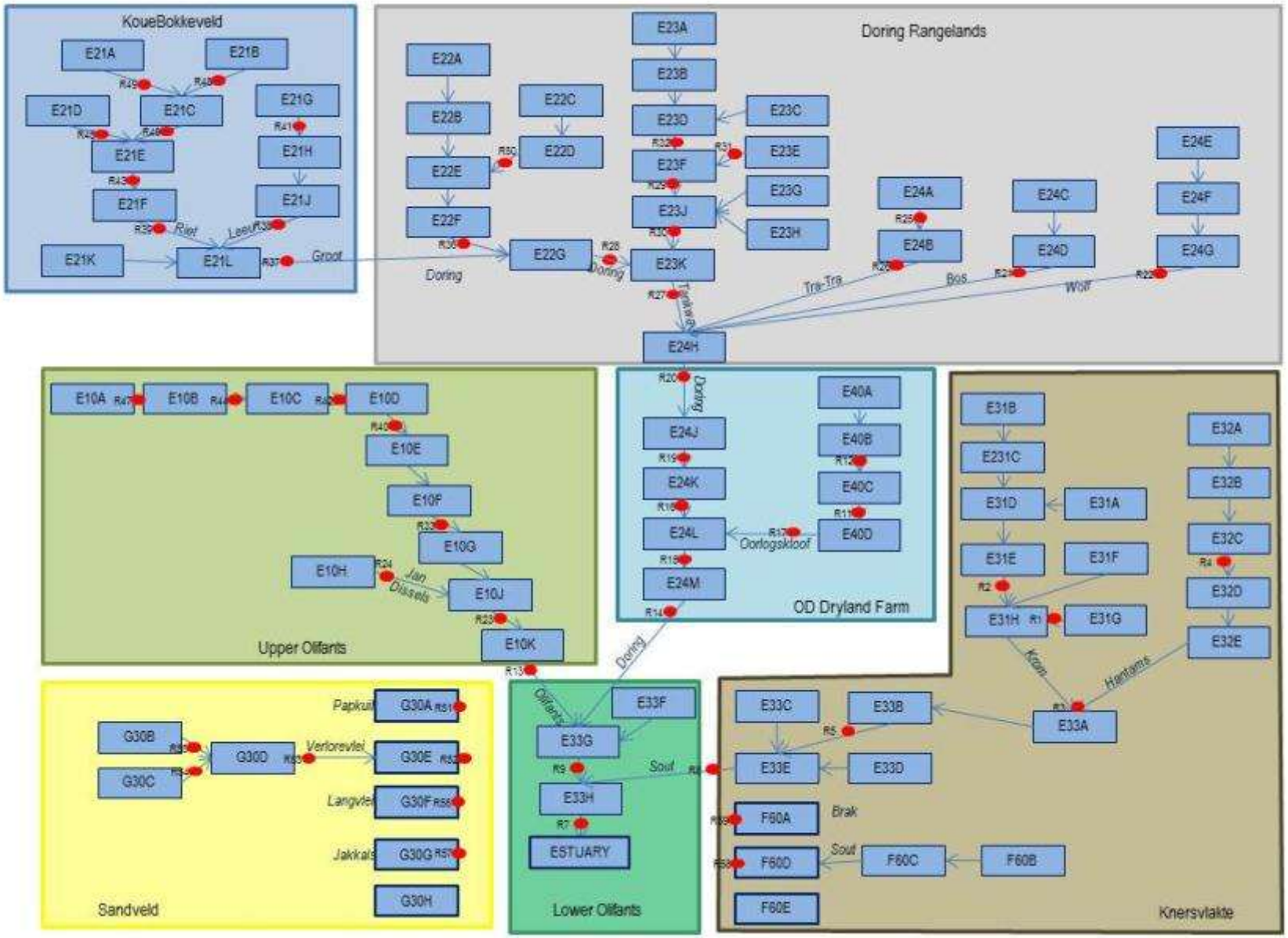

Figure 3.1: Flow diagram for the Olifants Doring WMA, indicating locality of river nodes

The balance sheet was set up only for the balancing of the river EWRs and although the Olifants Doring Estuary Reserve requirements were incorporated into the balance sheet, the requirements are simply not achievable with just a balance of the river EWRs thus a deficit in flows is always indicated for the estuarine flow requirement.

3.2. Catchment Configuration Scenarios

3.2.1. Scenario 1 - Ecological Sustainability Baseline Configuration (which would permit maximum use) scenario

The ESBC scenario is defined in the classification guidelines documents as the "*lowest theoretical level of protection required for the sustainable use of the entire catchment"*. In order to initiate the setting up of the balance a **starter configuration** is generated in which all the ecological categories is adjusted to a D category for both the cumulative and incremental catchment areas (Figure 3.2). It is not intended to provide a viable catchment configuration scenario but should rather be used to start the process on the lowest level (category D). The outcome of all catchment at a D category is represented in Figure 3.2. It is clear that is not feasible or possible to set all the ecological categories at D as this will result in a configuration in which the water required for the EWR (ecological Reserve) will not be achieved in the downstream catchments. Implying therefore that the water supplied by an ecological category D category in the upper catchment is not sufficient to comply with a D requirement in the lower parts of the catchments. Figure 3.2 indicates that in almost all of the catchments there is a deficit in complying with the EWR for maintaining the desired downstream ecological condition. In particular, a large deficit is evident at the Olifants/Doring Estuary.

Node	Quaternary		Directly linked nodes	Ecol Category (Node)				IncremFlow Category				Increm input	Channel evap	Cumul flow	EWR at node	Balance
	Single	Multiple		D	C	B	A/B	D	C	B	A/B					
48	E21A		0									**5.096**		5.096	5.096	0.000
49	E21B		0									**0.138**		0.138	0.138	0.000
46	E21C		2 49,48									0.144	0.18	5.198	5.285	-0.087
45	E21D		0									**6.490**		6.490	6.490	0.000
43	E21E		2 46,45									0.181	0.40	11.469	11.890	-0.421
39	E21F		1 43									0.264	0.71	11.023	15.012	-3.989
41	E21G		0									**7.139**		7.139	7.139	0.000
38	E21H	E21J	1 41									*11.026*	0.15	18.015	21.846	-3.831
37	E21K	E21L	2 38,39									*0.325*	0.60	28.763	30.314	-1.551
50	E22C	E22D	0									***0.601***		0.601	0.302	0.299
36	E22A	E22B E22E E22F	1 50									*3.154*	1.77	1.985	2.308	-0.323
28	E22G		2 37,36									0.791	1.26	30.279	40.196	-9.917
32	E23A	E23B E23C E23D	0									***2.991***		2.991	2.991	0.000
31	E23E		0									**0.666**		0.666	0.666	0.000
29	E23F		2 32,31									0.558	0.56	3.655	4.215	-0.560
30	E23G	E23H E23J	1 29									***2.716***		6.371	6.931	-0.560
27	E23K		2 28,30									0.675	0.84	36.485	39.666	-3.181
25	E24A		0									**0.510**		0.510	0.510	0.000
26	E24B		1 25									0.935	0.49	0.955	1.445	-0.490
21	E24C	E24D	0									***3.553***		3.553	3.554	-0.001
22	E24E	E24F E24G	0									***3.762***		3.762	3.762	0.000
20	E24H		4 27,26,21,22									1.040	2.00	43.795	63.240	-19.445
19	E24J		1 20									2.322	1.61	44.507	66.085	-21.578
16	E24K		1 19									**1.393**		45.900	67.805	-21.905
12	E40A	E40B	0									***3.288***		3.288	1.878	1.410
11	E40C		1 12									1.057	1.38	2.965	4.345	-1.380
17	E40D		1 11									1.085	1.33	2.720	5.430	-2.710
15	E24L		2 16,17									**1.052**	2.01	47.662	62.376	-14.714
14	E24M		1 15									1.149	1.77	47.041	77.744	-30.703
47	E10A		0									**7.834**		7.834	7.834	0.000
44	E10B		1 47									9.309	0.11	17.033	20.175	-3.142
42	E10C		1 44									7.268	0.21	24.091	28.418	-4.327
40	E10D		1 42									6.985	0.28	30.796	62.013	-31.217
33	E10E	E10F	1 40									*16.884*	0.77	46.910	94.296	-47.386
24	E10H		0									**4.874**		4.874	4.874	0.000
23	E10G	E10J	2 33,24									*15.209*	2.16	64.833	132.157	-67.324
13	E10K		1 23									1.031	0.73	65.134	134.213	-69.079
4	E32A	E32B E32C	0									***1.040***		1.040	1.040	0.000
2	E31B	E31C E31D E31E	0									***0.314***		0.314	0.314	0.000
1	E31G		0									**0.089**		0.089	0.089	0.000
3	E31F	E31H E32E	3 4,2,1									*0.490*	0.20	1.733	2.786	-1.053
5	E33A	E33B	1 3									*0.426*	0.05	2.109	2.354	-0.245
8	E33C	E33D E33E	1 5									*0.426*	0.10	2.435	1.691	0.744
9	E33F	E33G	2 14,13									*0.611*	1.30	111.486	124.883	-13.397
7	E33H		2 8,9									0.084	0.34	113.665	128.079	-14.414
Est	E33H		1 7									0.084		113.749	518.000	-404.251
	F60A		0									**0.023**		0.023	0.023	0.000
58	F60D	F60C F60B	0									**0.093**	0.20	-0.107	0.093	-0.200
	F60E		0									***0.006***		0.006	0.006	0.000
51	G30A		0									*1.244*		1.244	1.244	0.000
55	G30B		0									*2.028*		2.028	2.028	0.000
54	G30C		0									*2.429*		2.429	2.429	0.000
53	G30D		2 54,55									*1.829*	0.55	5.736	6.330	-0.594
52	G30E		1 53									**0.874**	0.74	5.870	7.222	-1.352
56	G30F		0									***1.649***		1.649	1.649	0.000
57	G30G		0									***0.659***		0.659	0.659	0.000
	G30H		0									***0.875***		0.875	0.875	0.000

Figure 3.2: Starter configuration with all the ecological categories selected as a D category

Node	Quaternary Single	Multiple	Directly linked nodes	Ecol Category (Node) D C B A/B	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance
48	E21A		0			**7.848**		7.848	7.848	0.000
49	E21B		0			**0.138**		0.138	0.138	0.000
46	E21C		2 49,48			0.144	0.18	7.950	5.285	2.665
45	E21D		0			**9.996**		9.996	9.996	0.000
43	E21E		2 46,45			0.181	0.40	17.727	11.890	5.837
39	E21F		1 43			0.264	0.71	17.281	15.012	2.269
41	E21G		0			**7.139**		7.139	7.139	0.000
38	E21H	E21J	1 41			*16.979*	0.15	23.968	21.846	2.122
37	E21K	E21L	2 38,39			*0.325*	0.60	40.974	30.314	10.660
50	E22C	E22D	0			***0.945***		0.945	0.475	0.470
36	E22A	E22B E22E E22F	1 50			*7.417*	1.77	6.592	2.308	4.284
28	E22G		2 37,36			0.791	1.26	47.097	40.196	6.901
32	E23A	E23B E23C E23D	0			***4.696***		4.696	4.695	0.001
31	E23E		0			**0.666**		0.666	0.666	0.000
29	E23F		2 32,31			0.876	0.56	5.678	4.215	1.463
30	E23G	E23H E23J	1 29			***2.716***		8.394	6.931	1.463
27	E23K		2 28,30			1.059	0.84	55.710	39.666	16.044
25	E24A		0			**0.510**		0.510	0.510	0.000
26	E24B		1 25			1.466	0.49	1.486	1.445	0.041
21	E24C	E24D	0			***5.575***		5.575	5.576	-0.001
22	E24E	E24F E24G	0			***5.902***		5.902	5.902	0.000
20	E24H		4 27,26,21,22			1.613	2.00	68.286	63.240	5.046
19	E24J		1 20			2.322	1.61	68.998	66.085	2.913
16	E24K		1 19			**1.393**		70.391	67.805	2.586
12	E40A	E40B	0			***7.714***		7.714	4.405	3.309
11	E40C		1 12			1.659	1.38	7.993	4.345	3.648
17	E40D		1 11			1.702	1.33	8.365	5.430	2.935
15	E24L		2 16,17			**1.052**	2.01	77.798	62.376	15.422
14	E24M		1 15			1.861	1.77	77.889	77.744	0.145
47	E10A		0			**17.931**		17.931	17.931	0.000
44	E10B		1 47			21.183	0.11	39.004	20.175	18.829
42	E10C		1 44			16.586	0.21	55.380	28.418	26.962
40	E10D		1 42			15.896	0.28	70.996	62.013	8.983
33	E10E	E10F	1 40			*38.824*	0.77	109.050	94.296	14.754
24	E10H		0			**4.874**		4.874	4.874	0.000
23	E10G	E10J	2 33,24			*23.326*	2.16	135.090	132.157	2.933
13	E10K		1 23			1.031	0.73	135.391	134.213	1.178
4	E32A	E32B E32C	0			***1.634***		1.634	1.634	0.000
2	E31B	E31C E31D E31E	0			***0.495***		0.495	0.494	0.001
1	E31G		0			**0.089**		0.089	0.089	0.000
3	E31F	E31H E32E	3 4,2,1			*0.772*	0.20	2.790	2.786	0.004
5	E33A	E33B	1 3			*0.426*	0.05	3.166	2.354	0.812
8	E33C	E33D E33E	1 5			*0.426*	0.10	3.492	1.691	1.801
9	E33F	E33G	2 14,13			*0.611*	1.30	212.591	124.883	87.708
7	E33H		2 8,9			0.084	0.34	215.827	128.079	87.748
Est	E33H		1 7			0.084		215.911	518.000	-302.089
	F60A		0			**0.023**		0.023	0.023	0.000
58	F60D	F60C F60B	0			**0.215**	0.20	0.015	0.216	-0.201
	F60E		0			***0.006***		0.006	0.006	0.000
51	G30A		0			*1.244*		1.244	1.244	0.000
55	G30B		0			*3.113*		3.113	3.113	0.000
54	G30C		0			*3.720*		3.720	3.720	0.000
53	G30D		2 54,55			*1.829*	0.55	8.112	6.330	1.782
52	G30E		1 53			**0.874**	0.74	8.246	7.222	1.024
56	G30F		0			***1.649***		1.649	1.649	0.000
57	G30G		0			***0.659***		0.659	0.659	0.000
	G30H		0			***0.875***		0.875	0.875	0.000

Figure 3.3: Scenario 1 - Ecological Sustainability Baseline Configuration (ESBC) – River EWRs

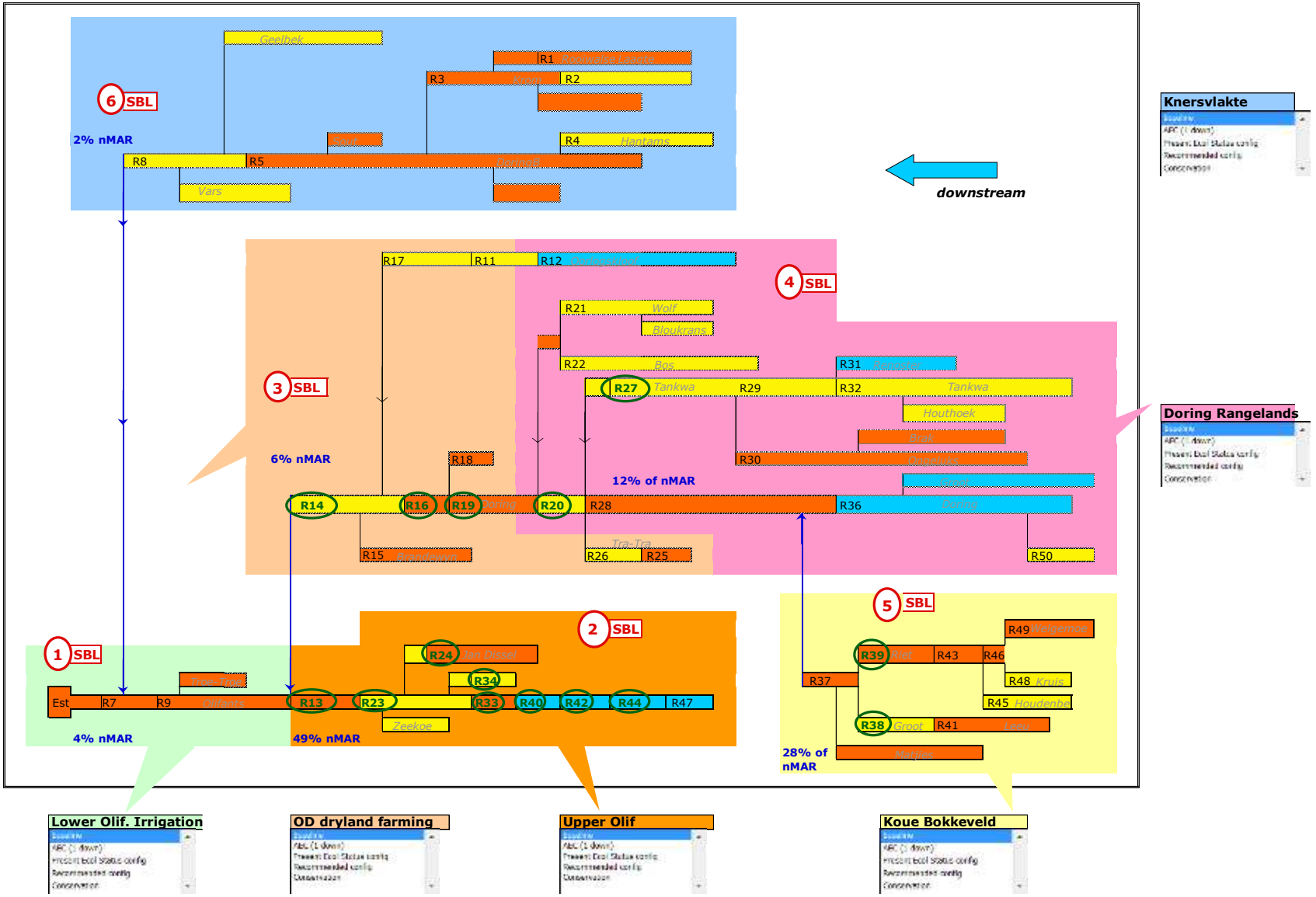

Figure 3.4: Scenario 1 - Ecological Sustainability Baseline Configuration (ESBC)

From the starter configuration the establishment of the ESBC scenario is achieved by moving sequentially upstream/downstream using the D category as the starting point at each node and adjusting the ecological category until sufficient water is supplied throughout the catchment to satisfy the required flow for the categories downstream (Figure 3.3). This requires starting at the downstream end of a catchment, and working upstream according to the river nodes, while considering the water quantity, quality and ecosystem condition and functions required for this base configuration.

Figures 3.3 and 3.4 provide a configuration of resource categories that ensures that the downstream EWRs are met throughout the catchment. This configuration of resource categories can therefore be seen as the lowest volume of EWRs that would be required to achieve a sustainable level of ecosystem functioning (D category – the lowest sustainable ecosystem category). The configuration does not address any freshwater biodiversity conservation aspects.

Table 3.1. Summary of water resource categories for the ESBC

Scenario 1: Ecological sustainability baseline configuration

Quaternary	Incremental C	Cumulative C
E10A	C	B
E10B	D	B
E10C	D	B
E10D	D	B
E10E	D	B
E10F	D	D
E10G	D	C
E10H	D	D
E10J	D	C
E10K	D	D
E21A	C	C
E21B	D	D
E21C	D	D
E21D	C	C
E21E	D	D
E21F	D	D
E21G	D	D
E21H	D	C
E21J	D	C
E21K	D	D
E21L	D	D
E22A	D	B
E22B	D	B
E22C	C	C
E22D	C	C
E22E	D	B
E22F	D	B
E22G	D	D
E23A	C	C
E23B	C	C

Quaternary	Incremental C	Cumulative C
E23C	C	C
E23D	C	C
E23E	D	D
E23F	D	B
E23G	D	D
E23H	D	D
E23J	D	D
E23K	D	C
E24A	D	D
E24B	D	C
E24C	C	C
E24D	C	C
E24E	C	C
E24F	C	C
E24G	C	C
E24H	D	C
E24J	D	D
E24K	D	D
E24L	D	D
E24M	D	C
E31A	D	D
E31B	C	C
E31C	C	C
E31D	C	C
E31E	C	C
E31F	D	C
E31G	D	D
E31H	D	C
E32A	C	C
E32B	C	C

Quaternary	Incremental C	Cumulative C
E32C	C	C
E32D	D	C
E32E	D	C
E33A	D	D
E33B	D	D
E33C	D	D
E33D	D	D
E33E	D	D
E33F	D	D
E33G	D	D
E33H	D	D
E40A	B	B
E40B	B	B
E40C	D	C
E40D	D	C
F60A	D	D
F60B	C	B
F60C	C	C
F60D	C	D
F60E	D	D
G30A	D	D
G30B	B	B
G30C	C	C
G30D	B	C
G30E	D	D
G30F	D	D
G30G	D	D
G30H	D	D

3.2.2. Present Ecological State (PES) scenario

For this scenario, the present ecological status (PES as recently updated in 2011), was used to generate the PES scenario. Figure 3.5 indicates that there are a large number of quaternaries where there is a deficit in achieving the EWR flows further downstream. This deficit is created by the insufficient supply from the upstream catchments. It should however be borne in mind that the spread sheet provides merely an indication of the ecological flow requirement balance in terms of the EWRs and does not take into account other non-flow related impacts on the PES. In many cases the condition of the streams in the WMA have a reduced ecological integrity as a result of habitat disturbances (bulldozing of the river bed and banks) and not as a result of a lack of flow. The flow category could therefore be much higher presently and there should be no need to adjust it lower.

Table 3.2: Summary of water resource categories for the PES Configuration (from the updated PES 2011)

Scenario 2: Present Ecological State Configuration

QUAT	PESC (2011) C	PES (2011) INC
E10A	C	C
E10B	B	C
E10C	B	B
E10D	C	C
E10E	C	C
E10F	D	C
E10G	D	C
E10H	D	D
E10J	D	D
E10K	D	D
E21A	E	C
E21B	D	D
E21C	C	B
E21D	D	D
E21E	B	C
E21F	AB	C
E21G	D	D
E21H	AB	B
E21J	AB	AB
E21K	B	B
E21L	AB	AB
E22A	B	AB
E22B	AB	AB
E22C	AB	B
E22D	B	AB
E22E	B	AB
E22F	B	B
E22G	B	AB
E23A	AB	AB
E23B	AB	AB

QUAT	PESC (2011) CU	PES (2011) INC
E23C	AB	AB
E23D	AB	AB
E23E	B	AB
E23F	B	B
E23G	B	B
E23H	AB	AB
E23J	B	AB
E23K	B	AB
E24A	B	B
E24B	B	B
E24C	C	B
E24D	C	B
E24E	AB	AB
E24F	B	AB
E24G	B	AB
E24H	B	AB
E24J	B	AB
E24K	AB	AB
E24L	B	C
E24M	B	C
E31A	B	B
E31B	B	B
E31C	B	B
E31D	B	B
E31E	B	B
E31F	B	B
E31G	B	B
E31H	B	B
E32A	B	B
E32B	B	B

QUAT	PESC (2011) C	PES (2011) IN
E32C	B	B
E32D	B	B
E32E	B	B
E33A	B	B
E33B	B	B
E33C	D	D
E33D	B	B
E33E	C	B
E33F	D	D
E33G	D	C
E33H	D	B
E40A	C	C
E40B	C	D
E40C	D	B
E40D	B	B
F60A	B	B
F60B	B	B
F60C	B	B
F60D	B	B
F60E	B	B
G30A	C	C
G30B	C	C
G30C	C	C
G30D	C	C
G30E	C	C
G30F	C	C
G30G	C	C
G30H	C	C

Node	Quaternary		Directly linked nodes	Ecol Category (Node)				Increm Flow Category				Increm input	Channel evap	Cumul flow	EWR at node	Balance
	Single	Multiple		D	C	B	A/B	D	C	B	A/B					
48	E21A		0									**5.096**		5.096	5.096	0.000
49	E21B		0									**0.138**		0.138	0.138	0.000
46	E21C		2 49,48									0.338	0.18	5.392	8.168	-2.776
45	E21D		0									**6.490**		6.490	6.490	0.000
43	E21E		2 46,45									0.284	0.40	11.766	27.314	-15.548
39	E21F		1 43									0.406	0.71	11.462	38.635	-27.173
41	E21G		0									**7.139**		7.139	7.139	0.000
38	E21H	E21J	1 41									*25.243*	0.15	32.232	56.606	-24.374
37	E21K	E21L	2 38,39									*0.937*	0.60	44.031	69.645	-25.614
50	E22C	E22D	0									***1.413***		1.413	0.711	0.702
36	E22A	E22B E22E E22F	1 50									*9.115*	1.77	8.758	5.427	3.331
28	E22G		2 37,36									2.242	1.26	53.771	121.620	-67.849
32	E23A	E23B E23C E23D	0									***8.629***		8.629	8.630	-0.001
31	E23E		0									**1.562**		1.562	1.562	0.000
29	E23F		2 32,31									1.310	0.56	10.941	9.895	1.046
30	E23G	E23H E23J	1 29									***6.376***		17.317	16.272	1.045
27	E23K		2 28,30									1.947	0.84	72.195	92.254	-20.059
25	E24A		0									**1.197**		1.197	1.197	0.000
26	E24B		1 25									2.193	0.49	2.900	3.390	-0.490
21	E24C	E24D	0									***5.575***		5.575	5.576	-0.001
22	E24E	E24F E24G	0									***8.826***		8.826	8.826	0.000
20	E24H		4 27,26,21,22									2.939	2.00	90.435	191.933	-101.498
19	E24J		1 20									6.562	1.61	95.387	200.591	-105.204
16	E24K		1 19									**3.957**		99.344	266.426	-167.082
12	E40A	E40B	0									***5.159***		5.159	2.946	2.213
11	E40C		1 12									2.480	1.38	6.259	4.345	1.914
17	E40D		1 11									2.546	1.33	7.475	12.741	-5.266
15	E24L		2 16,17									**2.460**	2.01	107.269	144.163	-36.894
14	E24M		1 15									1.861	1.77	107.360	236.079	-128.719
47	E10A		0									**12.064**		12.064	12.061	0.003
44	E10B		1 47									14.200	0.11	26.154	47.241	-21.087
42	E10C		1 44									16.586	0.21	42.530	66.772	-24.242
40	E10D		1 42									10.684	0.28	52.934	71.530	-18.596
33	E10E	E10F	1 40									*25.908*	0.77	78.072	108.881	-30.809
24	E10H		0									**4.874**		4.874	4.874	0.000
23	E10G	E10J	2 33,24									*15.209*	2.16	95.995	132.157	-36.162
13	E10K		1 23									1.031	0.73	96.296	134.213	-37.917
4	E32A	E32B E32C	0									***2.444***		2.444	2.444	0.000
2	E31B	E31C E31D E31E	0									***0.739***		0.739	0.739	0.000
1	E31G		0									**0.209**		0.209	0.209	0.000
3	E31F	E31H E32E	3 4,2,1									*1.153*	0.20	4.345	6.553	-2.208
5	E33A	E33B	1 3									*0.261*	0.05	4.556	5.536	-0.980
8	E33C	E33D E33E	1 5									*0.671*	0.10	5.127	1.691	3.436
9	E33F	E33G	2 14,13									*0.611*	1.30	202.967	124.883	78.084
7	E33H		2 8,9									0.197	0.34	207.951	128.079	79.872
Est	E33H		1 7									0.084		208.035	518.000	-309.965
	F60A		0									**0.053**		0.053	0.053	0.000
58	F60D	F60C F60B	0									**0.215**	0.20	0.015	0.216	-0.201
	F60E		0									***0.014***		0.014	0.014	0.000
51	G30A		0									*1.922*		1.922	1.922	0.000
55	G30B		0									*3.113*		3.113	3.113	0.000
54	G30C		0									*3.720*		3.720	3.720	0.000
53	G30D		2 54,55									*2.815*	0.55	9.098	9.706	-0.608
52	G30E		1 53									**1.347**	0.74	9.705	11.077	-1.372
56	G30F		0									***2.553***		2.553	2.553	0.000
57	G30G		0									***1.021***		1.021	1.021	0.000
	G30H		0									***1.349***		1.349	1.349	0.000

Figure 3.5: Scenario 2 - Present Ecological Status (PES) Configuration

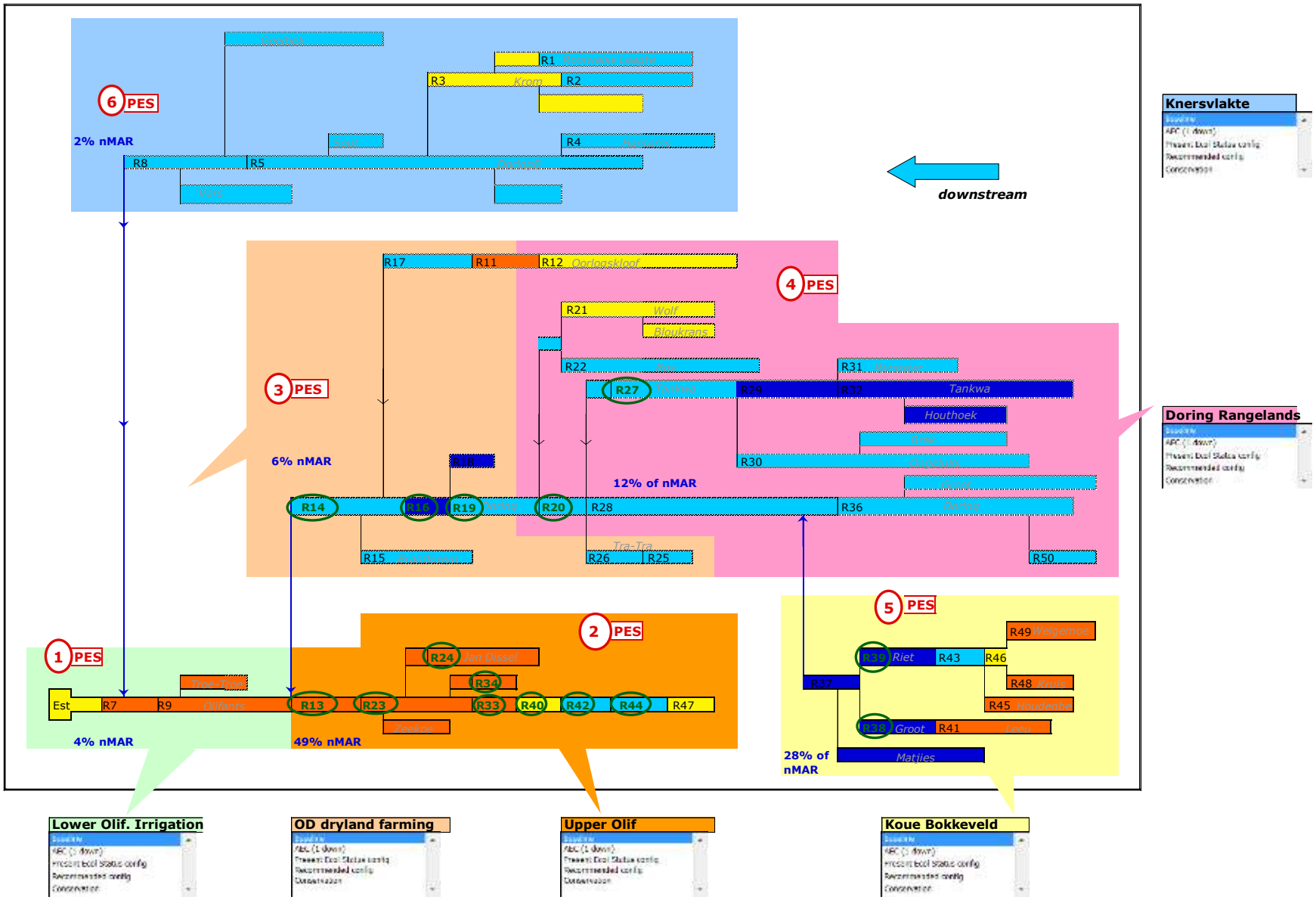

Figure 3.6: Scenario 2 - Present Ecological Status (PES) Configuration

3.2.3. RDM (approved ecological Reserve) scenario

In 2007, following the development of the classification system and pilot testing, the preliminary EWRs and preliminary water resource classes for the Olifants Doring Catchment was approved by the Director-General of the DWA. These EWRs and classes were based on the recommended water resource class configuration from the pilot testing of the classification procedure. The summary of the approved EWRs and water resource classes is provided in Table 3.3. These EWRs and resource classes were utilised, together with the approved Reserves for the Sandveld, to generate a configuration for RDM – Scenario 3 (Figure 3.7). This configuration indicates that there is a deficit of flows for some of the quaternary catchments. The approved Reserves (EWRs) however also included an additional condition relevant to the incremental catchments that the tributaries feeding the main stem should be maintained such that they can contribute either 20%, 40%, 60% or 80% of their flow to the main stem (See highlighted cells in Table 3.3 below).

Table 3.3: Approved ecological Reserve (EWRs) and preliminary resource classes for the Olifants Doring Catchment (DWA 2007)

Quat catch	Water Resource	nMAR (MCM)	Cumulative Reserve requirement (MCM)	Cumulative Reserve requirement (%MAR)	Incremental Reserve requirement (MCM)	Incremental Reserve requirement (%MAR)	Confidence level	Resource class
E10A	Olifants	61.373	8.336	13.58	12.280	20.0	Low	D – Largely modified
E10B	Olifants	131.157	27.858	21.24	41.880	32.0	Medium/low	B – largely natural
E10C	Olifants	180.907	71.427	39.48	29.880	16.5	Medium/low	B – largely natural
E10D	Olifants	229.932	31.173	13.56	9.800	4.3	Medium/low	C – moderately modified
E10E / E10F (EWR 1)	Olifants	331.551	88.403	26.66	21.000	6.3	High	D – Largely modified
E10H	Jan Dissels	33.507	7.119	21.25	27.640	82.5	Medium/low	C – moderately modified
E10G & H(scaled)	Jan Dissels	46.205	6.883	14.990	-	-	Medium/low	D – Largely modified
E10G E10J	Olifants	467.369	63.974	13.69	12.700	2.7	Low	D – Largely modified
EWR 3	Rondegat	7.45	3.239	43.47	-	-	High	B – largely natural
E21A	Kruis	34.884	4.351	12.47	6.980	20.0	Low	D – Largely modified
E21B	Welgemoed	26.936	5.216	19.36	10.760	40.0	Low	C – moderately modified
E21C	Winkelhaak	86.750	16.786	19.35	10.000	11.5	Low	C – moderately modified
E21D	Houdenbeks	45.369	5.659	12.47	9.080	20	Low	D – Largely modified
E21E	Riet	151.708	29.459	19.42	11.760	7.8	Low	C – moderately modified
E21F	Riet	168.254	35.738	21.24	9.900	6.0	Low	C – moderately modified
E21G	Groot/Leeu	30.561	6.218	20.35	12.240	40.0	Low	C – moderately modified
E21H E21J (EWR 6)	Groot	137.858	60.33	43.76	45.504	33.0	High	B/C – largely natural/ moderately modified
E21K/ E21L	Maatjies	278.509	55.108	19.79	18.240	6.5	Low	C – moderately modified
E22A / E22B / E22E / E22F	Doring	39.642	10.459	26.38	8.960	22.6	Low	B – largely natural
E22C / E22D	Doring	17.323	3.077	17.76	6.920	40.0	Low	C – moderately modified
E22G	Doring	319.264	145.595	45.60	0.880	0.3	Medium/low	B – largely natural
E23A / E23B / E23C / E23D	Tankwa	20.083	3.531	17.58	8.040	40	Low	C – moderately modified

Table 3.3 (*continue)*: Approved ecological Reserve (EWRs) and preliminary resource classes for the Olifants Doring Catchment

Quat catch	Water Resource	nMAR (MCM)	Cumulative Reserve requirement (MCM)	Cumulative Reserve requirement (%MAR)	Incremental Reserve requirement (MCM)	Incremental Reserve requirement (%MAR)	Confidence level	Resource class
E23E	Tankwa	6.6	1.164	17.64	2.640	40	Low	C – moderately modified
E23F	Tankwa/Renoster	27.201	4.786	17.60	0.100	0.4	Low	C – moderately modified
E23G E23H E23J	Ongeluks	35.171	6.177	17.56	3.200	9.1	Low	C – moderately modified
E23K	Tankwa	319.793	38.942	12.18	0.100	0.03	Low	D – Largely modified
E24A	Tra-tra	17.310	4.658	26.91	10.380	60.0	Low	B – largely natural
E24B	Tra-tra	27.583	7.397	26.82	6.180	22.4	Low	B – largely natural
E24C E24D	Bos	15.922	2.816	17.69	6.360	40.0	Low	C – moderately modified
E24E E24F E24G	Wolf	13.793	2.440	17.69	5.520	40.0	Low	C – moderately modified
E24H (EWR 4)	Doring	421.47	192.205	45.60	1.600	0.4	High	B – largely natural
E24J	Doring	401.440	183.070	45.60	8.120	2.0	Medium/low	B – largely natural
E24K (EWR 5)	Doring	509.621	232.405	45.60	6.120	1.2	High	B – largely natural
E24L	Brandewyn	462.055	91.202	19.74	9.360	2.0	Low	C – moderately modified
E24M	Doring	471.872	215.190	45.60	5.880	1.3	Medium/low	B – largely natural
E31B E31C E31D E31E	Kromme	3.091	0.807	26.12	1.860	60.0	Low	B – largely natural
E31F E31H E32E	Kromme	12.351	2.204	17.85	0.880	7.1	Low	C – moderately modified
E31G	Kromme	0.681	0.118	17.30	0.160	23.5	Low	C – moderately modified
E32A E32B E32C	Hantams	8.576	1.532	17.86	3.440	40.0	Low	C – moderately modified
E33A E33B	Sout	19.218	3.399	17.69	0.260	1.4	Low	C – moderately modified
E33C E33D E33E	Sout	22.265	4.056	18.22	0.600	2.7	Low	C – moderately modified
E33F E33G	Hol	949.760	118.937	12.52	1.160	0.1	Low	D – Largely modified
E33H	Olifants	972.643	130.360	13.4	0.120	0.1	Low	D – Largely modified
E40A E40B	Oorlogskloof	13.354	2.368	17.73	2.680	20.0	Low	C – moderately modified
E40C	Oorlogskloof	20.117	5.367	26.68	2.720	13.5	Low	B – largely natural
E40D	Oorlogskloof/Koebee	27.071	7.239	26.74	2.800	10.3	Low	B – largely natural
Estuary	Olifants	1055	597	56	0.120	0.01	High	C – moderately modified

Node	Quaternary		Directly linked nodes	Ecol Category (Node)				Increm Flow Category				Increm input	Channel evap	Cumul flow	EWR at node	Balance
	Single	Multiple		D	C	B	A/B	D	C	B	A/B					
48	E21A		0									**5.096**		5.096	5.096	0.000
49	E21B		0									**0.217**		0.217	0.217	0.000
46	E21C		2 49,48									0.226	0.18	5.359	8.168	-2.809
45	E21D		0									**6.490**		6.490	6.490	0.000
43	E21E		2 46,45									0.181	0.40	11.630	18.359	-6.729
39	E21F		1 43									0.264	0.71	11.184	20.821	-9.637
41	E21G		0									**10.994**		10.994	10.994	0.000
38	E21H	E21J	1 41									*30.835*	0.15	41.679	30.502	11.177
37	E21K	E21L	2 38,39									*0.325*	0.60	52.588	46.812	5.776
50	E22C	E22D	0									***0.945***		0.945	0.475	0.470
36	E22A	E22B E22E E22F	1 50									*7.417*	1.77	6.592	5.427	1.165
28	E22G		2 37,36									0.791	1.26	58.711	121.620	-62.909
32	E23A	E23B E23C E23D	0									***4.696***		4.696	4.695	0.001
31	E23E		0									**1.045**		1.045	1.045	0.000
29	E23F		2 32,31									0.558	0.56	5.739	6.616	-0.877
30	E23G	E23H E23J	1 29									***4.265***		10.004	10.880	-0.876
27	E23K		2 28,30									0.675	0.84	68.550	39.666	28.884
25	E24A		0									**1.197**		1.197	1.197	0.000
26	E24B		1 25									2.193	0.49	2.900	3.390	-0.490
21	E24C	E24D	0									***5.575***		5.575	5.576	-0.001
22	E24E	E24F E24G	0									***5.902***		5.902	5.902	0.000
20	E24H		4 27,26,21,22									1.040	2.00	81.967	191.933	-109.966
19	E24J		1 20									2.322	1.61	82.679	200.591	-117.912
16	E24K		1 19									**3.236**		85.915	205.375	-119.460
12	E40A	E40B	0									***5.159***		5.159	2.946	2.213
11	E40C		1 12									2.480	1.38	6.259	10.195	-3.936
17	E40D		1 11									2.546	1.33	7.475	12.741	-5.266
15	E24L		2 16,17									**1.646**	2.01	93.026	96.754	-3.728
14	E24M		1 15									1.149	1.77	92.405	236.079	-143.674
47	E10A		0									**7.834**		7.834	7.834	0.000
44	E10B		1 47									21.183	0.11	28.907	47.241	-18.334
42	E10C		1 44									11.140	0.21	39.837	66.772	-26.935
40	E10D		1 42									6.985	0.28	46.542	71.530	-24.988
33	E10E	E10F	1 40									*16.884*	0.77	62.656	94.296	-31.640
24	E10H		0									**4.874**		4.874	4.874	0.000
23	E10G	E10J	2 33,24									*15.209*	2.16	80.579	132.157	-51.578
13	E10K		1 23									1.031	0.73	80.880	134.213	-53.333
4	E32A	E32B E32C	0									***1.634***		1.634	1.634	0.000
2	E31B	E31C E31D E31E	0									***0.739***		0.739	0.739	0.000
1	E31G		0									**0.140**		0.140	0.140	0.000
3	E31F	E31H E32E	3 4,2,1									*0.490*	0.20	2.803	7.381	-4.578
5	E33A	E33B	1 3									*0.426*	0.05	3.179	3.702	-0.523
8	E33C	E33D E33E	1 5									*0.426*	0.10	3.505	2.656	0.849
9	E33F	E33G	2 14,13									*0.611*	1.30	172.596	124.883	47.713
7	E33H		2 8,9									0.084	0.34	175.845	128.079	47.766
Est	E33H		1 7									0.084		175.929	597.000	-421.071
55	G30B		0									*3.113*		3.113	3.113	0.000
54	G30C		0									*3.720*		3.720	3.720	0.000
53	G30D		2 54,55									*4.185*	0.55	10.468	14.443	-3.975
52	G30E		1 53									**2.002**	0.74	11.730	16.479	-4.749
56	G30F		0									***2.553***		2.553	2.553	0.000
57	G30G		0									***1.021***		1.021	1.021	0.000

Figure 3.7: RDM (approved ecological Reserve) scenario

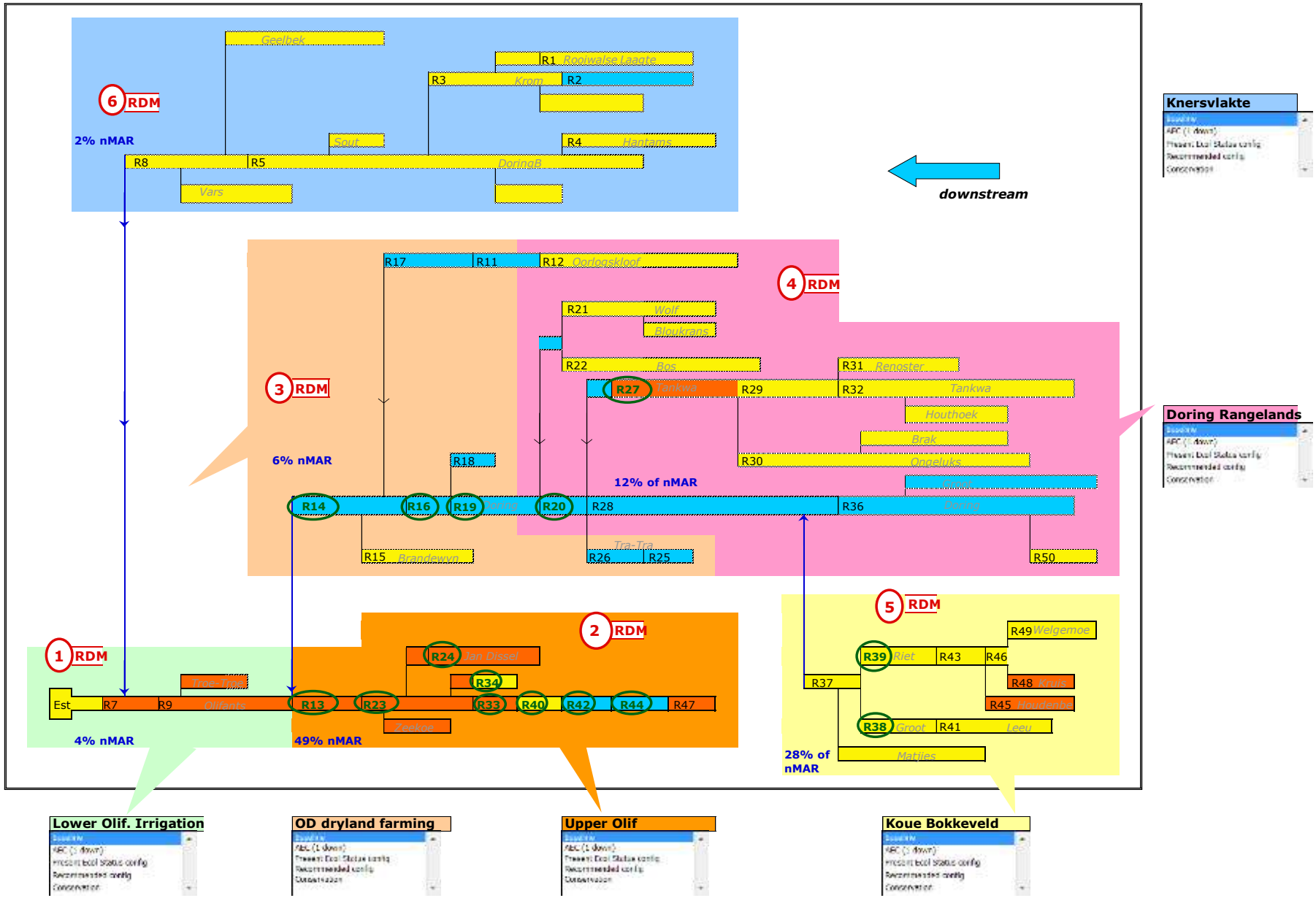

Figure 3.8: Scenario 3 - RDM (approved Ecological Reserve) Configuration

3.2.4. Conservation targets and ESB or Present Ecological Category scenarios

The National Freshwater Ecosystem Priority Areas (FEPA) project was utilised to generate a configuration that is intended to consider the freshwater biodiversity conservation targets as assumed represented by the FEPA within the WMA (Driver et al 2011).

River FEPAs (Figure 3.9) are intended to achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition. The FEPA guidelines indicate these rivers should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources. In some cases the river FEPAs may also still require some rehabilitation.

Wetland FEPAs (Figure3.9) were identified using ranks that were based on a combination of special features and modelled wetland condition. Although wetland condition was a factor in selection of wetland FEPAs, wetlands did not have to be in a good condition (A or B ecological category) to be chosen as a FEPA. Wetland FEPAs currently in an A or B ecological condition should be managed to maintain their good condition. Those currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition. Estuary FEPAs are the national priority estuaries identified in the National Biodiversity Assessment.

The FEPAs Implementation Guidelines indicate that the FEPA should inform the water resource classification system and process in the following ways:

- River, wetland and estuary FEPAs should be regarded as significant water resources;
- The location of FEPAs should be used to prioritise the allocation of resource unit nodes, which should be sited immediately downstream of the FEPA;
- Water-use scenarios should include at least one scenario that achieves the desired condition for FEPAs; and
- In examining the social, economic and ecological trade-offs of different water-use scenarios (and the impact each will have on future ecological condition of significant water resources), the consequences of not protecting a FEPA should be factored into the ecological assessment.

The FEPA rivers and wetlands are as listed in Table 3.4. The ‘rules’ applied to generating the configuration (Figure 3.9, 3.6.2 and 3.6.3) were as follows:

- The river FEPAs should aim to achieve an A/B category;
- The wetland FEPA also to achieve an A/B where possible but at least not result in any further degradation (i.e. PES category); and
- Fish support areas to have no further degradation (i.e. retain PES category).

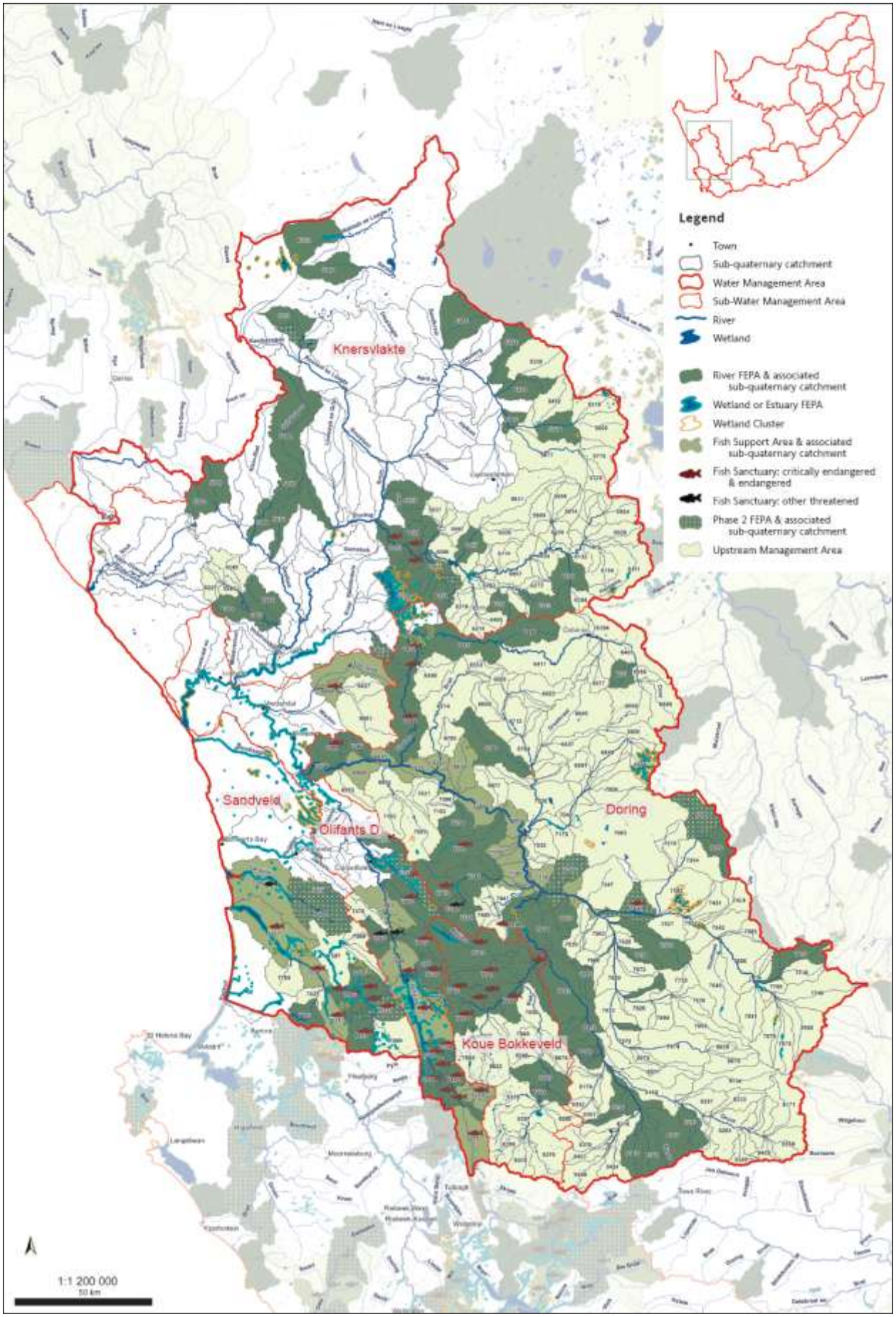

Figure 3.9: River and wetland FEPA map for the Olifants Doorn WMA (CSIR, 2011)

Table 3.4: Summary of water resource categories for the Conservation targets and ESB Configuration

Scenario 4: Ecological Sustainability Baseline Configuration combined with Conservation Targets

	ESBC&CONS	ESBC&CONS
Quaternary	INC	CUM
E10A	C	B
E10B	AB	B
E10C	AB	B
E10D	AB	B
E10E	AB	B
E10F	AB	D
E10G	AB	C
E10H	AB	D
E10J	AB	C
E10K	AB	D
E21A	C	C
E21B	D	D
E21C	AB	D
E21D	AB	C
E21E	AB	D
E21F	AB	D
E21G	AB	D
E21H	AB	C
E21J	AB	C
E21K	AB	D
E21L	AB	D
E22A	D	B
E22B	AB	B
E22C	AB	C
E22D	AB	C
E22E	AB	B
E22F	D	B
E22G	AB	D
E23A	AB	C
E23B	AB	C

	ESBC&CONS	ESBC&CONS
Quaternary	INC	CUM
E23C	AB	C
E23D	AB	C
E23E	AB	D
E23F	AB	B
E23G	AB	D
E23H	AB	D
E23J	AB	D
E23K	AB	C
E24A	AB	D
E24B	AB	C
E24C	AB	C
E24D	C	C
E24E	AB	C
E24F	AB	C
E24G	AB	C
E24H	AB	C
E24J	AB	D
E24K	AB	D
E24L	AB	D
E24M	AB	C
E31A	AB	D
E31B	AB	C
E31C	AB	C
E31D	C	C
E31E	C	C
E31F	AB	C
E31G	AB	D
E31H	AB	C
E32A	AB	C
E32B	AB	C

	ESBC&CONS	ESBC&CONS
Quaternary	INC	CUM
E32C	AB	C
E32D	AB	C
E32E	AB	C
E33A	AB	D
E33B	AB	D
E33C	AB	D
E33D	AB	D
E33E	AB	D
E33F	AB	D
E33G	AB	D
E33H	AB	D
E40A	AB	B
E40B	AB	B
E40C	AB	C
E40D	AB	C
F60A	AB	D
F60B	AB	B
F60C	AB	C
F60D	C	D
F60E	D	D
G30A	AB	D
G30B	AB	B
G30C	AB	C
G30D	AB	C
G30E	D	D
G30F	D	D
G30G	D	D
G30H	D	D

Node	Quaternary Single	Quaternary Multiple	Directly linked nodes	Ecol Category (Node) D	C	B	A/B	IncremFlow Category D	C	B	A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance
48	E21A		0									**7.848**		7.848	7.848	0.000
49	E21B		0									**0.138**		0.138	0.138	0.000
46	E21C		2 49,48									0.416	0.18	8.222	5.285	2.937
45	E21D		0									**9.996**		9.996	9.996	0.000
43	E21E		2 46,45									0.523	0.40	18.341	11.890	6.451
39	E21F		1 43									0.739	0.71	18.370	15.012	3.358
41	E21G		0									**7.139**		7.139	7.139	0.000
38	E21H	E21J	1 41									*30.835*	0.15	37.824	21.846	15.978
37	E21K	E21L	2 38,39									*0.937*	0.60	56.531	30.314	26.217
50	E22C	E22D	0									***0.945***		0.945	0.475	0.470
36	E22A	E22B E22E E22F	1 50									*7.417*	1.77	6.592	2.308	4.284
28	E22G		2 37,36									2.242	1.26	64.105	40.196	23.909
32	E23A	E23B E23C E23D	0									***4.696***		4.696	4.695	0.001
31	E23E		0									**0.666**		0.666	0.666	0.000
29	E23F		2 32,31									1.610	0.56	6.412	4.215	2.197
30	E23G	E23H E23J	1 29									***2.716***		9.128	6.931	2.197
27	E23K		2 28,30									1.947	0.84	74.340	39.666	34.674
25	E24A		0									**0.510**		0.510	0.510	0.000
26	E24B		1 25									2.694	0.49	2.714	1.445	1.269
21	E24C	E24D	0									***5.575***		5.575	5.576	-0.001
22	E24E	E24F E24G	0									***5.902***		5.902	5.902	0.000
20	E24H		4 27,26,21,22									2.939	2.00	89.470	63.240	26.230
19	E24J		1 20									2.322	1.61	90.182	66.085	24.097
16	E24K		1 19									**1.393**		91.575	67.805	23.770
12	E40A	E40B	0									***7.714***		7.714	4.405	3.309
11	E40C		1 12									3.048	1.38	9.382	4.345	5.037
17	E40D		1 11									3.128	1.33	11.180	5.430	5.750
15	E24L		2 16,17									**1.052**	2.01	101.797	62.376	39.421
14	E24M		1 15									3.117	1.77	103.144	77.744	25.400
47	E10A		0									**17.931**		17.931	17.931	0.000
44	E10B		1 47									25.925	0.11	43.746	20.175	23.571
42	E10C		1 44									20.276	0.21	63.812	28.418	35.394
40	E10D		1 42									19.415	0.28	82.947	62.013	20.934
33	E10E	E10F	1 40									*43.160*	0.77	125.337	94.296	31.041
24	E10H		0									**4.874**		4.874	4.874	0.000
23	E10G	E10J	2 33,24									*42.552*	2.16	170.603	132.157	38.446
13	E10K		1 23									2.887	0.73	172.760	134.213	38.547
4	E32A	E32B E32C	0									***1.634***		1.634	1.634	0.000
2	E31B	E31C E31D E31E	0									***0.495***		0.495	0.494	0.001
1	E31G		0									**0.089**		0.089	0.089	0.000
3	E31F	E31H E32E	3 4,2,1									*1.418*	0.20	3.436	2.786	0.650
5	E33A	E33B	1 3									*0.320*	0.05	3.706	2.354	1.352
8	E33C	E33D E33E	1 5									*1.230*	0.10	4.836	1.691	3.145
9	E33F	E33G	2 14,13									*1.762*	1.30	276.366	124.883	151.483
7	E33H		2 8,9									0.243	0.34	281.105	128.079	153.026
Est	E33H		1 7									0.084		281.189	597.000	-315.811
	F60A		0									**0.035**		0.035	0.035	0.000
58	F60D	F60C F60B	0									**0.215**	0.20	0.015	0.216	-0.201
	F60E		0									***0.006***		0.006	0.006	0.000
51	G30A		0									*1.922*		1.922	1.922	0.000
55	G30B		0									*5.654*		5.654	5.654	0.000
54	G30C		0									*6.081*		6.081	6.081	0.000
53	G30D		2 54,55									*5.112*	0.55	16.297	9.706	6.591
52	G30E		1 53									**0.874**	0.74	16.431	11.077	5.354
56	G30F		0									***1.649***		1.649	1.649	0.000
57	G30G		0									***0.659***		0.659	0.659	0.000
	G30H		0									***0.875***		0.875	0.875	0.000

Figure 3.10: Scenario 4: Conservation targets scenario and ESBC

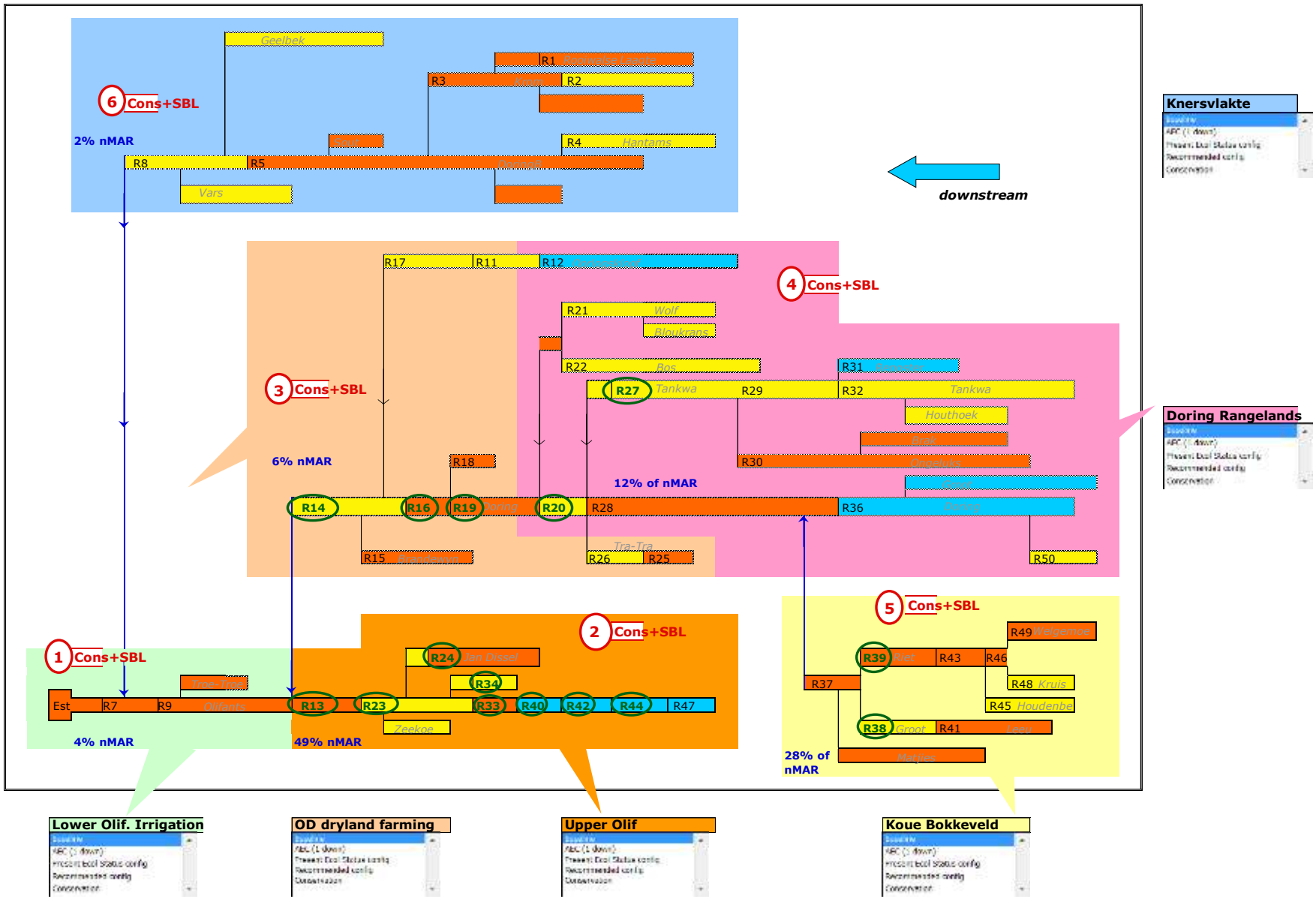

Figure 3.11: Scenario 4 - Conservation targets configuration and EBSC

Table 3.5: Summary of water resource categories for the Conservation targets and PES Configuration

Scenario 5: Present Ecological Status Configuration combined with Conservation Targets

Quaternary	PES&CONS INC	PES&CONS CUM
E10A	C	C
E10B	AB	B
E10C	AB	B
E10D	AB	C
E10E	AB	C
E10F	AB	D
E10G	AB	D
E10H	AB	D
E10J	AB	D
E10K	AB	D
E21A	C	D
E21B	D	D
E21C	AB	C
E21D	AB	D
E21E	AB	B
E21F	AB	AB
E21G	AB	D
E21H	AB	AB
E21J	AB	AB
E21K	AB	B
E21L	AB	AB
E22A	AB	B
E22B	AB	AB
E22C	AB	AB
E22D	AB	B
E22E	AB	B
E22F	B	B
E22G	AB	B
E23A	AB	AB
E23B	AB	AB

Quaternary	PES&CONS INC	PES&CONS CUM
E23C	AB	AB
E23D	AB	AB
E23E	AB	B
E23F	AB	B
E23G	AB	B
E23H	AB	AB
E23J	AB	B
E23K	AB	B
E24A	AB	B
E24B	AB	B
E24C	AB	C
E24D	B	C
E24E	AB	AB
E24F	AB	B
E24G	AB	B
E24H	AB	B
E24J	AB	B
E24K	AB	AB
E24L	AB	B
E24M	AB	B
E31A	AB	B
E31B	AB	B
E31C	AB	B
E31D	B	B
E31E	B	B
E31F	AB	B
E31G	AB	B
E31H	AB	B
E32A	AB	B
E32B	AB	B

Quaternary	PES&CONS INC	PES&CONS CUM
E32C	AB	B
E32D	AB	B
E32E	AB	B
E33A	AB	B
E33B	AB	B
E33C	AB	D
E33D	AB	B
E33E	AB	C
E33F	AB	D
E33G	AB	D
E33H	AB	D
E40A	AB	C
E40B	AB	C
E40C	AB	D
E40D	AB	B
F60A	AB	B
F60B	AB	B
F60C	AB	B
F60D	B	B
F60E	B	B
G30A	AB	C
G30B	AB	C
G30C	AB	C
G30D	AB	C
G30E	C	C
G30F	C	C
G30G	C	C
G30H	C	C

Node	Quaternary Single	Quaternary Multiple	Directly linked nodes	Ecol Category (Node) D C B A/B	PES	Increm Flow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance
48	E21A		0		E/F		**5.096**		5.096	5.096	0.000
49	E21B		0		D		**0.138**		0.138	0.138	0.000
46	E21C		2 49,48		C		0.416	0.18	5.470	8.168	-2.698
45	E21D		0		D		**6.490**		6.490	6.490	0.000
43	E21E		2 46,45		B		0.523	0.40	12.083	27.314	-15.231
39	E21F		1 43		AB		0.739	0.71	12.112	38.635	-26.523
41	E21G		0		D		**7.139**		7.139	7.139	0.000
38	E21H	E21J	1 41		AB		*30.835*	0.15	37.824	56.606	-18.782
37	E21K	E21L	2 38,39		B		*0.937*	0.60	50.273	69.645	-19.372
50	E22C	E22D	0		B		***1.413***		1.413	0.711	0.702
36	E22A	E22B E22E E22F	1 50		B		*9.115*	1.77	8.758	5.427	3.331
28	E22G		2 37,36		B		2.242	1.26	60.013	121.620	-61.607
32	E23A	E23B E23C E23D	0		AB		***8.629***		8.629	8.630	-0.001
31	E23E		0		B		**1.562**		1.562	1.562	0.000
29	E23F		2 32,31		B		1.610	0.56	11.241	9.895	1.346
30	E23G	E23H E23J	1 29		B		***6.376***		17.617	16.272	1.345
27	E23K		2 28,30		B		1.947	0.84	78.737	92.254	-13.517
25	E24A		0		B		**1.197**		1.197	1.197	0.000
26	E24B		1 25		B		2.694	0.49	3.401	3.390	0.011
21	E24C	E24D	0		C		***5.575***		5.575	5.576	-0.001
22	E24E	E24F E24G	0		B		***8.826***		8.826	8.826	0.000
20	E24H		4 27,26,21,22		B		2.939	2.00	97.478	191.933	-94.455
19	E24J		1 20		B		6.562	1.61	102.430	200.591	-98.161
16	E24K		1 19		AB		**3.957**		106.387	266.426	-160.039
12	E40A	E40B	0		C		***5.159***		5.159	2.946	2.213
11	E40C		1 12		D		3.048	1.38	6.827	4.345	2.482
17	E40D		1 11		B		3.128	1.33	8.625	12.741	-4.116
15	E24L		2 16,17		B		**2.460**	2.01	115.462	144.163	-28.701
14	E24M		1 15		B		3.117	1.77	116.809	236.079	-119.270
47	E10A		0		C		**12.064**		12.064	12.061	0.003
44	E10B		1 47		B		25.926	0.11	37.879	47.241	-9.362
42	E10C		1 44		B		20.276	0.21	57.945	66.772	-8.827
40	E10D		1 42		C		19.415	0.28	77.080	71.530	5.550
33	E10E	E10F	1 40		C		*43.160*	0.77	119.470	108.881	10.589
24	E10H		0		D		**4.874**		4.874	4.874	0.000
23	E10G	E10J	2 33,24		D		*42.552*	2.16	164.736	132.157	32.579
13	E10K		1 23		D		2.887	0.73	166.893	134.213	32.680
4	E32A	E32B E32C	0		B		***2.444***		2.444	2.444	0.000
2	E31B	E31C E31D E31E	0		B		***0.739***		0.739	0.739	0.000
1	E31G		0		B		**0.209**		0.209	0.209	0.000
3	E31F	E31H E32E	3 4,2,1		B		*1.418*	0.20	4.610	6.553	-1.943
5	E33A	E33B	1 3		B		*0.320*	0.05	4.880	5.536	-0.656
8	E33C	E33D E33E	1 5		C		*1.230*	0.10	6.010	1.691	4.319
9	E33F	E33G	2 14,13		D		*1.762*	1.30	284.164	124.883	159.281
7	E33H		2 8,9		D		0.243	0.34	290.077	128.079	161.998
Est	E33H		1 7		C		0.084		290.161	597.000	-306.839
	F60A		0				**0.053**		0.053	0.053	0.000
58	F60D	F60C F60B	0				**0.215**	0.20	0.015	0.216	-0.201
	F60E		0				***0.014***		0.014	0.014	0.000
51	G30A		0				*1.922*		1.922	1.922	0.000
55	G30B		0				*5.654*		5.654	5.654	0.000
54	G30C		0				*6.081*		6.081	6.081	0.000
53	G30D		2 54,55				*5.112*	0.55	16.297	9.706	6.591
52	G30E		1 53				**0.874**	0.74	16.431	11.077	5.354
56	G30F		0				***2.553***		2.553	2.553	0.000
57	G30G		0				***1.021***		1.021	1.021	0.000
	G30H		0				***1.349***		1.349	1.349	0.000

Figure 3.12: Scenario 5: Conservation targets scenario and PES

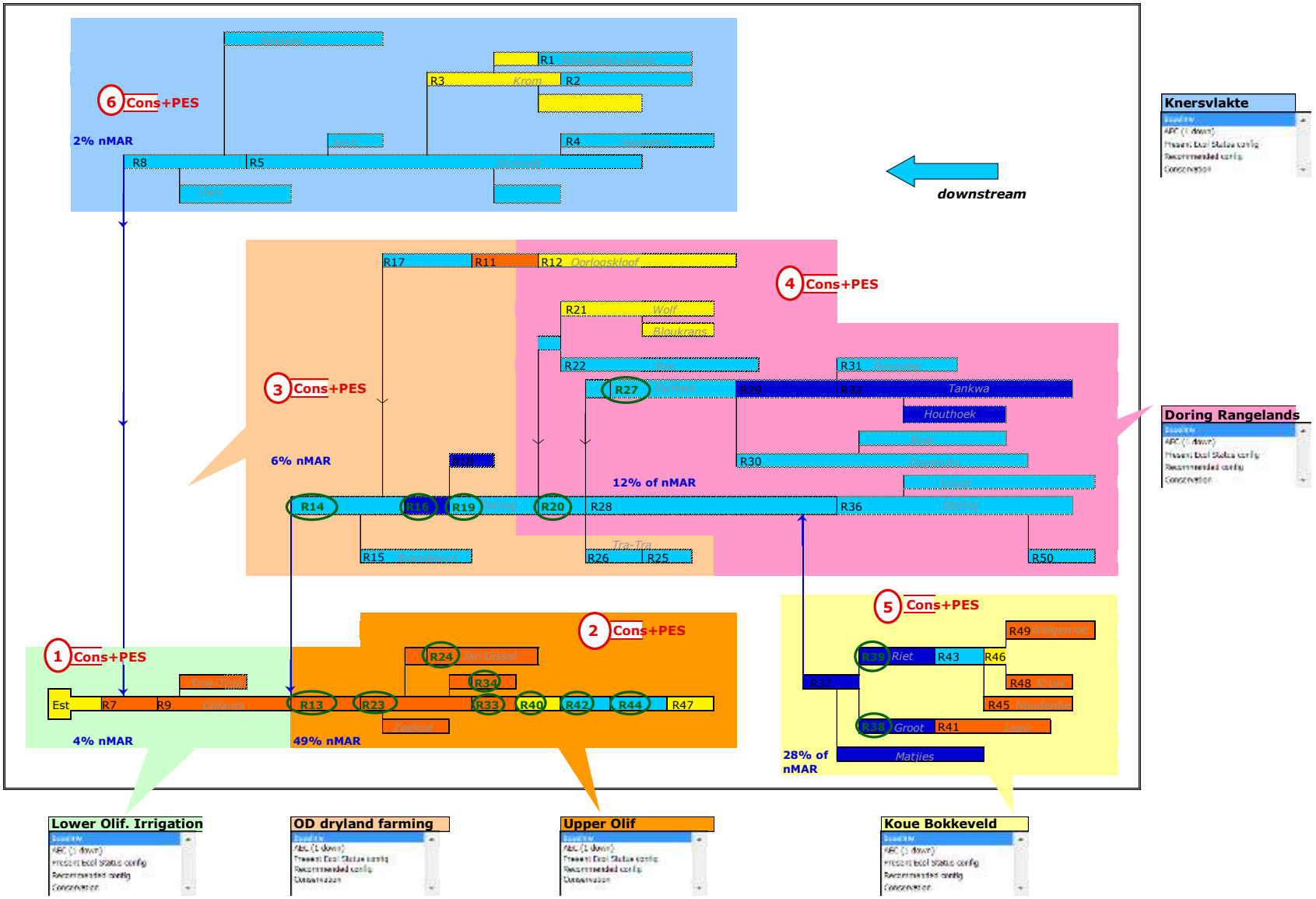

Figure 3.13: Scenario 5 - Conservation targets configuration and PES

4. EVALUATION OF STARTER CONFIGURATIONS

Table 4.1 below provides a summary of the category selection per quaternary catchment for the various scenarios. This provides a guideline of the possible categories that could be selected per quaternary catchment for the recommended scenario.

Table 4.1: Summary of ecological categories per quaternary catchment for the five scenarios

	ESBC	ESBC	PES	PES	RDM	RDM	ESBC&CONS	ESBC&CONS	PES & CONS	PES & CONS
Quat	INC	CUM	INC	CUM	INC	CUM	INC	CUM	INC	CUM
E10A	C	B	C	C	C	D	C	B	C	C
E10B	D	B	C	B	B	B	AB	B	AB	B
E10C	D	B	B	B	C	B	AB	B	AB	B
E10D	D	B	C	C	D	C	AB	B	AB	C
E10E	D	B	C	C	D	C	AB	B	AB	C
E10F	D	D	C	D	D	D	AB	D	AB	D
E10G	D	C	C	D	C	C	AB	C	AB	D
E10H	D	D	D	D	AB	D	AB	D	AB	D
E10J	D	C	D	D	D	D	AB	C	AB	D
E10K	D	D	D	D	D	D	AB	D	AB	D
E21A	C	C	C	D	C	D	C	C	C	D
E21B	D	D	D	D	AB	C	D	D	D	D
E21C	D	D	B	C	D	C	AB	D	AB	C
E21D	C	C	D	D	C	D	AB	C	AB	D
E21E	D	D	C	B	D	C	AB	D	AB	B
E21F	D	D	C	AB	D	C	AB	D	AB	AB
E21G	D	D	D	D	AB	C	AB	D	AB	D
E21H	D	C	B	AB	AB	C	AB	C	AB	AB
E21J	D	C	AB	AB	AB	C	AB	C	AB	AB
E21K	D	D	B	B	D	C	AB	D	AB	B
E21L	D	D	AB	AB	D	C	AB	D	AB	AB
E22A	D	B	AB	B	B	B	D	B	AB	B
E22B	D	B	AB	AB	B	B	AB	B	AB	AB
E22C	C	C	B	AB	AB	C	AB	C	AB	AB
E22D	C	C	AB	B	AB	C	AB	C	AB	B
E22E	D	B	AB	B	B	B	AB	B	AB	B
E22F	D	B	B	B	B	B	D	B	B	B
E22G	D	D	AB	B	D	B	AB	D	AB	B
E23A	C	C	AB	AB	AB	C	AB	C	AB	AB
E23B	C	C	AB	AB	AB	C	AB	C	AB	AB
E23C	C	C	AB	AB	AB	C	AB	C	AB	AB
E23D	C	C	AB	AB	AB	C	AB	C	AB	AB
E23E	D	D	AB	B	AB	C	AB	D	AB	B
E23F	D	B	B	B	D	C	AB	B	AB	B
E23G	D	D	B	B	D	C	AB	D	AB	B
E23H	D	D	AB	AB	D	C	AB	D	AB	AB
E23J	D	D	AB	B	D	C	AB	D	AB	B
E23K	D	C	AB	B	D	D	AB	C	AB	B
E24A	D	D	B	B	AB	B	AB	D	AB	B
E24B	D	C	B	B	B	B	AB	C	AB	B
E24C	C	C	B	C	AB	C	AB	C	AB	C
E24D	C	C	B	C	AB	C	C	C	B	C
E24E	C	C	AB	AB	AB	C	AB	C	AB	AB
E24F	C	C	AB	B	AB	C	AB	C	AB	B
E24G	C	C	AB	B	AB	C	AB	C	AB	B
E24H	D	C	AB	B	D	B	AB	C	AB	B
E24J	D	D	AB	B	D	B	AB	D	AB	B
E24K	D	D	AB	AB	D	B	AB	D	AB	AB
E24L	D	D	C	B	D	C	AB	D	AB	B
E24M	D	C	C	B	D	B	AB	C	AB	B

Table 4.1 (*continue)*: Summary of ecological categories per quaternary catchment for the five scenarios

	ESBC	ESBC	PES	PES	RDM	RDM	ESBC&CONS	ESBC&CONS	PES&CONS	PES&CONS
Quat	INC	CUM	INC	CUM	INC	CUM	INC	CUM	INC	CUM
E31A	D	D	B	B	B	B	AB	D	AB	B
E31B	C	C	B	B	AB	B	AB	C	AB	B
E31C	C	C	B	B	AB	B	AB	C	AB	B
E31D	C	C	B	B	AB	B	C	C	B	B
E31E	C	C	B	B	AB	B	C	C	B	B
E31F	D	C	B	B	D	C	AB	C	AB	B
E31G	D	D	B	B	D	C	AB	D	AB	B
E31H	D	C	B	B	D	C	AB	C	AB	B
E32A	C	C	B	B	AB	C	AB	C	AB	B
E32B	C	C	B	B	AB	C	AB	C	AB	B
E32C	C	C	B	B	AB	C	AB	C	AB	B
E32D	D	C	B	B	C	C	AB	C	AB	B
E32E	D	C	B	B	D	C	AB	C	AB	B
E33A	D	D	B	B	D	C	AB	D	AB	B
E33B	D	D	B	B	D	C	AB	D	AB	B
E33C	D	D	D	D	D	C	AB	D	AB	D
E33D	D	D	B	B	D	C	AB	D	AB	B
E33E	D	D	B	C	D	C	AB	D	AB	C
E33F	D	D	D	D	D	D	AB	D	AB	D
E33G	D	D	C	D	D	D	AB	D	AB	D
E33H	D	D	B	D	D	D	AB	D	AB	D
E40A	B	B	C	C	AB	C	AB	B	AB	C
E40B	B	B	D	C	AB	C	AB	B	AB	C
E40C	D	C	B	D	D	B	AB	C	AB	D
E40D	D	C	B	B	D	B	AB	C	AB	B
F60A	D	D	B	B	C	C	AB	D	AB	B
F60B	C	B	B	B	C	C	AB	B	AB	B
F60C	C	C	B	B	C	C	AB	C	AB	B
F60D	C	D	B	B	C	C	C	D	B	B
F60E	D	D	B	B	C	C	D	D	B	B
G30A	D	D	C	C	C	C	AB	D	AB	C
G30B	B	B	C	C	C	C	AB	B	AB	C
G30C	C	C	C	C	C	C	AB	C	AB	C
G30D	B	C	C	C	C	C	AB	C	AB	C
G30E	D	D	C	C	C	C	D	D	C	C
G30F	D	D	C	C	C	C	D	D	C	C
G30G	D	D	C	C	C	C	D	D	C	C
G30H	D	D	C	C	C	C	D	D	C	C

For the possible recommended scenario a combination of the above scenarios was sought, where the following objectives were also set:

- To achieve the balance in the river EWRs for the WMA (no deficit balance for any of the quaternaries in the balance sheet) - it was however accepted that the desired estuarine requirements for the Olifants Doring River System could not be achieved as a result of the river EWRs alone, however a maximum surplus balance at lowest point in the river should be strived for;
- To attempt to meet the FEPA requirements as far as possible;
- To seek the most feasible configuration in terms of the current ecological condition and water use in the WMA; and
- To allow for future water use as far as possible.

5. RECOMMENDED CATCHMENT CONFIGURATION SCENARIO

Table 5.1 provides the recommended catchment configuration for the Olifants Doorn WMA taking into account the objectives as mentioned in the previous section. Comment is also given regarding the reasons for the selected ecological category. Certain quaternaries within the catchment are critical for providing flow to the downstream reaches of the catchment and these are also highlighted in yellow in the table. Figure 5.1 shows the water balance in terms of the EWR for the WMA and Figure 5.2 the flow diagram for the recommended configuration.

Table 5.1: Recommended catchment configuration for the Olifants Doring WMA

NODE	QUAT	REC SCENARIO		COMMENT
		INC	CUM	
R 47	**E10A**	C	C	Incremental catchment; PES = C; maintain C for downstream
R 44	**E10B**	AB	C	Incremental AB for FEPA; Cum PES=B; maintain B for downstream
R 42	**E10C**	AB	C	Incremental AB for FEPA; Cum PES=B; maintain B for downstream & FEPA
R 40	**E10D**	AB	C	Incremental AB for FEPA; Cum PES=C; maintain C for downstream
	E10E	AB	C	Incremental AB for FEPA; Cum PES=C; maintain C for downstream
R 33	**E10F**	AB	D	Incremental AB for FEPA; Cum PES=D; maintain D (EWR 1=D CUM)
R 34	**E10G**	AB	D	Incremental AB for FEPA; Cum PES=D; maintain D (EWR 3 =B INC)
R 24	E10H	AB	D	Incremental AB for FEPA; Cum PES=D; maintain D
R 23	E10J	AB	D	Incremental AB for FEPA; Cum PES=D; maintain D
R 13	E10K	AB	D	Incremental AB for FEPA; Cum PES=D; maintain D (EWR 2=D CUM)
R 48	**E21A**	D	D	Incremental catchment; Cum PES = D; maintain D
R 49	E21B	D	D	Incremental catchment; Cum PES = D; maintain D
R 46	E21C	AB	C	Incremental AB for FEPA; Cum PES=C; maintain C for downstream
R 45	**E21D**	AB	D	Incremental catchment; PES=D; maintain D
R 43	E21E	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 39	E21F	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 41	**E21G**	AB	D	Incremental AB for FEPA; Cum PES=B; maintain D for downstream
	E21H	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 38	E21J	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream (EWR 6 =B/C CUM)
	E21K	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 37	E21L	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E22A	AB	B	Incremental B for FEPA; Cum PES=B; maintain B for downstream
	E22B	AB	B	Incremental B for FEPA; Cum PES=B; maintain B for downstream
	E22C	AB	B	Incremental catchment; PES = B; maintain C for downstream
R 50	E22D	AB	B	Incremental catchment; PES = B; maintain C for downstream
	E22E	AB	B	Incremental B for FEPA; Cum PES=B; maintain B for downstream
R 36	E22F	B	B	Incremental B; Cum PES=B; maintain B for downstream
R 28	E22G	AB	C	Incremental B; Cum PES=B; maintain C for downstream
	E23A	AB	C	Incremental catchment; PES = AB; maintain C for downstream
	E23B	AB	C	Incremental AB for FEPA; Cum PES=AB; maintain C for downstream
R 29	E23C	AB	C	Incremental AB for FEPA; Cum PES=AB; maintain C for downstream
R 32	E23D	AB	C	Incremental AB for FEPA; Cum PES=AB; maintain C for downstream
	E23E	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 31	E23F	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E23G	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E23H	AB	C	Incremental AB for FEPA; Cum PES=AB; maintain C for downstream
R 30	E23J	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream

Table 5.1 (*continue)*: Recommended catchment configuration for the Olifants Doring WMA

NODE	QUAT	REC SCENARIO		COMMENT
		INC	CUM	
R 27	E23K	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 25	E24A	AB	C	Incremental catchment; PES = B; maintain C for downstream
R 26	E24B	AB	C	Incremental AB for FEPA; Cum PES = B; maintain C for downstream
	E24C	AB	C	Incremental catchment; Cum PES = C; maintain C for downstream
R 21	E24D	C	C	Incremental PES=B; Cum PES= C; maintain C for downstream
	E24E	AB	B	Incremental catchment; PES = AB; maintain B for downstream
	E24F	AB	B	Incremental AB for FEPA; Cum PES=B; maintain B for downstream
R 22	E24G	AB	B	Incremental AB for FEPA; Cum PES=B; maintain B for downstream
R 20	E24H	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 19	E24J	AB	C	Incremental AB for FEPA; Cum PES=B; maintain B for downstream (EWR 4 =B CUM)
R 16	E24K	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 15	E24L	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream (EWR 5= B CUM)
R 14	E24M	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E31A	AB	C	Incremental catchment; PES = B; maintain C for downstream
	E31B	AB	C	Incremental catchment; PES = B; maintain C for downstream
	E31C	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E31D	C	C	Incremental PES=B; Cum PES=B; maintain C inc and cum for downstream
R 2	E31E	C	C	Incremental PES=B; Cum PES=B; maintain C inc and cum for downstream
	E31F	AB	D	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 1	E31G	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E31H	AB	D	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E32A	AB	C	Incremental catchment; PES = C; maintain C for downstream
	E32B	AB	C	Incremental catchment; PES = C; maintain C for downstream
R 4	E32C	AB	C	Incremental catchment; PES = C; maintain C for downstream
	E32D	AB	D	Incremental catchment; PES = C; maintain D for downstream
R 8	E32E	AB	D	Incremental catchment; PES = C; maintain C for downstream
	E33A	AB	C	Incremental catchment; PES = B; maintain C for downstream
R 5	E33B	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E33C	AB	C	Incremental AB for FEPA; Cum PES=D; maintain C for downstream
	E33D	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
R 3	E33E	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	E33F	AB	D	Incremental AB for FEPA; Cum PES=C; maintain D for downstream
R 9	E33G	AB	D	Incremental AB for FEPA; Cum PES=C; maintain D for downstream
R 7	E33H	AB	D	Incremental AB for FEPA; Cum PES=C; maintain D for downstream (Estuary EWR = C)
R 12	**E40A**	AB	C	Incremental catchment; PES = C; maintain C for downstream
	E40B	AB	C	Incremental AB for FEPA; Cum PES=C; maintain C for downstream
R 11	E40C	AB	D	Incremental AB for FEPA; Cum PES=D; maintain D for downstream
R 17	E40D	AB	C	Incremental AB for FEPA; Cum PES=B; maintain C for downstream
	F60A	AB	C	Incremental catchment; PES = C; maintain C for downstream
	F60B	AB	B	Incremental catchment; PES = C; maintain C for downstream
	F60C	AB	B	Incremental PES=B; Cum PES=B; maintain C inc and cum for downstream
R 58	F60D	B	B	Incremental PES=B; Cum PES=B; maintain C inc and cum for downstream
	F60E	C	C	Incremental catchment; PES = B; maintain C for downstream
R 51	G30A	AB	C	Incremental catchment; PES = C; maintain C for downstream
R 55	**G30B**	AB	C	Incremental catchment; PES = C; maintain C for downstream
R 54	**G30C**	AB	C	Incremental catchment; PES = C; maintain C for downstream
R 53	**G30D**	AB	C	Incremental PES=C; Cum PES=C; maintain C inc and cum for downstream
R 52	G30E	C	C	Incremental PES=B; Cum PES=B; maintain C inc and cum for downstream
R 56	G30F	D	D	Incremental catchment; PES = C; maintain D for downstream
R 57	G30G	D	D	Incremental catchment; PES = C; maintain D for downstream
R 58	G30H	D	D	Incremental catchment; PES = C; maintain D for downstream

Node	Quaternary		Directly linked nodes	Ecol Category (Node)				PES	IncremFlow Category				Increm input	Channel evap	Cumul flow	EWR at node	Balance
	Single	Multiple		D	C	B	A/B		D	C	B	A/B					
48	E21A		0					E/F					**5.096**		5.096	5.096	0.000
49	E21B		0					D					**0.138**		0.138	0.138	0.000
46	E21C		2 49,48					C					0.416	0.18	5.470	8.168	-2.698
45	E21D		0					D					**6.490**		6.490	6.490	0.000
43	E21E		2 46,45					B					0.523	0.40	12.083	18.359	-6.276
39	E21F		1 43					AB					0.739	0.71	12.112	20.821	-8.709
41	E21G		0					D					**7.139**		7.139	7.139	0.000
38	E21H	E21J	1 41					AB					*30.835*	0.15	37.824	30.502	7.322
37	E21K	E21L	2 38,39					B					*0.937*	0.60	50.273	46.812	3.461
50	E22C	E22D	0					B					***1.413***		1.413	0.711	0.702
36	E22A	E22B E22E E22F	1 50					B					*9.115*	1.77	8.758	5.427	3.331
28	E22G		2 37,36					B					2.242	1.26	60.013	47.204	12.809
32	E23A	E23B E23C E23D	0					AB					***4.696***		4.696	4.695	0.001
31	E23E		0					B					**1.045**		1.045	1.045	0.000
29	E23F		2 32,31					B					1.610	0.56	6.791	6.616	0.175
30	E23G	E23H E23J	1 29					B					***4.265***		11.056	10.880	0.176
27	E23K		2 28,30					B					1.947	0.84	72.176	61.812	10.364
25	E24A		0					B					**0.801**		0.801	0.801	0.000
26	E24B		1 25					B					2.694	0.49	3.005	2.267	0.738
21	E24C	E24D	0					C					***5.575***		5.575	5.576	-0.001
22	E24E	E24F E24G	0					B					***8.826***		8.826	8.826	0.000
20	E24H		4 27,26,21,22					B					2.939	2.00	90.521	74.662	15.859
19	E24J		1 20					B					6.562	1.61	95.473	78.017	17.456
16	E24K		1 19					AB					**2.167**		97.640	80.046	17.594
12	E40A	E40B	0					C					***5.159***		5.159	2.946	2.213
11	E40C		1 12					D					3.048	1.38	6.827	4.345	2.482
17	E40D		1 11					B					3.128	1.33	8.625	5.430	3.195
15	E24L		2 16,17					B					**1.646**	2.01	105.901	96.754	9.147
14	E24M		1 15					B					3.117	1.77	107.248	91.768	15.480
47	E10A		0					C					**7.834**		7.834	7.834	0.000
44	E10B		1 47					B					25.925	0.11	33.649	28.071	5.578
42	E10C		1 44					B					20.276	0.21	53.715	39.678	14.037
40	E10D		1 42					C					19.415	0.28	72.850	71.530	1.320
33	E10E	E10F	1 40					C					*43.160*	0.77	115.240	94.296	20.944
24	E10H		0					D					**4.874**		4.874	4.874	0.000
23	E10G	E10J	2 33,24					D					*42.552*	2.16	160.506	132.157	28.349
13	E10K		1 23					D					2.887	0.73	162.663	134.213	28.450
4	E32A	E32B E32C	0					B					***1.634***		1.634	1.634	0.000
2	E31B	E31C E31D E31E	0					B					***0.495***		0.495	0.494	0.001
1	E31G		0					B					**0.140**		0.140	0.140	0.000
3	E31F	E31H E32E	3 4,2,1					B					*1.418*	0.20	3.487	2.786	0.701
5	E33A	E33B	1 3					B					*0.320*	0.05	3.757	3.702	0.055
8	E33C	E33D E33E	1 5					C					*1.230*	0.10	4.887	2.656	2.231
9	E33F	E33G	2 14,13					D					*1.762*	1.30	270.373	124.883	145.490
7	E33H		2 8,9					D					0.243	0.34	275.163	128.079	147.084
Est	E33H		1 7					C					0.084		275.247	597.000	-321.753
	F60A		0					C					**0.035**		0.035	0.035	0.000
58	F60D	F60C F60B	0					C					**0.215**	0.20	0.015	0.216	-0.201
	F60E		0					C					***0.009***		0.009	0.009	0.000
51	G30A		0					C					*1.922*		1.922	1.922	0.000
55	G30B		0					C					*3.113*		3.113	3.113	0.000
54	G30C		0					C					*3.720*		3.720	3.720	0.000
53	G30D		2 54,55					C					*5.112*	0.55	11.395	9.706	1.689
52	G30E		1 53					C					**0.874**	0.74	11.529	11.077	0.452
56	G30F		0					C					***1.649***		1.649	1.649	0.000
57	G30G		0					C					***0.659***		0.659	0.659	0.000
	G30H		0					C					***0.875***		0.875	0.875	0.000

Figure 5.1: Recommended Catchment Configuration for the Olifants Doorn WMA

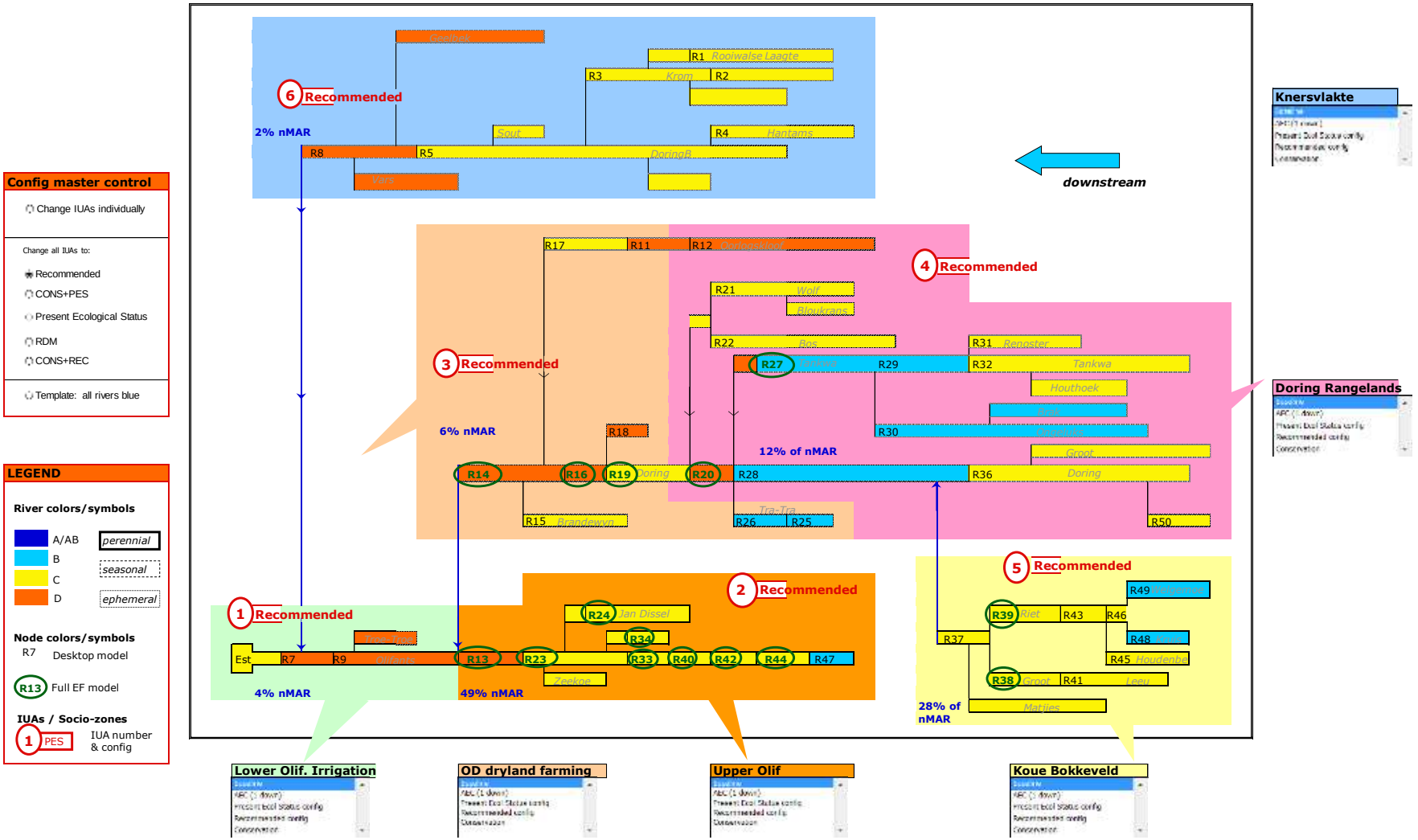

Figure 5.2: Recommended Catchment Configurations Scenario

The few deficits (shortage to comply with the ecological Reserve) balances in the above EWR Balance Sheet result from the fact that quaternary catchment E21A and E21D are significant contributors to the flow in the river reaches below these sub-catchments, however the upper reaches are already in a largely modified state. A EWR for a D ecological category could thus only be likely to be achievable for these two quaternary catchments. This is however not sufficient to meet the EWR for a C category that should be achieved in the downstream quaternary catchments of E21C, E and F. As previously stated the EWR for the estuary will also not be achieved as significantly more water is required to maintain the estuary in a similar ecological state to the river upstream.

The recommended catchment configuration is summarised in Table 5.2 according to the overall Class per IUA. If one uses the cumulative categories to derive the IUA classes, all of the areas are Class 3 (Heavily used) with only the Olifants Doring Dry lands classed as Class 1 (Minimally used). The guidelines (as provided in the classification guideline documents) for the calculation of the IUA Class are provided in Table 5.3.

Table 5.2: IUA Class assignations for catchment configurations

Integrated Units of Analysis	**Recommended Scenario**		
	Incremental	**Cumulative**	**Combined**
Knersvlakte	Class 1	**Class 3**	Class 1
Koue Bokkeveld	Class 1	**Class 3**	Class 1
Doring Rangelands	Class 1	**Class 3**	Class 1
Olifants Doring Drylands	Class 1	**Class 1**	Class 1
Lower Olifants Irrigation Area	Class 1	**Class 3**	Class 1
Upper Olifants Irrigation Area	Class 1	**Class 3**	Class 1
Sandveld	Class 1	**Class 3**	Class 3

Table 5.3: Guidelines for the calculation of the IUA Class for the recommended scenario

IUA Class		**Percentage category representation at units represented by biophysical nodes IUA**				
		≥A/B	**≥B**	**≥C**	**≥D**	**<D**
Class 1		≥40	≥60	≥80	≥99	-
Class 2		-	≥40	≥70	≥95	-
Class 3	**Either**	-	-	≥30	≥80	-
	Or		-	-	100	-

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