DEPARTMENT: WATER AFFAIRS AND FORESTRY
DIRECTORATE: RESOURCE DIRECTED MEASURES

OLIFANTS/DORING CATCHMENT ECOLOGICAL WATER REQUIREMENTS STUDY

RIVERINE RDM REPORT

VOLUME 2: ENVIRONMENTAL WATER REQUIREMENTS

FINAL
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DIRECTOR

Milestone (Reporting) List

Milestone Report		Due Date	Date first draft submitted	Date final report submitted
Project Report 1:	Inception Report	October 2003	September 2003	December 2003
Project Report 2:	Delineation Report	March 2004	April 2004	May 2004
Project Report 3:	Groundwater TOR	May 2004	December 2003	March 2004
Project Report 4.1:	Riverine RDM Report (VOL 1).	March 2005	March 2005	May 2005
Project Report 4.2:	*Riverine RDM Report (VOL 2).*	*March 2005*	*March 2005*	*May 2005*
Project Report 4.3:	Riverine Water Quality Reserve (VOL 3).	June 2005		
Project Report 5:	Estuarine RDM Report.	July 2005		
Project Report 6:	Scenario Report	May 2005		
Project Report 7:	Monitoring Appendix	October 2005		
Project Report 8:	Main Summary Report.	December 2005		
Scenario-creation database for the rivers (in electronic format).		December 2005		

EXECUTIVE SUMMARY

OLIFANTS/DORING CATCHMENT ECOLOGICAL WATER REQUIREMENTS STUDY –

RIVERINE RDM REPORT

VOLUME 2: ENVIRONMENTAL WATER REQUIREMENTS

INTRODUCTION

This report forms part of a Comprehensive Assessment of the Ecological Water Requirements of the Olifants/Doring River Catchment, initiated and funded by the Department of Water Affairs and Forestry: Directorate Resource Directed Measures (RDM). The project is being managed for the Client by Ninham Shand Consulting Services. The main technical consultant for the project is Southern Waters Ecological Research and Consulting cc, with the following main sub-consultants:

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Project duration is from July 2003 to March 2006.

This Riverine RDM Report is the fourth in a series of eight project-related reports, and is comprised of three separate volumes. The aims of the report are:

Volume 1:

- to provide the overall Present Ecological Status of the river reaches represented by each of six EWR sites;
- to provide the information (data and literature reviews) on which the specialists based their deliberations;
- to provide the hydrological information on which the deliberations were based.

Volume 2:

- to explain the application of the DRIFT methodology in the Olifants/Doring Rivers;
- to summarise the results obtained from the DRIFT Database;
- to provide three detailed scenarios linking different volumes of river flow to river condition for each of the six EWR sites.

Volume 3:

- to provide the Water Quality Reserve for the relevant reaches of the Olifants/Doring Rivers.

EWR SITES

In this study, funds were available for the consideration of six EWR sites, the locations of which are provided in Figure E.1 and Table E.2.

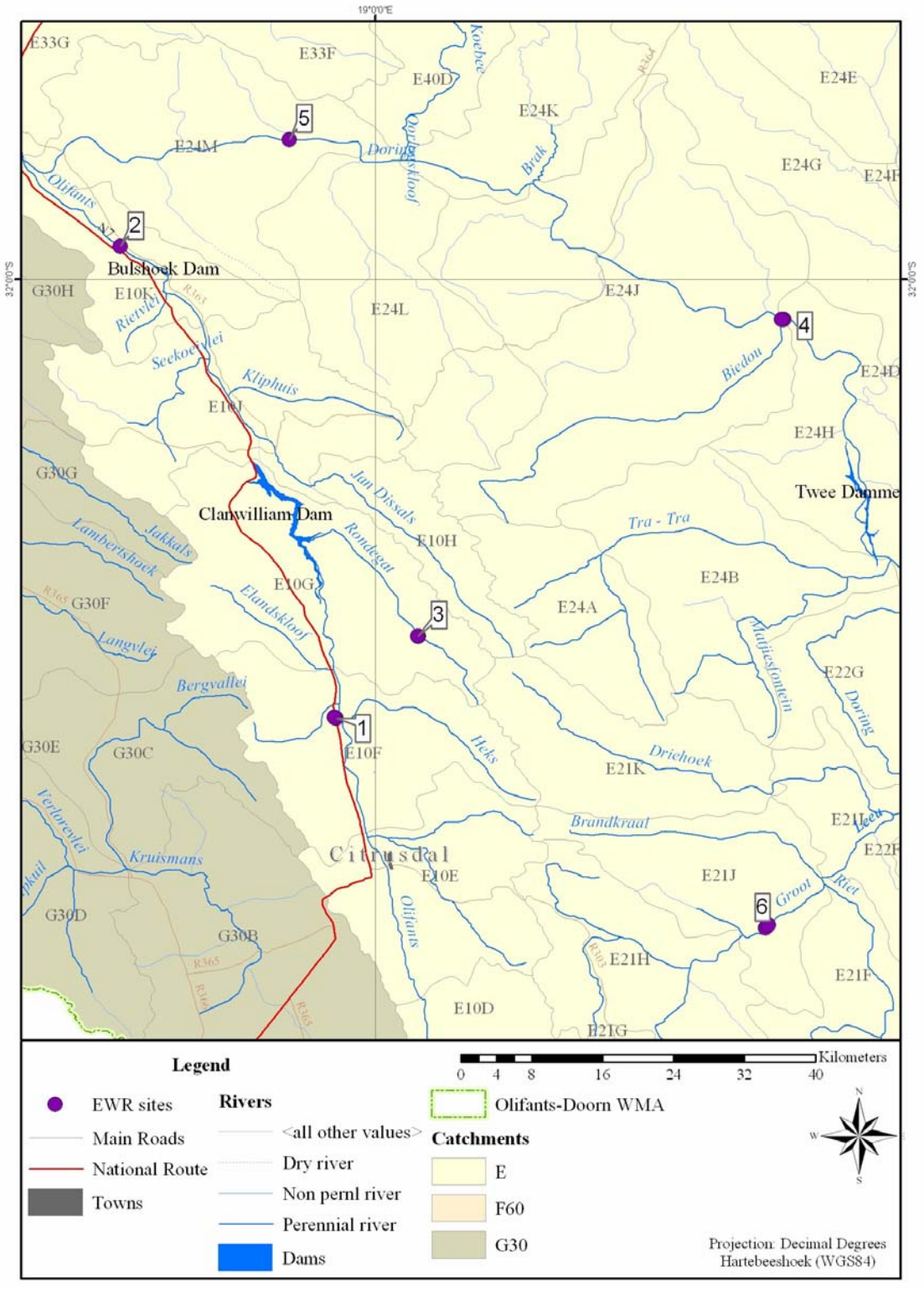

Figure E.1 Map of the study area showing the location of the six EWR sites.

Table E.1 Locations of each of the six EWR sites selected.

Site No[1].	River	Site Name	Description	Latitude	Longitude
1a 1b	Olifants	Olifants at Hex River	N7 downstream of the confluence with the Hex River.	32°26.764 32°26.680	18°57.601 18°57.504
2	Olifants	Olifants at Alwynskop	Downstream of Bulshoek Barrage, just downstream of Cascade Pools.	31°57.974	18°44.463
3a 3b	Rondegat	Rondegat at Algeria	Upstream of the Algeria staff accommodation, on the road between Algeria and Clanwilliam.	32°21.760 32°21.739	19°02.618 19°02.593
4a 4b	Doring	Doring at Biedou	Immediately upstream of the confluence with the Biedou River	32°02.410 32°02.416	19°24.896 19°24.783
5	Doring	Doring at Ou Drif	At Ou Drif.	31°51.446	18°54.754
6a 6b	Groot	Groot at Mount Cedar	Upstream of the bridge at Groot Rivier.	32°39.552 32°39.377	19°23.786 19°23.982

PRESENT ECOLOGICAL STATUS, RECOMMENDED ECOLOGICAL CATEGORY AND ALTERNATIVE ECOLOGICAL CATEGORY

The Present Ecostatus, and the Recommended Ecological Category (REC) and Alternative Ecological Category (AEC) for which Reserves are presented in this report, are indicated in Table E.2.

Table E.2. The Present Ecostatus, and the Recommended Ecological Category (REC) and Alternative Ecological Category (AEC) for which Reserves are presented in this report.

EWR Site	Present Ecostatus	REC	AEC
Site 1	D	D	None
Site 2	E	D	None
Site 3	B	B	C
Site 4	B/C	B	C
Site 5	B	B	C
Site 6	B/C	B/C	C

[1] The notations a and b in Table 2.1 refer to the transects that were surveyed in at each site.

RECOMMENDED EWRS

The annual estimates of the Reserves for the REC for each EWR site are given in Table E.3.

Table E.3. The annual estimates of the Reserves for the REC for each EWR site.

Site	Portion of the EWR	Recommended Ecological Category (REC)	Calculation Notation	MCMa^{-1}	%nMAR	%nMAR, excluding ≥1:2 year floods[2]
EWR SITE 1	MAINTENANCE TOTAL (Volume)	D	DRIFT Annual[3]	185.9	55	25%
			Long-term average[4]	128.57	38.5	
EWR SITE 2	MAINTENANCE TOTAL (Volume)	D	DRIFT Annual	194	38	N/a
			Long-term average	Not available for this site.		
EWR SITE 3	MAINTENANCE TOTAL (Volume)	B	DRIFT Annual	4.83	63	38%
			Long-term average	4.06	53	
EWR SITE 4	MAINTENANCE TOTAL (Volume)	B	DRIFT Annual	277	66	34%
			Long-term average	199	47	
EWR SITE 5	MAINTENANCE TOTAL (Volume)	B	DRIFT Annual	310	61	33%
			Long-term average	234.39	46	
EWR SITE 6	MAINTENANCE TOTAL (Volume)	B/C	DRIFT Annual	79	57	34%
			Long-term average	63	46	

KEY ISSUES PERTAINING TO THE RESERVE DELIBERATIONS AT EACH EWR SITE

EWR Site 1

- The Present Ecostatus is driven predominately by non-flow related issues, such as bulldozing of the channel, cultivation of the alluvial floodplains and encroachment of alien and other riparian vegetation.
- Present day hydrology is reasonable with the notable exception of the summer months, when the naturally perennial Olifants River is pumped dry, sometimes for up to several weeks.
- There is some opportunity for further abstractions from the river while still maintaining a D-category river BUT only if some summer flows are reinstated.
- Opportunities for additional abstraction are limited by the fact that hydrology is presently supporting the D-category condition of the river, whereas other 'drivers' of river condition, such as geomorphology are in an E. If the hydrological regime is further restricted, this will result in the river falling to an E category.
- The most reliable way to increase the level of abstraction possible, and still maintain a D-category river, is to implement river restoration aimed at reversing some of the non-flow related geomorphological impacts.
- Only one scenario is presented, *viz*. maintain a D-category as this can best be made a C-category by restoration work addressing non-flow related issues.
- The Recommended Ecological Category (REC) is a D-category.

[2] For comparison with Desktop results.

[3] Calculated as the volume of water required to meet the full requirements.

[4] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.

- Environmental Flow to support REC = 186[5] MCM per annum (i.e., 55% nMAR).
- A dam in the upper reaches of the Olifants River, i.e., upstream of EWR Site 1 would negatively affect the hydrological and geomorphological condition of the system (with knock-on effects on other aspects of the river ecosystem) mainly through the reduction in variability of the large to medium sized floods, and through the reduction of sediment supply.

EWR Site 2

- The Present Ecostatus is E-category with the deviations from natural predominately driven by flow-related issues. These are primarily attenuation of floods and severely reduced dry season lowflows as a result of Clanwilliam Dam and Bulshoek Barrage.
- Additional impacts include reduced sediment supply, encroachment of reeds and palmiet, and cultivation of flood terraces.
- Recent repair work at Bulshoek Barrage has resulted in stoppage of leaks from the dam, which were in the order of 1 cumec in the wet season (Francois van Heerden, DWAF, pers. comm.).
- The EWR work reported here was done under conditions prior to the repair work, i.e., present Ecostatus assumes leakage from Bulshoek Barrage.
- Opportunities for improving the Present Ecostatus through releases from Clanwilliam Dam/Bulshoek Barrage are limited.
- Only one scenario is presented, *viz*. achieve a D-category, as there is little or no opportunity for improvement to a C-category.
- At the EWR Workshop water was 'added-back' into the river at EWR Site 2 to arrive at the predictions generated, except for some of the intra-annual floods, where the consequences of both reduction and increase in flood frequency was considered.
- Due to a lack of hydrological data for the site, the floods with a return period of 2 years and greater were excluded from the analysis.
- The Recommended Ecological Category (REC) is a D-category.
- Environmental Flow to support REC = 194 MCM per annum (i.e., 38% nMAR) – excl. inter-annual flood volumes.
- *The risk of the recommended Environmental Flow NOT supporting the REC is extremely high.*
- *From the perspective of the entire Olifants-Doring River it is recommended that consideration be given to not building a major impoundment or abstraction weir on the Doring River but instead maximising yield from Clanwilliam Dam/Bulshoek Barrage through not releasing an EWR. This is an issue that could be addressed in a Classification Process.*
- A 'reduced' EWR, in the region of 10-17% of the nMAR would result in an improvement in Present Ecostatus, albeit not to a D-category.

EWR Site 3

- The Present Ecostatus is B-category, with the deviations from natural predominately driven by non-flow related issues, such as historic manipulation of the floodplain and invasion of alien vegetation into the riparian zone.
- There are NO gauging weirs on the Rondegat River and this affected the reliability of the hydrology. Nonetheless, it is unlikely that there are major alterations to flow regime, as all water abstraction is either run-of river or as a result of minor changes in landuse (in particular, forestry).
- Fish communities are in a pristine condition in the upper half of the Rondegat River, largely because of the absence of alien predators such as bass.
- Opportunities for improving the condition through flow manipulations are deemed to be limited.

[5] If river restoration works restore geomorphology to a high D *AND* summer flows were reinstated then this figure could drop as low as *c.* 83 MCM (c. 25% nMAR).

- Two EWR Options are presented, *viz*. achieve a B-Category and to achieve a C-Category, as there is little opportunity for improvement to an A-Category using flow.
- The Recommended Ecological Category (REC) is a B-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B-category) = 4.8 MCM per annum (i.e., 63% nMAR).
- Environmental Flow to support AEC (C-category) = 2.0 MCM per annum (i.e., 26% nMAR).
- Given the conservation importance of this system (and other tributaries feeding the Olifants River[6]), the precautionary principle was applied.

EWR Site 4

- The Present Ecostatus is B/C-category.
- The Recommended Ecological Category (REC) is a B-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B-category) = 277 MCM per annum (i.e., 66% nMAR – incl. volume of inter-annual floods).
- Environmental Flow to support AEC (C-category) = 136 MCM per annum (i.e., 33% nMAR – incl. volume of inter-annual floods).
- The flows recommended for BOTH scenarios provided here represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation.
- At the time of this study, no data or models were available to assess the implications of flow changes on the unique water chemistry of the Doring River. It is thus, highly possible that the water quality implications of the changes in flow are underestimated.
- The invasion of biota into the Doring River, primarily *Nerium oleander*, is a major threat to the future ecostatus of this system.
- The physical presence (i.e., aside from influence on the flow regime) of a dam in the Doring or Groot River, i.e., upstream of EWR Site 4 or 5 would critically affect the geomorphological condition of the system (with knock-on effects on other aspects of the river ecosystem, e.g., geomorphology and water quality) mainly through the reduction in variability of the large to medium sized flood, and through the reduction of sediment supply/sediment transport capacity. It would also represent a barrier to fish and other fauna movement, and provide a safe haven for alien invaders, such as smallmouthed bass.

EWR Site 5

- The Present Ecostatus is B-category.
- The Recommended Ecological Category (REC) is a B-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B-category) = 310 MCM per annum (i.e., 61% nMAR – incl. volume of inter-annual floods).
- Environmental Flow to support AEC (C-category) = 185 MCM per annum (i.e., 36% nMAR – incl. volume of inter-annual floods).
- The flows recommended for BOTH scenarios provided here represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation.
- At the time of this study, no data or models were available to assess the implications of flow changes on the unique water chemistry of the Doring River. It is thus, highly possible that the water quality implications of the changes in flow are underestimated.
- The invasion of biota into the Doring River, primarily *Nerium oleander*, is a major threat to the future ecostatus of this system.

[6] See note re possible extrapolations of these data to other tributaries in Section 6.1.

- The physical presence (i.e., aside from influence on the flow regime) of a dam in the Doring or Groot River, i.e., upstream of EWR Site 5 would critically affect the geomorphological condition of the system (with knock-on effects on other aspects of the river ecosystem, e.g., geomorphology and water quality) mainly through the reduction in variability of the large to medium sized flood, and through the reduction of sediment supply/sediment transport capacity. It would also represent a barrier to fish, and other fauna, movement, and provide a safe haven for alien invaders, such as smallmouthed bass.

EWR Site 6

- The Present Ecostatus is B/C-category.
- Detailed explanations of the ecosystem response to the different change levels presented here are provided as individual comments from specialists in the accompanying the DRIFT DATABASE (EWR Site 6), and are not detailed here.
- The Recommended Ecological Category (REC) is a B/C-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B/C-category) = 79 MCM per annum (i.e., 57% nMAR – incl. volume of ≥ 1:5 return period floods). Long-term Average = 63 MCM (i.e., 46% nMAR).
- Environmental Flow to support AEC (C-category) = 56 MCM per annum (i.e., 41% nMAR – incl. volume of inter-annual floods). Long-term Average = 53 (i.e., 38% nMAR).

DISCUSSION

The Olifants and Doring River, and their tributaries, have been the focus of several water development studies. Clearly, there is a perceived need for additional development in the area, for which water will be required. The EWR assessments reported on here can assist in providing direction for such developments, providing decision-makers with a clear indication of the likely consequence for the river resource of selecting one option versus another. They highlight where additional water is available, but equally importantly, they highlight the time of year when additional water is available, and the dangers of over-abstraction at key times in the year, all of which will need to be taken into account if genuine, sustainable development of the Olifants-Doring Rivers is to take place.

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Glossary and Abbreviations

AQUIFER	Water-bearing soil or rock layer.
BIOTA	A collective term for all the organisms (plants, animals, fungi and bacteria) in an ecosystem.
BIOTOPE	The place in which a certain assemblage of organisms live.
BM	Bench Mark.
Ca	Calcium (mg l^{-1}).
Cl	Chloride (mg l^{-1}).
D: RDM	Directorate: Resource Directed Measures.
DSLF	Dry season lowflow.
DWAF	Department of Water Affairs and Forestry.
EC	Electrical conductivity (mS m^{-1}).
EIS	Ecological importance and sensitivity.
ENVIRONMENTAL WATER REQUIREMENT	Flow in a river, or into a wetland or coastal zone (which may be groundwater) that maintains the ecosystem in a negotiated ecological condition.
EWR	Ecological Water Requirements.
FDC	Flow Duration Curve.
GROUNDWATER	Water in a porous medium, beneath the soil surface, with a pressure greater than or equal to atmospheric pressure, and where all the voids are filled with water.
HABITAT INTEGRITY	The maintenance of an integrated composition of physicochemical and habitat characteristics on a temporal and spatial scale that is comparable to the characteristics of natural habitats of the region.
HABITAT	The place in which a plant or animal lives. (See BIOTOPE.)
HARD	Total hardness, as $CaCO_3$, (mg l^{-1}).
HYDRAULICS	The branch of science and technology concerned with the mechanics of fluids.
HYDROLOGY	Science dealing with properties, distribution and circulation of water in the biosphere.
INVERTEBRATE	An animal without a backbone - includes insects, snails, sponges, worms, crabs and shrimps.
K	Potassium (mg l^{-1}).
LB	Left Bank (looking downstream).
LONG-TERM AVERAGE VOLUME	Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
MACRO-REACH	A length of river channel along which the structural characteristics are uniform. Reach boundaries were defined by changes in channel structure, slope, streambed, valley floor width and bank material.
MAP	Mean Annual Precipitation.
MAR	Mean Annual Runoff.
MCM	Millions of Cubic Metres.
Mg	Magnesium (mg l^{-1}).

Mm^3	Millions of Cubic Metres.
MSL	Mean Sea Level.
Na	Sodium (mg l^{-1}).
NO_3-N	Nitrate nitrogen, as N (mg l^{-1}).
NH_4-N	Ammonium nitrogen, as N (mg l^{-1}).
NUTRIENT	In aquatic biology, usually a limiting nutrient – an element whose scarcity can limit plant growth (e.g. compounds of nitrogen, phosphorus).
PD	Present Day.
PES	Present Ecological State.
pH	The negative log of the hydrogen ion activity; a measure of acidity (pH<7) or alkalinity (pH>7).
PMC	Project Management Committee.
POLLUTION	Unfavourable alteration of our surroundings, normally as a result of human actions; the presence of any substances that impairs the usefulness of water.
PO_4-P	Orthophosphate, as P (mg l^{-1}).
RB	Right Bank (looking downstream).
RDM	Resource Directed Measures.
RESOURCE QUALITY OBJECTIVE (RQO)	Quantitative and auditable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection.
RESOURCE QUALITY	The quality of all the aspects of a water resource including (a) the quantity, pattern, timing, water level and assurance of instream flow; (b) the water quality, including the physical, chemical and biological characteristics of the water; (c) the character and condition of the instream and riparian habitat; and (d) the characteristics, condition and distribution of the aquatic biota.
RESOURCE UNIT	Stretches of river that are sufficiently ecologically distinct to warrant their own specification of Ecological Water Requirements.
RIPARIAN HABITAT	The physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.
RIPARIAN	Pertaining to the river bank.
SEGMENT [GEOMORPHOLOGICAL]	A length of river channel along which there is no significant change in the flow or sediment load. Segment boundaries were defined by major tributary junctions.

TERRACE	Relic floodplain or valley floor deposits above the present river level representing a former floodplain level prior to incision.
TKN	Total (Kjeldahl) nitrogen, as N (mg l^{-1}).
TP	Total phosphorus, as P (mg l^{-1}).
SO_4	Sulphate (mg l^{-1}).
WETLAND	Land that 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, in normal circumstances supports or would support, vegetation typically adapted to life in saturated soil.
WSLF	Wet season lowflow.

1. BACKGROUND

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1.1 OBJECTIVES AND LAYOUT OF THIS REPORT

This Riverine RDM Report is the fourth in a series of eight project-related reports, and is comprised of three separate volumes. The aims of the report are:

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Volume 3:

- to provide the Water Quality Reserve for the relevant reaches of the Olifants/Doring Rivers.

1.1.1 Layout of this report

This report is divided into several discrete sections. Each deals with one aspect of the riverine RDM information. The sections are as follows:

Section 1: Provides a brief background to the project and an outline of the Riverine RDM reporting. Additional background to the project is available in the Inception Report.

Section 2: Provides a general description of the study sites. Additional detail on the study area, delineation and the reasoning behind the selection of the study sites is provided in the Delineation Report.

Section 3: Provides a brief summary of the DRIFT methodology. Additional detail on DRIFT is available in various WRC reports.

Section 4: Provides the results for EWR Site 1, on the Olifants River downstream of the confluence with the Hex River. An EWR is recommended for maintaining a D-category river at that site.

Section 5: Provides the results for EWR Site 2, on the Olifants River at Alwynskop. An EWR is tentatively recommended for maintaining a D-category river at that site, and the practicalities and uncertainties around the EWR assessment itself, the possible implementation of an EWR and the likely effectiveness of the EWR in the reach of river represented by EWR 2 are discussed.

Section 6: Provides the results for EWR Site 3, on the Rondegat River downstream of Algeria Forest Station. An EWR is recommended for maintaining a B-category river at that site. A second EWR option, for maintenance of a C-category is also given.

Section 7: Provides the results for EWR Site 4, on the Doring River upstream of the confluence with the Biedou River. An EWR is recommended for maintaining a B-category river at that site. A second EWR option, for maintenance of a C-category is also given.

Section 8: Provides the results for EWR Site 5, on the Doring River at Ou Drif. An EWR is recommended for maintaining a B-category river at that site. A second EWR option, for maintenance of a C-category is also given.

Section 9: Provides the results for EWR Site 6, on the Groot River at Mount Cedar. An EWR is recommended for maintaining a B/C-category river at that site. A second EWR option, for maintenance of a C-category, is also given.

Section 10: Discussion.

Note: Ecospecs are not provided in this report. They will be detailed for the selected EWR for each EWR site and presented in a separate report (see Inception Report).

2. GENERAL DESCRIPTION OF THE STUDY SITES

The Olifants/Doring River catchment is situated in the south-west of South Africa. Significant portions of the catchment fall within the Northern Cape Province, in particular the upper reaches of the Doring River, and some of its northern tributaries, such as the Tankwa River. The remainder, and wetted portion, of the catchment falls within the Western Cape Province.

2.1 THE EWR SITES (from the Delineation Report)

In an ecological sense, rivers should be viewed as continuous longitudinal systems. They possess continuous gradients of physical and chemical conditions that are progressively and continuously modified downstream from the headwaters to the sea. Any changes taking place in the upstream reaches will influence downstream processes, and different sections of a river should never be viewed in isolation.

However, different sections of a river can have different natural flow patterns, and can react differently to stresses according to their individual sensitivities. As a result they each require individual specifications of their EWRs. Also, in order to facilitate the best management of a river, it needs to be broken down into discrete, manageable units. Although both natural and artificial barriers, which cause sudden changes in the characteristics of the river, do occur along rivers, it is not always possible to identify distinct units on a biophysical basis. Biophysical considerations, the practicalities of a certain number of units and expert judgement, all need to be taken into account when identifying discrete management units. As such, it is important to remember that the discrete units are primarily artificial distinctions to aid in the management of a river and not ecologically independent reaches.

Ideally, within each Resource Unit at least one site that is representative of conditions within that Unit should be selected. This is seldom possible because of financial constraints (restricting the number of sites that can be addressed in a study), access and/or because representative sites are not always suitable for use as EWR sites. In this study, funds were available for the consideration of six sites.

The names, locations, brief descriptions and number of transects for each EWR site are provided in Table 2.1. The notations a and b in Table 2.1 refer to the transects that were surveyed in at each site. More detailed descriptions and site photographs are provided in the Delineation Report.

Table 2.1 Locations of each of the six EWR sites selected.

Site No.	River	Site Name	Description	Latitude	Longitude
1a 1b	Olifants	Olifants at Hex River	N7 downstream of the confluence with the Hex River.	32°26.764 32°26.680	18°57.601 18°57.504
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5a 5b	Doring	Doring at Ou Drif	At Ou Drif.	31°51.446	18°54.754
6a 6b	Groot	Groot at Mount Cedar	Upstream of the bridge at Groot Rivier.	32°39.552 32°39.377	19°23.786 19°23.982

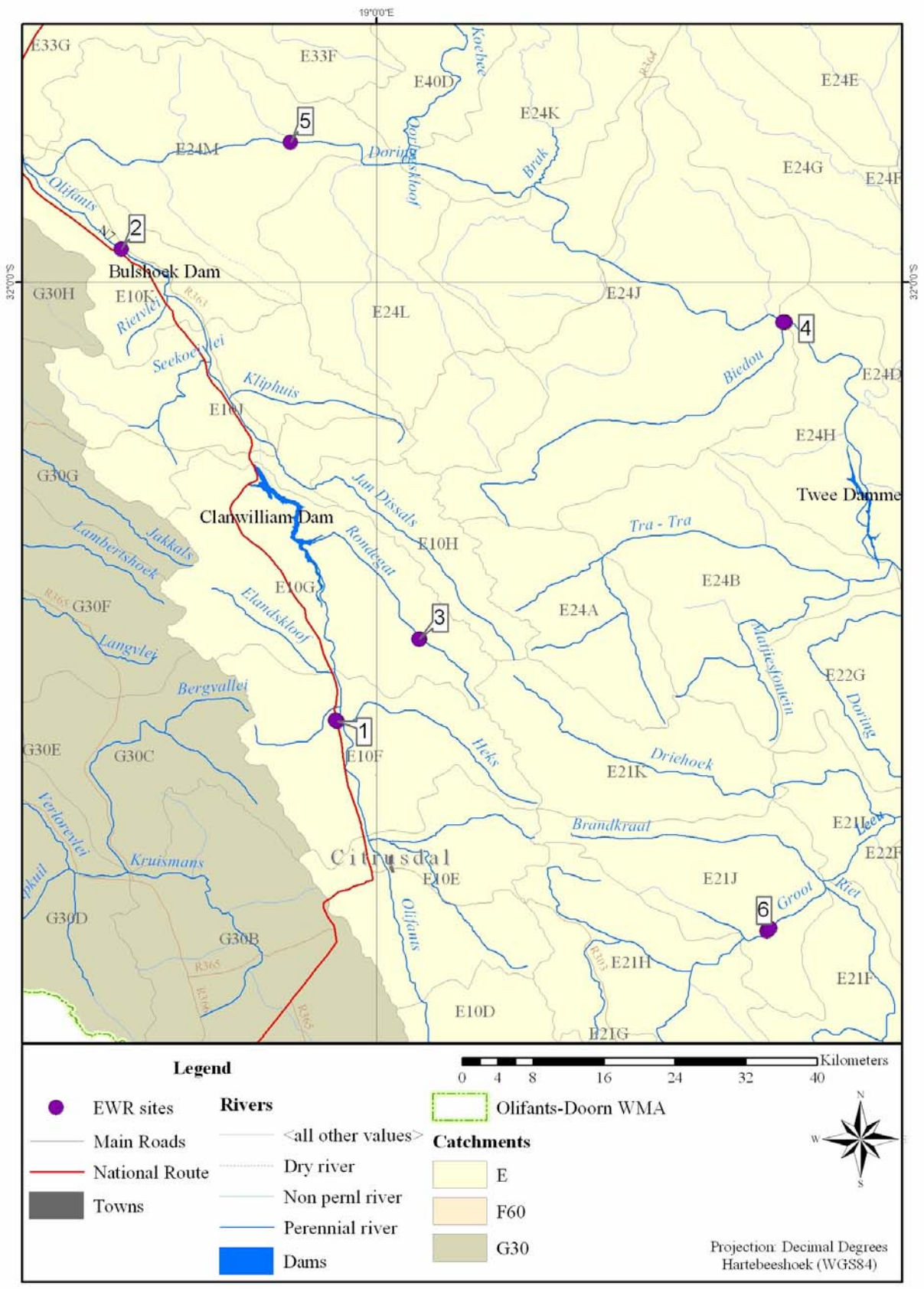


Figure 2.1 Map of the study area showing the location of the six EWR sites.

3. SUMMARY OF METHODOLOGY

3.1 METHODOLOGY

DRIFT (an acronym for Downstream Response to Imposed Flow Transformations) is an interactive, holistic approach for advising on environmental flows for rivers. The DRIFT methodology can be used to provide flow scenarios and descriptive summaries of their consequences in terms of the condition of the river ecosystem, for examination and comparison by decision makers. In its totality, DRIFT consists of four modules (biophysical, subsistence use, scenario development and compensation economics). This report focuses on the results of the biophysical module, in which the river ecosystem is described and predictive capacity developed on how it would change with flow changes.

DRIFT is essentially a data-management tool, allowing data and knowledge to be used to their best advantage in a structured way. Within DRIFT, each specialist, to derive the links between river flow and river condition, uses component-specific methods. The central rationale of DRIFT is that different aspects of the flow regime of a river elicit different responses from the riverine ecosystem. Thus, removal of part or all of a particular element of the flow regime will affect the riverine ecosystem differently than will removal of some other element.

Furthermore:

- it is possible to identify and isolate these elements of the flow regime from the historical hydrological record;
- it is possible to describe the probable biophysical consequences of partial or whole removal of a particular element of the flow regime, in isolation;
- once these biophysical consequences have been described, it is possible to combine them in various ways to describe the overall impact on river condition of a range of potential flow regimes; and
- once the potential changes in river condition have been described, it is possible to describe their socio-economic implications.

3.2 DRIFT SOLVER

The DRIFT biophysical database template is a site-specific framework designed to receive information from specialists and to use this to predict the ecological consequences of future (altered) flow regimes. Once populated, the database provides a permanent record of flow-related information provided by the specialists for that particular system, and the pathway used to develop the flow scenarios is transparent, from information provided by the specialists through to the final scenarios.

The flow scenarios are generated, and evaluated in terms of river condition, using multi-criteria analysis (MCA).

There is one scenario creation worksheet, called DRIFT-SOLVER, wherein, the predictive data, represented by the Integrity Ratings are combined in a range of permutations to create scenarios. Each scenario consists of a flow regime (one change level from each of the flow categories) together with its predicted ecosystem changes.

Integrity Ratings for each Component linked to the flow change levels are summed, taking into account their positive and negative values, to produce an Overall DRIFT Integrity Score for each scenario. The objective of SOLVER is to maximise the Overall DRIFT Integrity Score, and in doing so describe the distribution of flows, within an available volume of water, that would result in the least damage to the riverine ecosystem.

3.3 DRIFT CATEGORY

DRIFT-CATEGORY is the scenario evaluation component of the DRIFT Database. It uses the results from DRIFT SOLVER and displays the relationship between the volume of water remaining in the river and river condition. This is displayed in a plot where the volume of water is either shown as MCM or as % MAR. More detail on the DRIFT-CATEGORY plots is provided in the results for each EWR site.

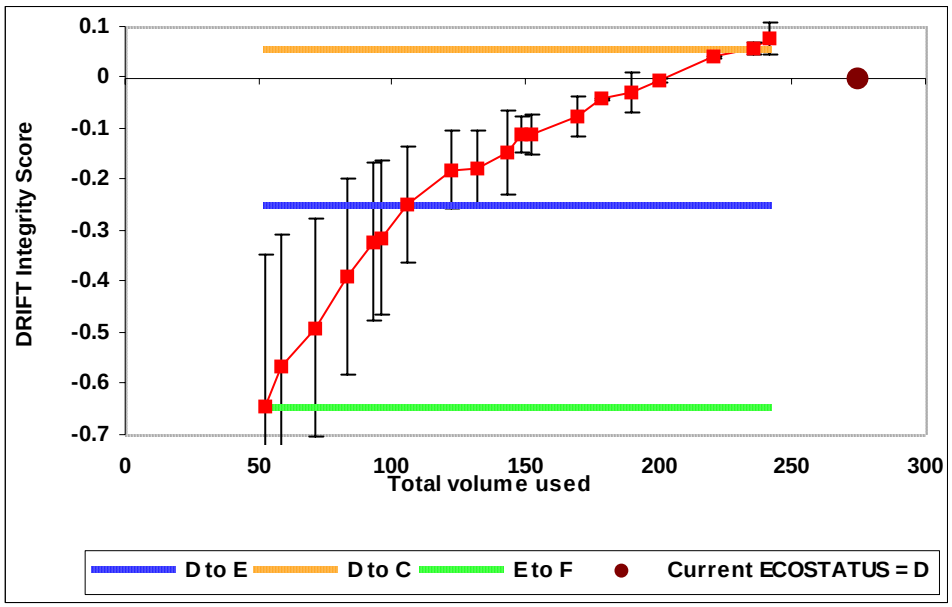


Figure 3.1 Example DRIFT Category plot.

3.4 PRESENT ECOLOGICAL STATUS, ECOSTATUS AND RECOMMENDED ECOLOGICAL CATEGORY

The myriad of terms used to describe river condition frequently results in confusion, particularly as the terms tend to change, and new terms adopted as processes are increasingly refined. In an attempt to minimise the confusion in this report, we have used the following terms:

Present Ecological Status (PES): The PES of the river is expressed in terms of various components i.e., drivers (physico-chemical, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic invertebrates), which are combined to arrive at the EcoStatus.

Present Ecostatus: The condition of the study river(s) at the time at which the study was undertaken, *viz*. 2003/4.

Where appropriate, a range of alternative ECs must be addressed during Reserve studies. These are:

Recommended Ecological Category (REC): The determination of the REC is based on a combination of the EIS and the PES. In most cases the REC will be the same category as the Present Ecostatus. If, however, the EIS is high, then there is motivation for an improvement in Present Ecostatus. Alternatively, if the Present Ecostatus is lower than a D-category, the REC will be for a D-category, as in terms of the RDM

policy the Ecostatus Category should not be less that D (DWAF 1999).

Alternative Ecological Categories (AEC): In addition to the REC, specialists undertaking a Reserve determination are expected to recommend EWRs that will facilitate maintenance of a category higher than the PES and one lower than the PES, where applicable (see Table 3.1).

Table 3.1 Guidelines for the AECs to be addressed (depending on the REC, after Kleynhans *et al.* 2005).

REC	AECs
A	A
A/B	B/C
B	C
B/C	B, C/D
C	B, D
C/D	B/C, D
D	C

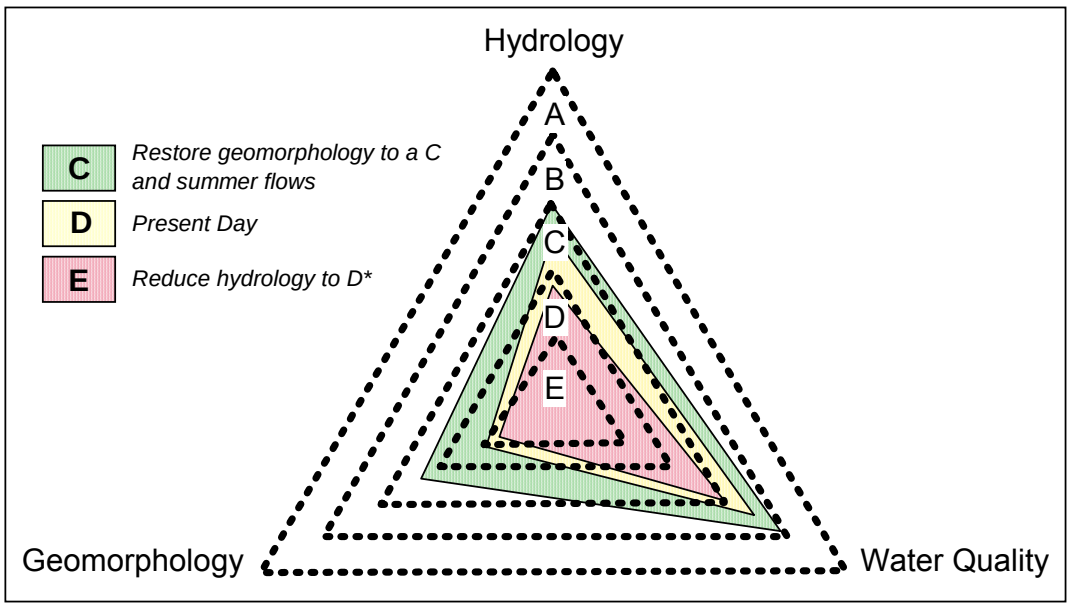
3.5 OBTAINING DATA FROM AND CHECKING THE DRIFT SCENARIOS WITH THE RIVER SPECIALISTS

The specialists provide their predictions on how the items on their generic lists are likely to change with the changes in flow during the River Workshop held in November 2004 (see Volume 1). These were then entered into the DRIFT Database and used to generate the DRIFT scenarios presented in this report. Before being finalised, these DRIFT scenarios were checked with the specialists, and adjusted where necessary, during a DRIFT Scenario Workshop, held on 11 April 2005.

4. RESULTS FOR EWR SITE 1 (OLIFANTS RIVER AT THE HEX)

KEY ISSUES AT EWR SITE 1:

- The Present Ecostatus is driven predominately by non-flow related issues, such as bulldozing of the channel, cultivation of the alluvial floodplains and encroachment of alien and other riparian vegetation.
- Present day hydrology is reasonable with the notable exception of the summer months, when the naturally perennial Olifants River is pumped dry, sometimes for up to several weeks.
- There is some opportunity for further abstractions from the river while still maintaining a D-category river BUT only if some summer flows are reinstated.
- Opportunities for additional abstraction are limited by the fact that hydrology is presently supporting the D-category condition of the river, whereas other 'drivers' of river condition, such as geomorphology are in an E. If the hydrological regime is further restricted, this will result in the river falling to an E category (Figure 4.1).
- The most reliable way to increase the level of abstraction possible, and still maintain a D-category river, is to implement river restoration aimed at reversing some of the non-flow related geomorphological impacts.
- Only one scenario is presented, *viz*. maintain a D-category as this can best be made a C-category by restoration work addressing non-flow related issues.
- The Recommended Ecological Category (REC) is a D-category.
- Environmental Flow to support REC = 186[7] MCM per annum (i.e., 55% nMAR).
- A dam in the upper reaches of the Olifants River, i.e., upstream of EWR Site 1, would negatively affect the hydrological and geomorphological condition of the system (with knock-on effects on other aspects of the river ecosystem) mainly through the reduction in variability of the large to medium sized floods, and through the reduction of sediment supply.



* would still require reinstatement of summer flows

Figure 4.1 Radar diagramme indicating how changes to one of the drivers (hydrology, water quality and geomorphology) of ecosystem condition can affect the over all ecological category of the river.

[7] If river restoration works restore geomorphology to a high D *AND* summer flows were reinstated then this figure could drop as low as *c.* 83 MCM (c. 25% nMAR).

4.1 RIVER REACH REPRESENTED BY EWR SITE 1

EWR Site 1 is representative of Olifants Resource Unit (RU) 4, which is Citrusdal to Clanwilliam Dam, plus Clanwilliam Dam to Bulshoek Barrage.

4.2 PRESENT ECOSTATUS

The Present Ecostatus for EWR Site 1 is Category D (Figure 4.2 and Table 4.1). Details of the PES assessments comprising this are provided in RDM Riverine Report (Volume 1).

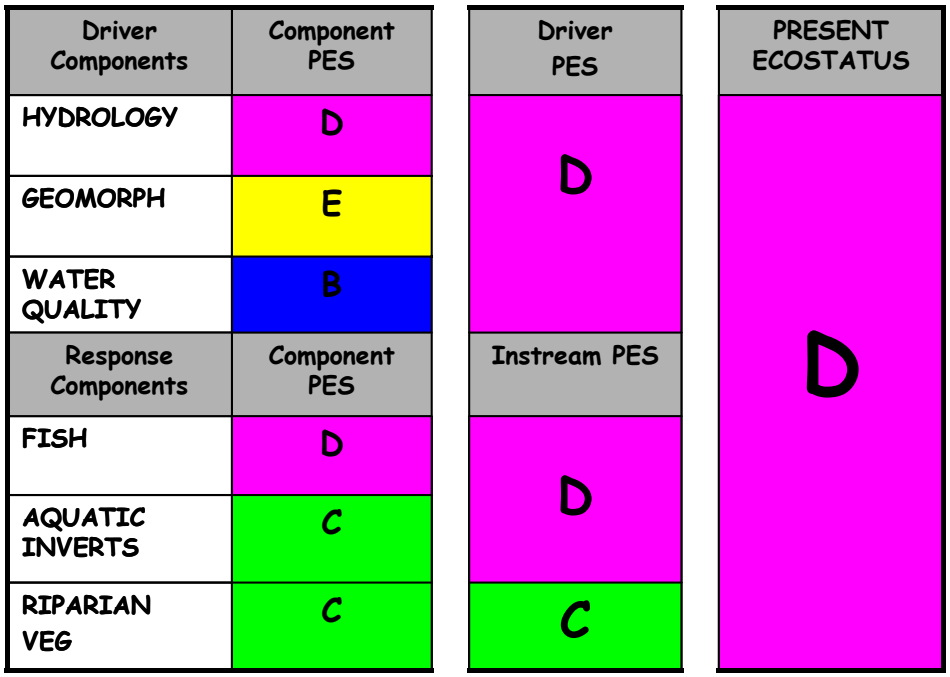


Figure 4.2 Summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 1.

Table 4.1 Present Ecostatus, Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC) for EWR Site 1.

Component of the riverine ecosystem	PES		EIS	Recommended Ecological Category*
	Category	Trajectory		
Hydrology	D	Negative	*Moderate EIS*, because of the presence of rare and endangered species (fish) and a diversity of habitat types.	D
Water quality	B	Stable		
Geomorphology	E	Stable		
Riparian vegetation	C	Negative		
Macroinvertebrates	C	Stable		
Fish	D	Negative		
PRESENT ECOSTATUS	**D**	**Negative**		

* In terms of the RDM policy the Ecostatus Category should not be less that D (DWAF 1999).

4.2.1 Major contributing factors to the Present Ecostatus

The major factors contributing to the Present Ecostatus for EWR Site 1 were:

- manual manipulation of the river channel (non-flow related);

- o cultivation of the floodplain (non-flow related);
- o reduced summer flows and long no-flow periods over the summer (flow related);
- o invasion of alien vegetation (mainly non-flow related).

4.2.2 Change levels considered by the specialists

The change levels considered by the specialists for lowflows are provided below, and those for the floods in Table 4.2.

Lowflows change levels were as follows:
Dry Season Lowflows:
Change Level 1: Reduction: Capped at 20th percentile (except for February, which was capped at the 10th percentile).
Change Level 2: Increase: Minimum dry season lowflow of 0.01 m^3s^{-1}.
Change Level 3: Increase: Reinstate to the 50th percentile on the Natural Flow Duration Curve (FDC).
Change Level 4: None.

Wet Season Lowflows:
Change Level 1: Reduction: Capped at the 10th percentile on the Present Day FDC.
Change Level 2: Reduction: Capped at the 40th percentile on the Present Day FDC.
Change Level 3: Reduction: Capped at the 70th percentile on the Present Day FDC.
Change Level 4: Reduction: Capped at the 90th percentile on the Present Day FDC.

Table 4.2 The change levels considered by the specialists for floods. Flood change levels consider changes in frequency of flood events within a magnitude class.

Flood Class	Magnitude (daily average peak size class)	Frequency: Present Day	Change 1	Change 2	Change 3	Change 4
Class 1[8]	7.00-14.20	13	Decrease (6)	Decrease (3)	Decrease (1)	Decrease (0)
Class 2	14.21-28.40	1	Decrease (0)			
Class 3	28.41-56.82	1	Decrease (0)			
Class 4	56.83-113.65	1	Decrease (0)			

4.3 DRIFT CATEGORY OUTPUT FOR EWR SITE 1

The DRIFT CATEGORY output provides a summary view of the predicted changes in the condition of the river under study with changes in the percentage of the MAR assigned to the river, assuming that there are no limitations on the distribution of that water, i.e., it can be distributed over the year in the way most beneficial to the river ecosystem. The output allows the decision maker the opportunity to select points along the continuum where they would like more detailed information. These points are then used as the position of the more detailed scenarios, which can also explore the consequences of not being able to make certain releases, such as floods, i.e., consequences of non-optimal distribution of flows.

The DRIFT CATEGORY output was generated by calculating the maximised Overall Integrity Scores for different annual volumes of water, distributed in the least damaging manner. The output for EWR Site 1 is provided in Figure 4.3.

[8] Change levels 2 and 3 were extrapolated from the consequences provided for Change levels 1 and 4. This allowed the specialists to consider the additional consequences of a major dam upstream of the site, which has implications for the sediment transport in the river, and thus knock-on effects for other components of the ecosystem. These additional impacts were computed separately and are reported on in Section 4.4.1.

- The plot depicts river condition at the level of the whole ecosystem, relative to the current state of the system, and the volumes provided are the **maximum annual** volume linked to each scenario[9].
- The DRIFT reported volumes usually include the volume contained in the floods with a return period of 1:2, 1:5, 1:10 and 1:20 years or more. Results reported in the Building Block Methodology usually exclude some or all of the inter-annual floods as it is assumed that they will pass through the system, and cannot be managed[10].
- PRESENT ECOSTATUS = Overall Integrity Score of zero (0).
- The blue horizontal line in Figure 4.2 depicts the position at which river condition is expected to change from one category to the next, i.e., it estimates the position of the **threshold between categories**. For example, the Present Ecostatus of EWR Site 1 is D, and is represented by an Integrity Score of 0 in the figure. Overall decline in condition, i.e., negative Overall Integrity Score, would lead to an E (blue line) category river.

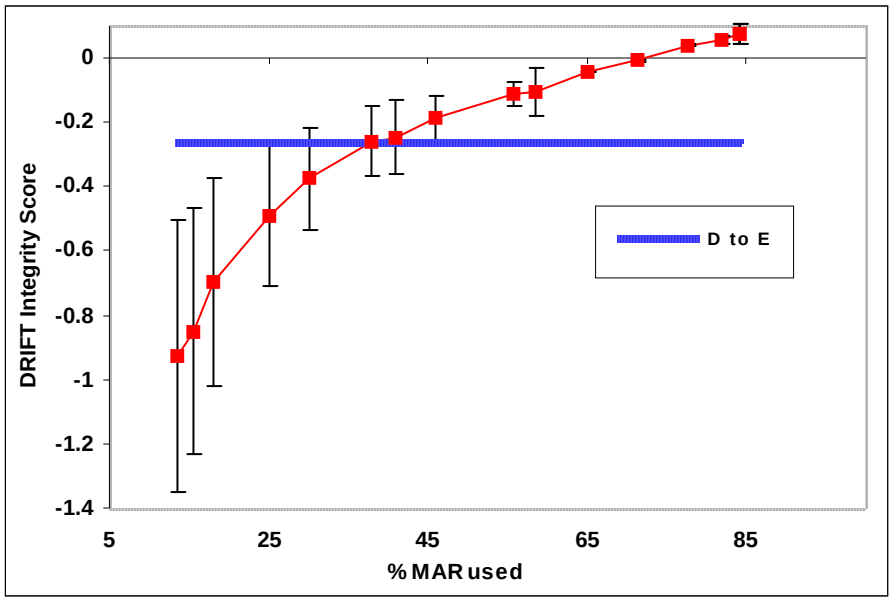


Figure 4.2 The DRIFT CATEGORY output for EWR Site 1. See notes above for explanation.

4.4 DETAILED EWR OPTION 1: MAINTAIN RECOMMENDED ECOLOGICAL CATEGORY (REC)

4.4.1 Overview of EWR Option 1

The following is a brief summary of EWR Option 1 (REC) for EWR Site 1.

TARGET ECOLOGICAL CATEGORY

Maintain Recommended Ecological Category (REC) = D.

[9] These volumes are revised for the selected detailed scenarios to produce the **average annual** volumes. As a general rule, the volumes given in DRIFT Category are higher than the final volumes that would be arrived at through detailed calculations for a particular releases from a dam, when floods are capped and/or are not cued by climatic events.

[10] This is in fact not always the case, as large dams can and do severely attenuate floods with return periods of 1:2, 1:5 and 1:10 years.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period[11]). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume required for the river for Scenario 1 – EWR Site 1:

Including the volume for the ≥ 1:5 year floods: 186[12] MCM a^{-1}
= *c*. 55% nMAR and 67% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[13]: 144.47 MCM a^{-1}
= *c*. 43% nMAR and 52% present day MAR.

Note: The long-term average is 38.5% of nMAR, incl. 1:5 year floods.

KEY CONSIDERATIONS

Opportunities for additional abstraction are limited by the fact that hydrology is presently supporting the D-category condition of the river, whereas other 'drivers' of river condition, such as geomorphology are in an E. If the hydrological regime is further restricted, without undertaking any measures to restore other components of the system, this will result in the river falling to an E category (Figure 4.1). If, however, river restoration work was undertaken to improve the condition of the other components of the ecosystem, this would make more water available for abstraction, while still maintaining a D-category river. Furthermore, current impacts on the river, in particular those during the dry season (bulldozing, etc.) are likely to result in a **negative trajectory** for this site, which means that with time, if these continue, the condition is likely to deteriorate to an E-category.

FLOW REDUCTION LEVELS USED

For EWR Option 1 (REC) at EWR Site 1, the following mix of change levels for the 10 components was selected for the Minimum Degradation Scenario – relative to Present Day:

1	Wet season lowflows	Level 3, i.e., Capped at the 40% percentile of the PD lowflow duration curve.
2	Dry season lowflows:	Level 2, i.e., INCREASED dry season lowflows[14].
3	Class 1 Intra-annual floods:	10 Class I floods[15] - reduced from PD 13 but no deemed affects.
4	Class 2 Intra-annual floods:	present day.
5	Class 3 Intra-annual floods:	present day.
6	Class 4 Intra-annual floods:	Level 1, i.e., no Class IV floods.
7	Inter-annual floods (1:2 year):	Present Day, i.e., no dam.
8	Inter-annual floods (1:5 year):	Present Day, i.e., no dam.
9	Inter-annual floods (1:10 year):	Present Day, i.e., no dam.
10	Inter-annual floods (1:20 year):	Present Day, i.e., no dam.

[11] Previously all inter-annual floods were excluded in the reported volume, but recent studies have started to include floods with a 1:2 year return period i.e. Komati Basin EWR Study.

[12] If river restoration works restore geomorphology to a high D *AND* summer flows were reinstated then this figure could drop as low as *c.* 83 MCM (c. 25% nMAR). See Key Considerations.

[13] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the Ecostatus target for this scenario.

[14] DRIFT SOLVER actually selected Change level 3, i.e., reinstate the dry season lowflows to the 50th percentile of natural, thus highlighting the perceived importance of dry season lowflows. However, the PRACTICALITIES of reinstating the required flows are such that Southern Waters adjusted DRIFT's output to Level 2 change DSLF, viz. 0.001 minimum flows during the dry season, and Level 3 Change WSLF. This results in a slightly higher Overall Integrity Score but is deemed to be a more feasible option. No flows during the dry season (as occurs presently) is extremely damaging to the river, and thus should not form part of any recommended flow regime for the river.

[15] Many of these will be required in the wet season, which will make up for some of the variability lost by capping the wet season lowflows.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 1 (REC) was specifically designed to limit possible impacts as a result of changes in the flow components that are deemed to threaten the overall Ecostatus. This Ecostatus would, however, be threatened should the non-flow related factors contributing to the poor condition of the river, such as destruction of the floodplain and manipulation of the channel, continue unabated.

OVERALL INTEGRITY SCORE: EWR OPTION 1 (REC)

EWR Option 1 (REC) was assigned an **Overall Integrity Score of -0.15**, i.e., a slight REDUCTION in Present Ecostatus but maintaining a D-category.

EXPECTED EC

EWR Option 1 (REC) is expected to maintain a Category-D condition. Should river restoration aimed at reversing some of the non-flow related geomorphological impacts result in an improved geomorphology PES, however, then this flow regime should support a C/D or even C Category river.

ADDITIONAL EFFECTS SHOULD A LARGE DAM BE CONSTRUCTED IN THE UPPER REACHES, E.G., AT ROSENDAL

Figure 4.3 illustrates the expected effect of a large > 1 MAR dam in the upper reaches of the Oliants River, i.e., REC will not be achieved. This is mainly a result of the dampening of variability associated with such a structure, with reduced sediment transport capacity.

Similar trends are expected for the other sites, i.e., far greater impacts associated with large in-channel structures than associated with smaller structures and/or off-channel dams and run-of-river abstractions.

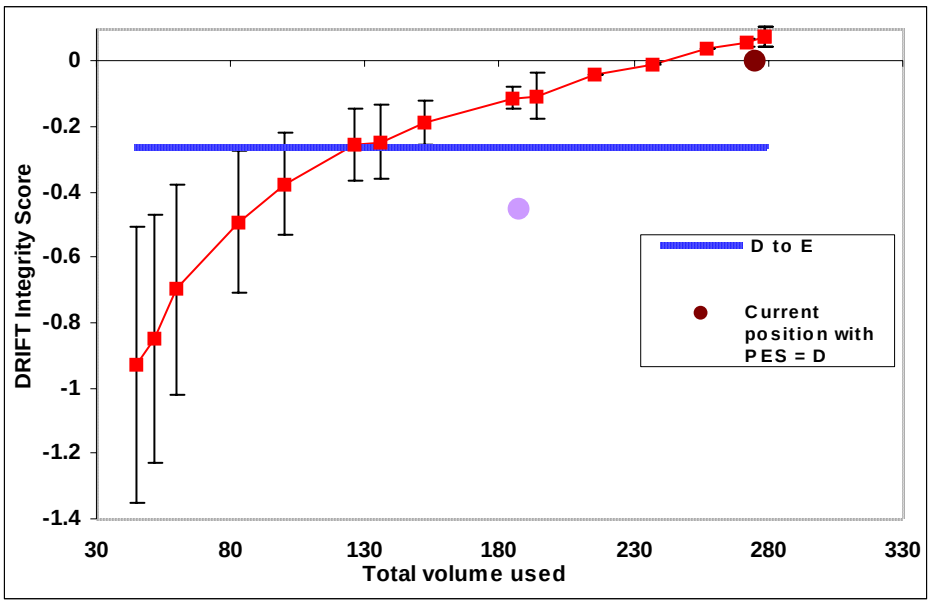


Figure 4.3 The DRIFT CATEGORY output for EWR Site 1 (showing actual volume instead of percentage MAR as shown in Figure 4.2), illustrating the expected DRIFT integrity score with a large dam in the upper reaches of the Olifants (purple circle).

4.4.2 EWR Option 1 (REC) Hydrology

A portion of the modified flow regime for EWR Option 1 (REC) is shown in Figure 4.4 and Table 4.3 provides a breakdown of the flow regime required to meet EWR Option 1 (REC). The flood requirements are detailed in Table 4.4 and the rule curves are given in Table 4.5.

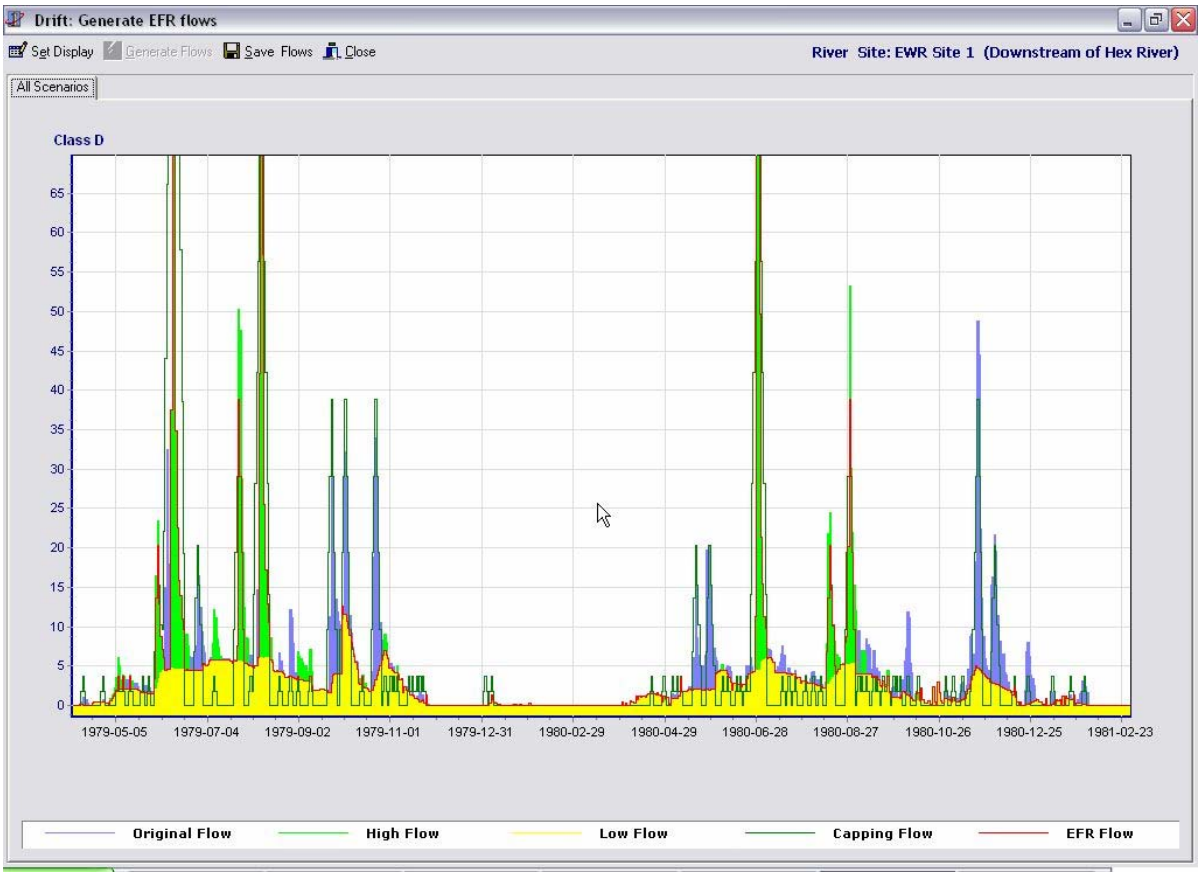


Figure 4.4 A portion of the modified flow regime for EWR Option 1 (REC) at EWR Site 1. The blue line (original flow) is Present Day flow in the river.

Table 4.3 Water quantity for EWR Option 1 (REC) at EWR Site 1 (Olifants River at Hex). To be met at the Algeria bridge. MCM = million cubic metres[16].

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 331.5 MCM (estimated). PD MAR = 274.7														
EWR Ecostatus Category = D.														
MAINTENANCE														
CAPPING FLOWS	Not set												N/a	
LOW FLOWS Q m^3s^{-1}	3.3	0.9	0.1	0.1	0.1	0.1	0.6	2.0	4.5	6.0	6.0	4.0	67	20
FLOOD Class 1: 9[17]: m^3s^{-1}	1.5	3				1		3				1.5	3.3x10	10
FLOOD Class 2: 20: m^3s^{-1}									1				6.5x1	2
FLOOD Class 3: 36: m^3s^{-1}									1				12.4x1	4
FLOOD Class 4: 85: m^3s^{-1}									-				-	-
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)[18]												45	14
MAINTENANCE TOTAL (Volume)	**Annual[19]**												**185.9**	**55**
	Long-term average[20]												**128.57**	**38.5**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.39	0.01	0.01	0.01	0.01	0.01	0.01	0.37	1.87	1.69	2.23	1.48	21.4	6
FLOOD Peak[21] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***7.1***	***3.4***	***1.7***	***0.66***	***0.16***	***0.6***	***2.6***	***5.3***	***25.1***	***40.8***	***25.7***	***15.3***	**128.57**	**38.5**

[16] Values given are an ESTIMATE of the flows required. Actual volumes depend on climate.
[17] Daily average peak
[18] Volume of 1:2 year flood is c. 25 MCM per annum (i.e., 50 MCM per event).
[19] Calculated as the volume of water required to meet the full requirements.
[20] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
[21] Daily average peak

Table 4.4 Summary of the flood requirements for EWR Site 1 – EWR Option 1 (REC): Maintain a D-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	9	3	3.3	10	April - June September - November
Class 2	20	6	6.5	1	June- September
Class 3	36	7	12.4	1	June- September
Class 4	85	10	30.4	0	Not applicable
Inter-annual Class (return period given below)					
1:2	380	12	52.5	Present	Not stipulated
1:5	530	14	81.29	Present	Not stipulated
1:10	665	14	164.4	Present	Not stipulated
1:20	870	14	164.4	Present	Not stipulated

Table 4.5 Exceedence curves for the complete flow regime (floods and droughts included) required to meet Option 1 (REC) for EWR Site 1. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	69.087	9.726	6.012	4.354	3.408	2.241	1.752	0.905	0.274	0.01	0.01	0.01	0.01	128.567
Jan	3.41	1.219	0.773	0.323	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.661
Feb	0.69	0.47	0.27	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.16
Mar	2.238	1.57	0.8	0.428	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.637
Apr	4.06	3.532	2.525	1.795	1.257	0.891	0.607	0.363	0.152	0.01	0.01	0.01	0.01	2.683
May	9.705	2.383	2.088	2.03	2.022	2.013	2.008	2	1.8	1.508	0.955	0.522	0.009	5.281
Jun	120.9	43.147	10.913	4.548	4.526	4.515	4.508	4.501	4.072	3.288	2.181	1.927	1.31	25.092
Jul	154.42	70.38	38.196	15.127	6.137	6.049	6.013	6.004	5.698	4.19	3.12	1.69	1.17	40.801
Aug	84.456	38.822	19.608	6.088	6.042	6.026	6.003	6	5.686	4.193	2.912	2.365	1.496	25.741
Sep	70.38	12.14	4.206	4.035	4.03	4.023	4.012	4	3.95	3.221	2.056	1.564	1.027	15.275
Oct	4.499	3.665	3.398	3.337	3.307	3.3	3.27	2.578	1.98	1.465	0.96	0.39	0.1	7.068
Nov	4.52	3.665	3.061	2.241	1.832	1.377	1.056	0.848	0.649	0.279	0.01	0.01	0.01	3.449
Dec	4.289	2.425	1.832	0.975	0.584	0.359	0.105	0.01	0.01	0.01	0.01	0.01	0.01	1.719
Wet[22]	103.63	34.779	13.672	6.036	6	4.522	4.056	4	2.936	2.025	1.812	1.418	0.414	112.19
Dry[23]	3.979	3.355	3.264	1.832	1.049	0.584	0.246	0.01	0.01	0.01	0.01	0.01	0.01	16.377

[22] May-October.

[23] November-April.

Table 4.6 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 1 (REC) for EWR Site 1. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	3.411	3.291	1.901	0.747	0.144	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	14.902
Feb	3.41	1.18	0.76	0.31	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.625
Mar	0.69	0.47	0.27	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.16
Apr	2.01	1.57	0.74	0.39	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.611
May	2.134	2.084	2.053	2.027	2.016	2.012	2.006	2	1.7	1.38	0.85	0.37	0	4.562
Jun	4.716	4.638	4.55	4.528	4.518	4.513	4.506	4.5	4.01	3.22	2.18	1.87	1.31	10.285
Jul	6.32	6.214	6.096	6.049	6.024	6.011	6.007	6	5.62	4.19	3.12	1.69	1.17	14.165
Aug	6.095	6.087	6.066	6.038	6.021	6.003	6	6	5.16	3.94	2.82	2.23	1.39	13.891
Sep	4.625	4.056	4.041	4.032	4.027	4.02	4.01	4	3.93	3.15	2.03	1.48	0.96	9.315
Oct	3.411	3.401	3.371	3.33	3.304	3.3	3.26	2.47	1.97	1.39	0.85	0.39	0.1	6.699
Nov	4.52	3.47	2.67	2.07	1.54	1.28	0.99	0.8	0.59	0.18	0.01	0.01	0.01	3.213
Dec	2.72	2.05	1.43	0.78	0.51	0.33	0.08	0.01	0.01	0.01	0.01	0.01	0.01	1.208
Wet[24]	6.242	6.065	6.032	6.002	5.05	4.51	4.034	4	2.759	2.018	1.74	1.31	0.37	52.218
Dry[25]	3.812	3.32	3.026	1.634	0.967	0.527	0.22	0.01	0.01	0.01	0.01	0.01	0.01	14.902

[24] May-October.

[25] November-April.

5. RESULTS FOR EWR SITE 2 (OLIFANTS RIVER AT ALWYNSKOP)

KEY ISSUES AT EWR SITE 2:

- The Present Ecostatus is predominately driven by flow-related issues. These are primarily attenuation of floods and severely reduced dry season lowflows as a result of Clanwilliam Dam and Bulshoek Barrage.
- Additional impacts include reduced sediment supply, encroachment of reeds and palmiet, and cultivation of flood terraces.
- Recent repair work at Bulshoek Barrage has resulted in stoppage of leaks from the dam, which were in the order of 1 cumec in the wet season (Francois van Heerden, DWAF, pers. comm.).
- The EWR work reported here was done under conditions prior to the repair work, i.e., present Ecostatus assumes leakage from Bulshoek Barrage.
- Opportunities for improving the Present Ecostatus through releases from Clanwilliam Dam/Bulshoek Barrage are limited.
- Only one scenario is presented, *viz*. achieve a D-category, as there is little or no opportunity for improvement to a C-category.
- At the EWR Workshop water was 'added-back' into the river at EWR Site 2 to arrive at the predictions generated, except for some of the intra-annual floods, where the consequences of both reduction and increase in flood frequency were considered.
- Due to a lack of hydrological data for the site, the floods with a return period of 2 years and greater were excluded from the analysis.
- The Recommended Ecological Category (REC) is a D-category.
- Environmental Flow to support REC = 194 MCM per annum (i.e., 38% nMAR) – excl. inter-annual flood volumes.
- *The risk of the recommended Environmental Flow NOT supporting the REC is extremely high.*
- *From the perspective of the entire Olifants-Doring River it is recommended that consideration be given to not building a major impoundment or abstraction weir on the Doring River but instead maximising the yield from Clanwilliam Dam/Bulshoek Barrage through not releasing a 'complete' EWR. This is an issue that could be addressed in a Classification Process.*
- A 'reduced' EWR, in the region of 10-17% of the nMAR would result in an improvement in Present Ecostatus, albeit not to a D-category.

5.1 RIVER REACH REPRESENTED BY EWR SITE 2

EWR Site 2 is representative of Olifants Resource Unit (RU) 6, which is Bulshoek Barrage to the confluence with the Doring River.

5.2 PRESENT ECOSTATUS

The Present Ecostatus for EWR Site 2 is Category E (Figure 5.1) and the EIS is High (Table 5.1). Details of the PES assessments comprising this are provided in RDM Riverine Report (Volume 1).

5.2.1 Major contributing factors to the Ecostatus

The major factors contributing to the Ecostatus for EWR Site 2 were:

- reduced summer flows and long no-flow periods over the summer (flow related);
- considerable flood attenuation (flow related);
- barriers to fish migration (non-flow related);
- barriers to sediment movement (non-flow related).

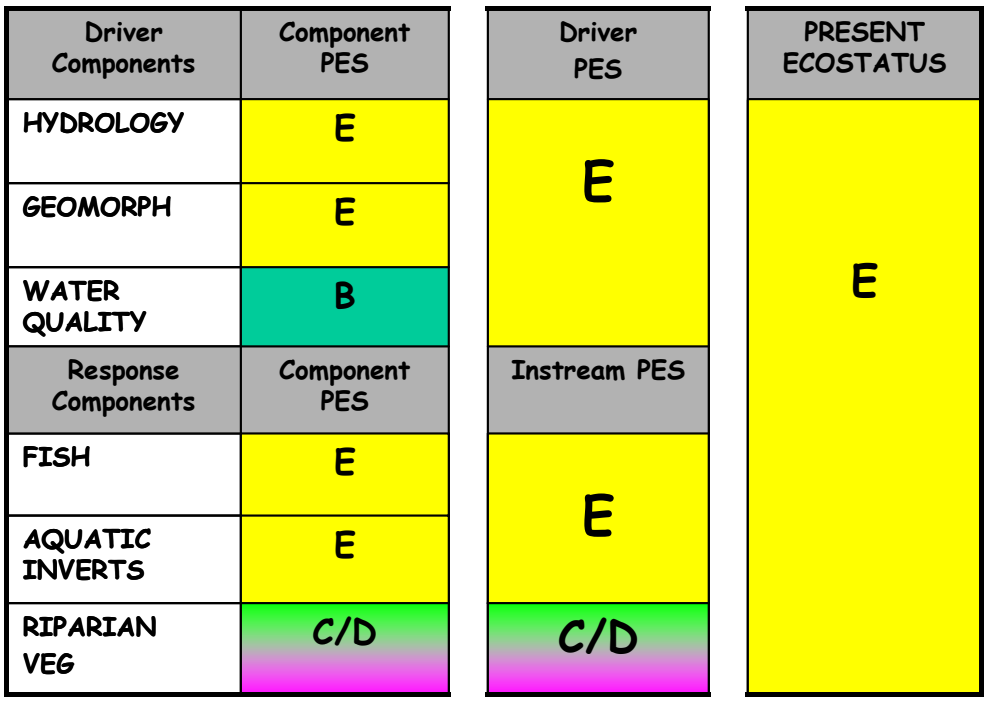


Figure 5.1 Summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 2.

Table 5.1 Present Ecostatus, Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC) for EWR Site 2.

Component of the riverine ecosystem	PES		EIS	Recommended Ecological Category*
	Category	Trajectory		
Hydrology	E	Negative	High	E*
Water quality	B	Stable		
Geomorphology	E	Stable		
Riparian vegetation	C/D	Negative		
Macroinvertebrates	E	Negative		
Fish	E	Negative		
PRESENT ECOSTATUS	**E**	**Negative**		

* In terms of the RDM policy the Ecostatus Category should not be less than D (DWAF 1999).

5.2.2 Change levels considered by the specialists

The change levels considered by the specialists for lowflows are provided below, while those for the floods are in Table 5.2.

Lowflows change levels were as follows:
Dry Season Lowflows:
Present Day: Assumed = 0.2 m^3s^{-1} (i.e., pre repair to leakage from Bulshoek Barrage)
Change Level 1: No flow.
Change Level 2: Natural FDC capped at 1 m^3s^{-1}.
Change Level 3: Natural FDC capped at 2 m^3s^{-1}.

Wet Season Lowflows:
Change Level 1: Reduction: Capped at the 10th percentile on the Present Day FDC.
Change Level 2: Reduction: Capped at the 50th percentile on the Present Day FDC.
Change Level 3: Reduction: Capped at the 70th percentile on the Present Day FDC.
Change Level 4: Reduction: Capped at the 90th percentile on the Present Day FDC.

Table 5.2 The change levels considered by the specialists for floods. Flood change levels consider changes in frequency of flood events within a magnitude class.

Flood Class	Magnitude (daily peak size class)	Frequency: Present Day	Change 1	Change 2	Change 3	Change 4
Class 1	7-14	1	Decrease (0)	Increase(2)	Increase(3)	Increase(5)
Class 2	14-28	2	Decrease (0)	Increase(3)		
Class 3	28-56	1	Decrease (0)	Increase(2)		
Class 4	56-113	2	Decrease (0)	Increase(3)		

5.3 DRIFT CATEGORY OUTPUT FOR EWR SITE 2

The DRIFT CATEGORY output for EWR Site 2 is provided in Figure 5.2.

- The plot depicts river condition at the level of the whole ecosystem, relative to the current state of the system, and the volumes provided are the **maximum annual** volume linked to each scenario[26].
- The DRIFT reported volumes usually include the volume contained in the floods with a return period of 1:2, 1:5, 1:10 and 1:20 years or more. Results reported in the Building Block Methodology usually exclude some or all of the inter-annual floods as it is assumed that they will pass through the system, and cannot be managed[27].
- ECOSTATUS = Overall Integrity Score of zero (0).
- The coloured horizontal lines in Figure 5.2 depict the position at which river condition is expected to change from one category to the next, i.e., they estimate the position of the **threshold between categories**. For example, the Present Ecostatus of EWR Site 2 is E, and is represented by an Integrity Score of 0 in the figure. Improvement in the overall condition of the river, i.e., positive Overall Integrity could lead to a D category (blue line).

[26] These volumes are revised for the selected detailed scenarios to produce the **average annual** volumes. As a general rule, the volumes given in DRIFT Category are higher than the final volumes that would be arrived at through detailed calculations for particular releases from a dam, when floods are capped and/or are not cued by climatic events.

[27] This is in fact not always the case, as large dams can and do severely attenuate floods with return periods of 1:2, 1:5 and 1:10 years. Section 4.4.1 of this report considers briefly the effects of this 'capping' of flood events by impoundments on sediment movement and hence on channel morphology.

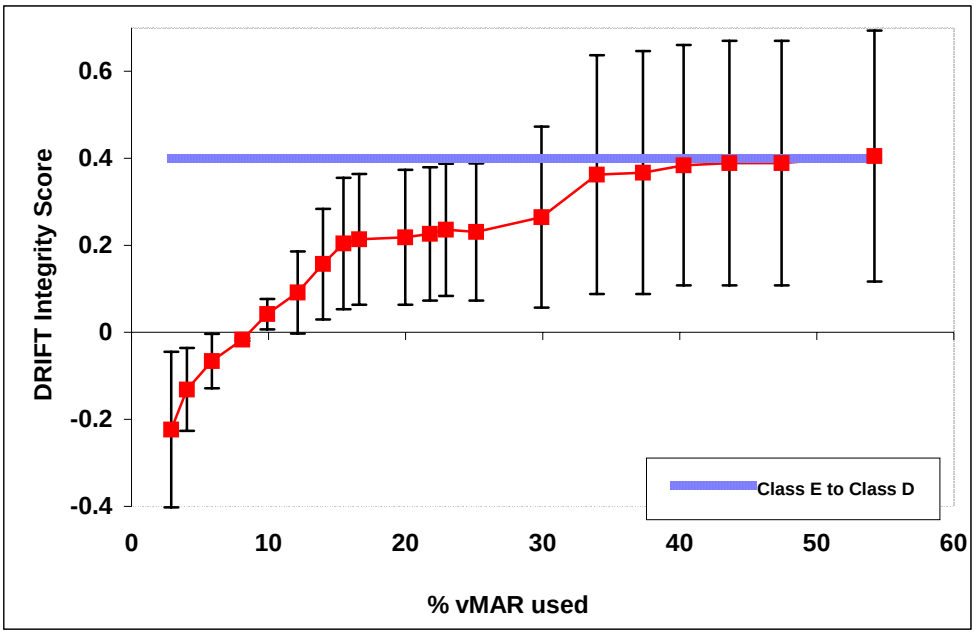


Figure 5.2 The DRIFT CATEGORY output for EWR Site 2. See notes above for explanation.

5.4 DETAILED OPTION 1: MAINTAIN RECOMMENDED ECOLOGICAL CATEGORY (REC)

5.4.1 Overview of EWR Option 1

The following is a brief summary of EWR Option 1 (REC) for EWR Site 2.

TARGET ECOLOGICAL CATEGORY

Maintain Recommended Ecological Category (REC) = D.

ECOLOGICAL WATER REQUIREMENTS

The DRIFT volumes are reported both excluding the volumes of the ≥ 1:2 year return period flood, as data on these floods were not available for EWR Site 2.

Mean annual volume required for the river for EWR Option 1 – EWR Site 2:
Excluding the volume for the ≥ 1:2 year floods[28]: 194 MCM a^{-1}
= *c*. 38% nMAR.

KEY CONSIDERATIONS

The results of the EWR assessment indicate that there is little or no certainty that the condition of EWR Reach 2 can be improved to a D-category solely by implementing flow releases from Bulshoek Barrage. Thus, the EWRs provided here are of extremely low confidence (see error bars of Figure 5.2). However, there was also general agreement that completely stopping the dry season (summer) flows would exacerbate the poor condition further.

[28] Floods of greater than 1:1 year return period were excluded from the analysis for EWR Site2.

FLOW REDUCTION LEVELS USED

For EWR Option 1 (REC) at EWR Site 2, the following mix of change levels for the 10 components was selected:

1	Wet season lowflows	Change level 4.
2	Dry season lowflows:	Change level 2.
3	Class 1 Intra-annual floods:	Change level 4.
4	Class 2 Intra-annual floods:	Change level 2.
5	Class 3 Intra-annual floods:	Change level 2.
6	Class 4 Intra-annual floods:	Change level 2.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 1 (REC) was specifically designed to limit possible impacts as a result of changes in the flow components that are deemed to threaten the Present Ecostatus. The Ecostatus would, however, be continue to be threatened should the non-flow related factors contributing to the poor condition of the river, such as destruction of the floodplain and manipulation of the channel, continue unabated.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 1 (REC) was assigned an **Overall Integrity Score of 0.36**, i.e., CONSIDERABLE INCREASE in Present Ecostatus.

EXPECTED EC

Category E. The error bars in Figure 5.2 indicate that a great deal of uncertainly exists that the REC would be achieved using flow alone, even with the allocation of considerable quantities of water to the EWR.

5.4.2 EWR Option Hydrology

Tables 5.3 provides a breakdown of the flow regime required to meet EWR Option 1 (REC), and the flood requirements are detailed in Table 5.4. The rule curves for the lowflow component of the flow regime are given in Table 5.5.

NOTE: The lack of daily data (and flood data) for this site means that the rule curve for the whole flow regime could not be generated.

Table 5.3 Water quantity for EWR Option 1 (REC) at EWR Site 2 (Olifants River at Alwynskop). To be met at the pedestrian bridge at the confluence with the Doring River. MCM = million cubic metres[29].

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 519 MCM (estimated). PD MAR = unknown.														
EWR Ecostatus Category = D.														
MAINTENANCE														
CAPPING FLOWS	Not set												N/a	
LOW FLOWS Q m^3s^{-1}	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.7	3.0	3.6	3.1	56	11
FLOOD Class 1[30] 10.5: m^3s^{-1}	1							1		1	2		3x5	3
FLOOD Class 2: 21 m^3s^{-1}									3				6x3	3
FLOOD Class 3: 42 m^3s^{-1}									1		1		12x2	5
FLOOD Class 4: 84.5 m^3s^{-1}									3				30x3	17
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												**Not available for this site.**	
MAINTENANCE TOTAL (Volume)	**Annual[31]**												**194**	**38**
	Long-term average[32]												**Not available for this site.**	
DROUGHT														
LOW FLOWS m^3s^{-1}	0.38	0	0	1	0.44	0	0	0.14	0.75	1.2	3.2	3.2	27.1	5
FLOOD Peak m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	**Not available for this site.**													

[29] Values given are an ESTIMATE of the flows required. Actual volumes depend on climate.
[30] Daily average peak.
[31] Calculated as the volume of water required to meet the full requirements.
[32] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.

Table 5.4 Summary of the flood requirements for EWR Site 2 – EWR Option 1 (REC): Maintain a D-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	10	3	3	5	September - June
Class 2	21	6	6	3	June - September
Class 3	42	7	12	2	
Class 4	84	10	30	3	
Inter-annual Class (return period given below)					
1:2	Not included in the assessment.				
1:5					
1:10					
1:20					

Table 5.5 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 1 (REC) for EWR Site 2. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	1.193	1.098	1.031	1.029	1.02	1.015	1.01	1.008	1.004	1.001	1	1	0.31	2.684
Feb	1.014	1.011	1.009	1.008	1.006	1.004	1.003	1	1	0.99	0.86	0.44	0	2.296
Mar	1.047	1.02	1.016	1.012	1.006	1.003	1.001	1	0.95	0.67	0	0	0	2.224
Apr	1.1	1.085	1.071	1.045	1.029	1.017	1.011	1.006	1.003	1	0.67	0.1	0	2.426
May	1.151	1.113	1.08	1.033	1.018	1.014	1.01	1.004	1.001	0.86	0.32	0.14	0.08	2.402
Jun	2.184	2.132	2.078	2.042	2.029	2.022	2.017	2.013	2.007	2	1.74	0.75	0.27	4.928
Jul	4.25	4.202	4.18	4.108	4.069	4.051	4.043	4.028	4.018	4.01	4	1.2	0	10.22
Aug	4.257	4.222	4.111	4.08	4.063	4.043	4.03	4.023	4.016	4.007	3.98	3.22	0.88	10.521
Sep	4.255	4.214	4.139	4.058	4.044	4.033	4.027	4.021	4.017	4.008	4	3.17	1.14	10.189
Oct	1.608	1.571	1.548	1.538	1.527	1.515	1.511	1.509	1.506	1.502	1.35	0.38	0.04	3.831
Nov	1.037	1.03	1.026	1.017	1.012	1.009	1.007	1.004	1.002	1	0.47	0	0	2.309
Dec	1.171	1.053	1.044	1.038	1.015	1.012	1.01	1.006	1.001	1	0.17	0	0	2.392
Wet[33]	4.248	4.15	4.082	4.043	4.023	4.008	2.075	2.006	1.516	1.114	1.003	0.502	0.055	42.09
Dry[34]	1.137	1.052	1.036	1.02	1.012	1.009	1.006	1.003	1	1	0.642	0	0	14.331

[33] May-October.

[34] November-April.

6. RESULTS FOR EWR SITE 3 (RONDEGAT RIVER BELOW ALGERIA FOREST STATION)

KEY ISSUES AT EWR SITE 3:

- The Present Ecostatus is B-category, with the deviations from natural driven predominately by non-flow related issues, such as historic manipulation of the floodplain and invasion of alien vegetation into the riparian zone.
- There are NO gauging weirs on the Rondegat River and this affected the reliability of the hydrology. Nonetheless, it is unlikely that there are major alterations to flow regime, as all water abstraction is either run-of river or as a result of minor changes in landuse (in particular, forestry).
- Fish communities are in a pristine condition in the upper half of the Rondegat River, largely because of the absence of alien predators, such as bass.
- Opportunities for improving the condition through flow manipulations are deemed to be limited.
- Two EWR Options are presented, *viz*. achieve a B-Category and to achieve a C-Category, as there is little opportunity for improvement to an A-Category using flow.
- The Recommended Ecological Category (REC) is a B-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B-category) = 4.8 MCM per annum (i.e., 63% nMAR).
- Environmental Flow to support AEC (C-category) = 2.0 MCM per annum (i.e., 26% nMAR).
- Given the conservation importance of this system (and other tributaries feeding the Olifants River[35]), the precautionary principle was applied.

6.1 RIVER REACH REPRESENTED BY EWR SITE 3

The Rondegat River is a tributary of the Olifants River. EWR Site 3 is representative of the section of the Rondegat River upstream of the dense invasions of *A. mearnsii et al*. prevalent in the lower reaches of the river. EWR assessment data can be extrapolated to the Huis, Hex and Jan Dissels Rivers. The Rondegat River is in the best ecological condition of the four tributaries.

6.2 PRESENT ECOSTATUS

A summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 3 is presented in Figure 6.1.

[35] See note re possible extrapolations of these data to other tributaries in Section 6.1.

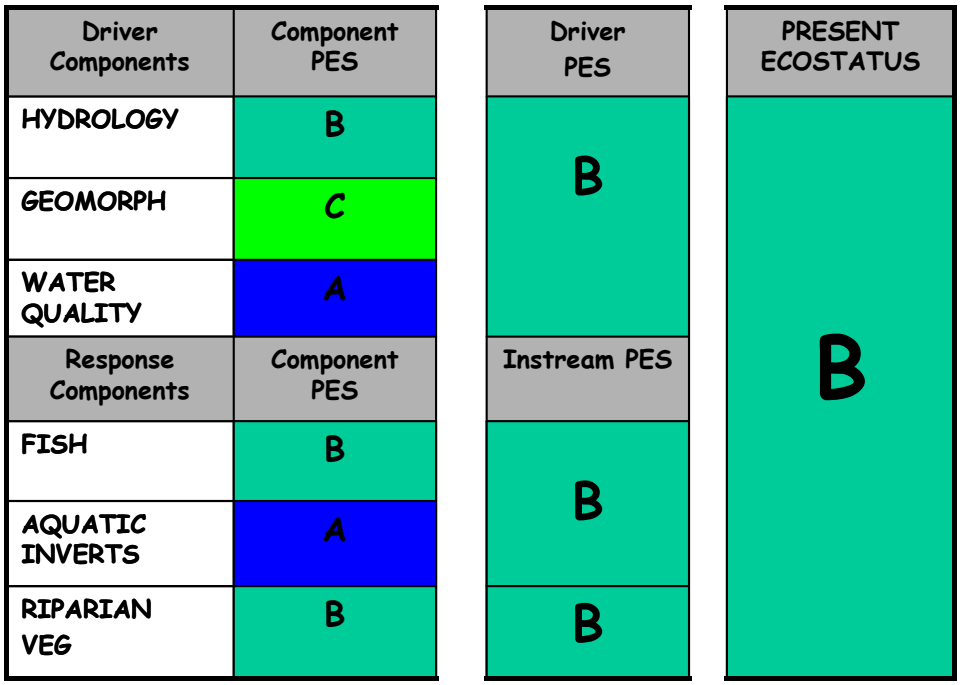


Figure 6.1 Summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 3.

Table 6.1 Present Ecostatus, Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC) for EWR Site 3.

Component of the riverine ecosystem	PES		EIS	Recommended Ecological Category*
	Category	Trajectory		
Hydrology	B	*Negative*	Very high	B
Water quality	A	*Stable*		
Geomorphology	C	*Negative*		
Riparian vegetation	B	*Stable*		
Macroinvertebrates	A	*Stable*		
Fish	B	*Stable*		
PRESENT ECOSTATUS	**B**	***Stable***		

* In terms of the RDM policy the Ecostatus Category should not be less than D (DWAF 1999).

6.2.1 Major contributing factors to the Ecostatus

The major factors contributing to the Ecostatus for EWR Site 3 were:
- o reduced summer flows and longer than natural no-flow periods over the summer (flow related);
- o alien vegetation in the channel (non-flow related).

6.2.2 Change levels considered by the specialists

The change levels considered by the specialists for lowflows are provided below, while those for the floods are in Table 6.2.

Lowflows change levels were as follows:
Dry Season Lowflows:
Change Level 1: Reduction: Capped at the 30th percentile on the Present Day FDC.
Change Level 2: Reduction: Capped at the 50th percentile on the Present Day FDC.
Change Level 3: Reduction: Capped at the 60-70th percentile on the Present Day FDC.
Change Level 4: Reduction: Capped at the 90th percentile on the Present Day FDC.

Wet Season Lowflows:
Change Level 1: Reduction: Capped at the 10th percentile on the Present Day FDC.
Change Level 2: Reduction: Capped at the 50th percentile on the Present Day FDC.
Change Level 3: Reduction: Capped at the 70th percentile on the Present Day FDC.
Change Level 4: Reduction: Capped at the 90th percentile on the Present Day FDC.

Table 6.2 The change levels considered by the specialists for floods. Flood change levels consider changes in frequency of flood events within a magnitude class.

Flood Class	Frequency: Present Day	Change 1	Change 2	Change 3	Change 4
Class 1	4	Decrease (3)	Decrease (2)	Decrease (1)	Decrease (0)
Class 2	3	Decrease (2)	Decrease (1)	Decrease (0)	-
Class 3	2	Decrease (1)	Decrease (0)	-	-
Class 4	2	Decrease (1)	Decrease (0)	-	-

6.3 DRIFT CATEGORY OUTPUT FOR EWR SITE 3

The DRIFT CATEGORY output provides a summary view of the predicted changes in the river condition with changes in the percentage of the MAR assigned to the river, assuming that there are no limitations on the distribution of that water, i.e., it can be distributed over the year in the way most beneficial to the river ecosystem. Points along the continuum can be selected and more detailed information provided as required.

The DRIFT CATEGORY output for EWR Site 3 is provided in Figure 6.2.
- The plot depicts the river condition at the level of the whole ecosystem, relative to the current state of the system, and the volumes provided are the **maximum annual** volume linked to each scenario[36].
- The DRIFT reported volumes usually include the volume contained in the floods with a return period of 1:2, 1:5, 1:10 and 1:20 years or more. Results reported in the Building Block Methodology usually exclude some or all of the inter-annual floods as it is assumed that they will pass through the system, and cannot be managed[37].
- ECOSTATUS = Overall Integrity Score of zero (0).
- The coloured horizontal lines in Figure 6.2 depict the position at which river condition is expected to change from one category to the next, i.e., they estimate the position of the **threshold between categories**. For example, the Present Ecostatus of EWR Site 3 is B[38], and is represented by an Integrity Score of 0 in the figure. The river is expected to remain in a B-category even with some

[36] These volumes are revised for the selected detailed scenarios to produce the **average annual** volumes. As a general rule, the volumes given in DRIFT Category are higher than the final volumes that would be arrived at through detailed calculations for particular releases from a dam, when floods are capped and/or are not cued by climatic events.
[37] This is in fact not always the case, as large dams can and do severely attenuate floods with return periods of 1:2, 1:5 and 1:10 years. Section 4.4.1 of this report considers the effects of this 'capping' of flood events by impoundments on sediment movement and hence on channel morphology.
[38] Increases in the amount of water available were not considered for EWR Site 3, thus the threshold between a B and A-category is not depicted.

additional abstraction but if this abstraction results in a drop below the orange line, the overall condition is expected to decline to a C-category.

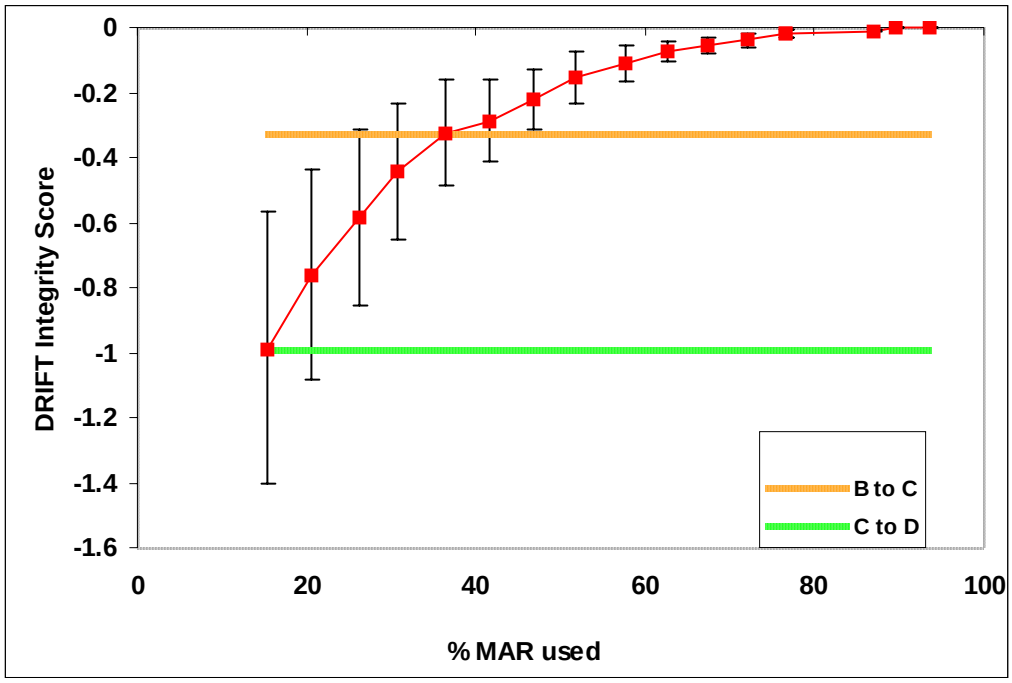


Figure 6.2 The DRIFT CATEGORY output for EWR Site 3. See notes above for explanation.

6.4 DETAILED OPTION 1: MAINTAIN RECOMMENDED ECOLOGICAL CATEGORY (REC)

6.4.1 Overview of EWR Option 1

The following is a brief summary of EWR Option 1 (REC) for EWR Site 3.

TARGET ECOLOGICAL CATEGORY

Maintain Recommended Ecological Category (REC) = B.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume required for the river for EWR Option 1 (REC) – EWR Site 3:

Including the volume for the ≥ 1:5 year floods: 4.83 MCM a^{-1}
= *c*. 63% nMAR and 65% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[39]: 3.73 MCM a^{-1}
= *c*. 48% nMAR and 51% present day MAR.

[39] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the REC.

KEY CONSIDERATIONS

The distribution of the flow is a consideration that is at least as important as that of volume. In the case of EWR Site 3, withdrawal of water from the winter lowflows is predicted to have considerably less impact on the Rondegat River than abstraction during the dry summer months. Similarly, the preservation of the Class 1, 3 and 4 intra-annual floods in the flow regime to support a B-category river points to the deemed importance of flow variability in the system.

FLOW REDUCTION LEVELS USED

For EWR Option 1 (REC) at EWR Site 3, the following mix of change levels for the 10 components was selected for a B-category river:

Wet season lowflows:	change level 3.
Dry season lowflows:	change level 2.
Class 1 Intra-annual floods:	present day.
Class 2 Intra-annual floods:	present day.
Class 3 Intra-annual floods:	present day.
Class 4 Intra-annual floods:	present day.
Inter-annual floods (1:2 year):	present day.
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 1 (REC) was specifically designed to limit possible impacts as a result of changes in the flow components that are deemed to threaten the overall Ecostatus. This Ecostatus would, however, be threatened should the non-flow related factors contributing to the poor condition of the river, such as destruction of the floodplain and manipulation of the channel, continue unabated.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 1 (REC) was assigned an **Overall Integrity Score of – 0.07**, i.e., SLIGHT REDUCTION in present Ecostatus. The overall ecostatus is, however, expected to remain in a B-category, provided other (non-flow related) impacts on the river are maintained at a level that facilitates maintenance of a B-category.

EXPECTED EC

EWR Option 1 (REC) for EWR Site 3 is expected to maintain a B-category in the Rondegat River, provided other non-flow related impacts on the river are also controlled to a level to facilitate maintenance of the B-category.

6.4.2 EWR Option 1 (REC) Hydrology

A portion of the modified flow regime for EWR Option 1 (REC) is shown in Figure 6.3 and Table 6.3 provides a breakdown of the flow regime required to meet EWR Option 1 (REC). The flood requirements for EWR Option 1 (REC) are given in detail in Table 6.4 and the rule curves are provided in Table 6.5 (whole flow regime) and Table 6.6 (lowflows only).

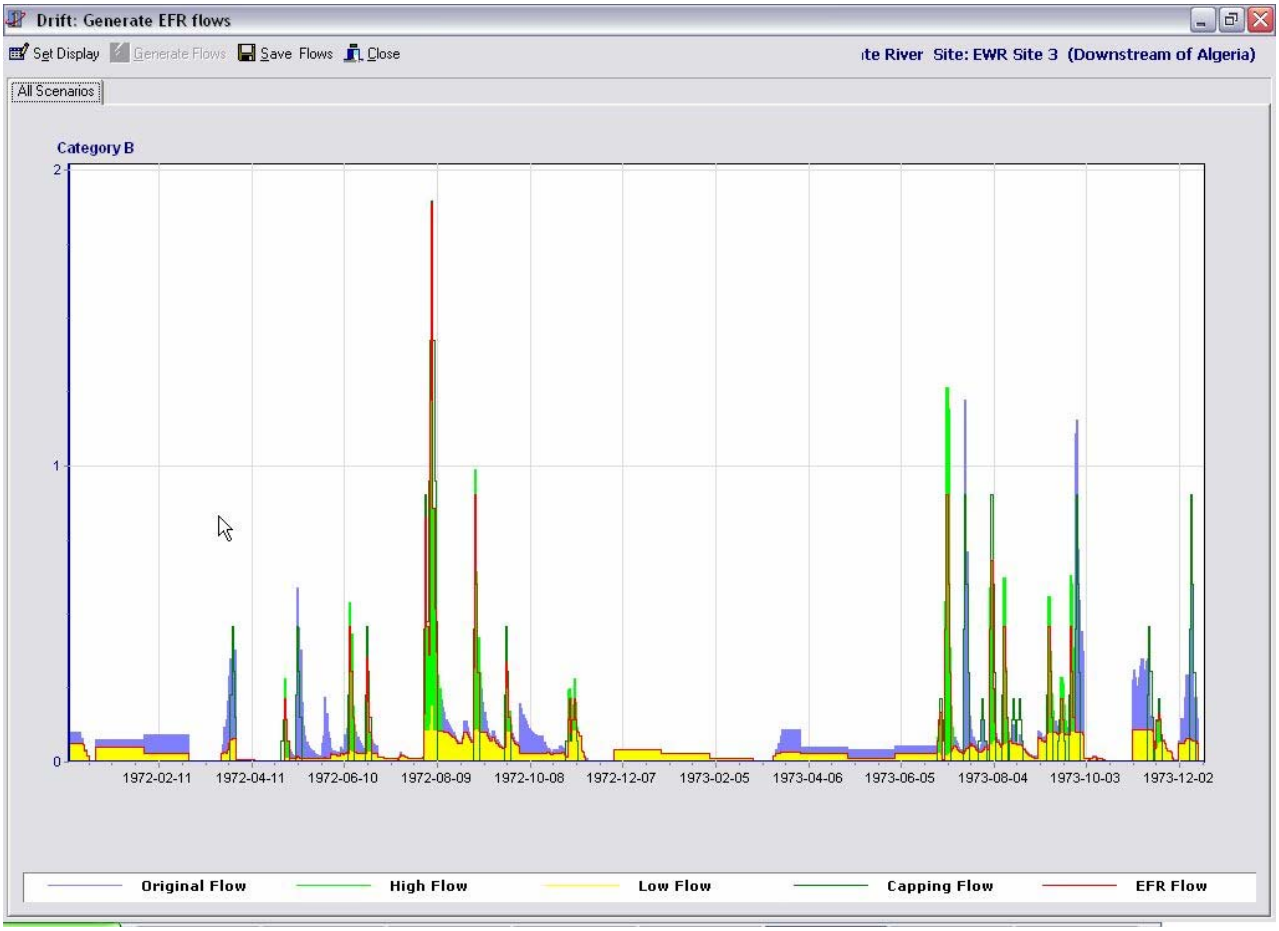


Figure 6.3 A portion of the modified flow regime for EWR Option 1 (REC) at EWR Site 3.

Table 6.3 Water quantity for EWR Option 1 (REC) at EWR Site 3 (Rondegat River downstream of Algeria). To be met at the pedestrian bridge at Algeria. MCM = million cubic metres[40].

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 7.7 MCM. PD MAR = 7.3 MCM.														
EWR Ecostatus Category = B.														
MAINTENANCE														
CAPPING FLOWS	Not set												N/a	
LOW FLOWS Q m^3s^{-1}	0.07	0.06	0.04	0.04	0.02	0.02	0.02	0.02	0.04	0.09	0.09	0.12	1.64	21
FLOOD Class 1[41]: 0.32 m^3s^{-1}	0.5	1				1		1				0.5	0.05x4	3
FLOOD Class 2: 0.64 m^3s^{-1}								1	1		1		0.11x3	4
FLOOD Class 3: 1.28 m^3s^{-1}									1		1		0.22x2	1
FLOOD Class 4: 2.56 m^3s^{-1}									2				0.33x2	8
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												1.1	14
MAINTENANCE TOTAL (Volume)	**Annual[42]**												**4.83**	**63**
	Long-term average[43]												**4.06**	**53**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.004	0	0	0.004	0.004	0	0	0	0.01	0.01	0.01	0.01	0.14	2
FLOOD Peak[44] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***0.22***	***0.22***	***0.14***	***0.11***	***0.07***	***0.06***	***0.07***	***0.15***	***0.32***	***0.93***	***1.05***	***0.64***	**4.06**	**53**

[40] Values given are an ESTIMATE of the flows required. Actual volumes depend on climate.
[41] Daily average peak
[42] Calculated as the volume of water required to meet the full requirements.
[43] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
[44] Daily average peak

Table 6.4 Summary of the flood requirements for EWR Site 3 – EWR Option 1 (REC): Maintain a B-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	0.32	3	0.05	4	April - June September - November
Class 2	0.64	3	0.11	3	June- September
Class 3	1.28	4	0.22	2	June- September
Class 4	2.56	4	0.44	2	June- September
Inter-annual Class (return period given below)					
1:2	2.8	7	1.02	Present	Not stipulated
1:5	3.9	8	1.3	Present	Not stipulated
1:10	6.5	8	1.88	Present	Not stipulated
1:20	11.0	10	2.87	Present	Not stipulated

Table 6.5 Exceedence curves for the complete flow regime (floods and droughts included) required to meet Option 1 (REC) for EWR Site 3. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	1.897	0.474	0.144	0.105	0.1	0.061	0.043	0.031	0.03	0.021	0.01	0	0	4.066
Jan	0.062	0.06	0.053	0.052	0.051	0.05	0.05	0.041	0.031	0.03	0.02	0.01	0	0.111
Feb	0.195	0.032	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.013	0.01	0	0	0.073
Mar	0.062	0.032	0.031	0.031	0.03	0.03	0.02	0.02	0.01	0.01	0	0	0	0.063
Apr	0.142	0.032	0.031	0.03	0.03	0.03	0.03	0.02	0.011	0.01	0	0	0	0.069
May	0.903	0.301	0.071	0.026	0.024	0.023	0.023	0.022	0.021	0.01	0	0	0	0.154
Jun	1.556	0.575	0.295	0.05	0.046	0.043	0.042	0.042	0.041	0.031	0.01	0.01	0	0.319
Jul	3.101	1.723	0.949	0.458	0.121	0.11	0.106	0.105	0.103	0.074	0.023	0.011	0	0.926
Aug	4.196	2.019	1.017	0.379	0.105	0.104	0.103	0.103	0.102	0.086	0.045	0.011	0	1.047
Sep	1.897	0.919	0.474	0.229	0.143	0.142	0.142	0.141	0.141	0.112	0.071	0.041	0.02	0.639
Oct	0.996	0.306	0.108	0.101	0.101	0.101	0.1	0.092	0.064	0.042	0.02	0.01	0	0.305
Nov	0.458	0.153	0.11	0.105	0.104	0.102	0.075	0.062	0.04	0.032	0	0	0	0.216
Dec	0.213	0.071	0.062	0.062	0.061	0.061	0.06	0.04	0.03	0.021	0.01	0	0	0.143
Wet[45]	2.443	0.949	0.474	0.142	0.11	0.103	0.1	0.061	0.042	0.024	0.016	0.004	0	3.391
Dry[46]	0.213	0.105	0.074	0.061	0.049	0.032	0.03	0.03	0.025	0.013	0.002	0	0	0.675

[45] May-October.

[46] November-April.

Table 6.6 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 1 (REC) for EWR Site 3. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	0.061	0.059	0.053	0.051	0.05	0.05	0.05	0.04	0.031	0.03	0.02	0.01	0	0.109
Feb	0.032	0.032	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.013	0.01	0	0	0.061
Mar	0.032	0.032	0.031	0.031	0.03	0.03	0.02	0.02	0.01	0.01	0	0	0	0.054
Apr	0.034	0.031	0.031	0.03	0.03	0.03	0.03	0.02	0.011	0.01	0	0	0	0.054
May	0.027	0.027	0.026	0.024	0.023	0.023	0.022	0.022	0.02	0.01	0	0	0	0.049
Jun	0.058	0.05	0.05	0.046	0.043	0.043	0.042	0.041	0.04	0.03	0.01	0.01	0	0.098
Jul	0.122	0.114	0.113	0.11	0.107	0.106	0.105	0.104	0.1	0.07	0.02	0.01	0	0.24
Aug	0.107	0.106	0.105	0.104	0.103	0.103	0.103	0.102	0.1	0.08	0.04	0.01	0	0.239
Sep	0.16	0.144	0.143	0.142	0.142	0.142	0.142	0.141	0.14	0.11	0.07	0.04	0.02	0.326
Oct	0.15	0.102	0.102	0.101	0.101	0.101	0.1	0.09	0.06	0.04	0.02	0.01	0	0.21
Nov	0.111	0.11	0.105	0.104	0.102	0.1	0.07	0.06	0.04	0.03	0	0	0	0.173
Dec	0.071	0.063	0.062	0.062	0.061	0.061	0.06	0.04	0.03	0.021	0.01	0	0	0.118
Wet[47]	0.146	0.142	0.141	0.107	0.103	0.101	0.086	0.048	0.041	0.023	0.014	0.003	0	1.162
Dry[48]	0.109	0.102	0.066	0.059	0.046	0.031	0.03	0.03	0.024	0.013	0.002	0	0	0.569

6.5 DETAILED OPTION 2: DROP ONE CATEGORY TO CATEGORY C (AEC)

6.5.1 Overview of EWR Option 2

The following is a brief summary of EWR Option 2 (AEC) for EWR Site 3.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume required for the river for EWR Option 2 (AEC) – EWR Site 3:

Including the volume for the ≥ 1:5 year floods: 2.01 MCM a^{-1}
= *c*. 26% nMAR and 27% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[49]: 1.42 MCM a^{-1}
= 18% nMAR and 19% present day MAR.

KEY CONSIDERATIONS

The difference between the flow regime requested for EWR Option 1 (B-category) and EWR Option 2 (C-category) lies in a reduced flood requirement for Option 2. The requirement for Class 3 and 4 intra-annual floods has been dropped, as has the requirement for a 1:2 year flood.

[47] May-October.

[48] November-April.

[49] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the AEC.

FLOW REDUCTION LEVELS USED

For EWR Option 2 (AEC) at EWR Site 3, the following mix of change levels for the 10 components was selected for the EWR Option 2 (AEC): drop one category to Category C – relative to the Present Ecostatus:

Wet season lowflows:	change level 4.
Dry season lowflows:	change level 3.
Class 1 Intra-annual floods:	change level 1.
Class 2 Intra-annual floods:	change level 2.
Class 3 Intra-annual floods:	change level 2.
Class 4 Intra-annual floods:	change level 1.
Inter-annual floods (1:2 year):	not present (change level 1).
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 2 (AEC) was specifically designed to limit possible impacts as a result of changes in the flow components that are deemed to threaten the overall Ecostatus to those that would drop the condition of the river by one category to a Category C.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 2 (AEC) was assigned an **Overall Integrity Score of - 0.59**, i.e., a REDUCTION in present Ecostatus from a B-category to a C-category river. The precautionary principle has been applied and a flow regime selected that is immediately below the C/B-category theoretical threshold. Clearly some scope exists for further reduction, while maintaining a C-category, however, this would be accompanied by an increased risk of not meeting a C-category.

EXPECTED EC

Category C.

6.5.2 EWR Option 2 Hydrology

A portion of the modified flow regime for EWR Option 2 (AEC) is shown in Figure 6.4 and Table 6.7 provides a breakdown of the flow regime required to meet EWR Option 2. The flood requirements for EWR Option 2 (AEC) are given in detail in Table 6.9 and the rule curves are provided in Tables 6.9 (whole flow regime) and 6.10 (lowflows only).

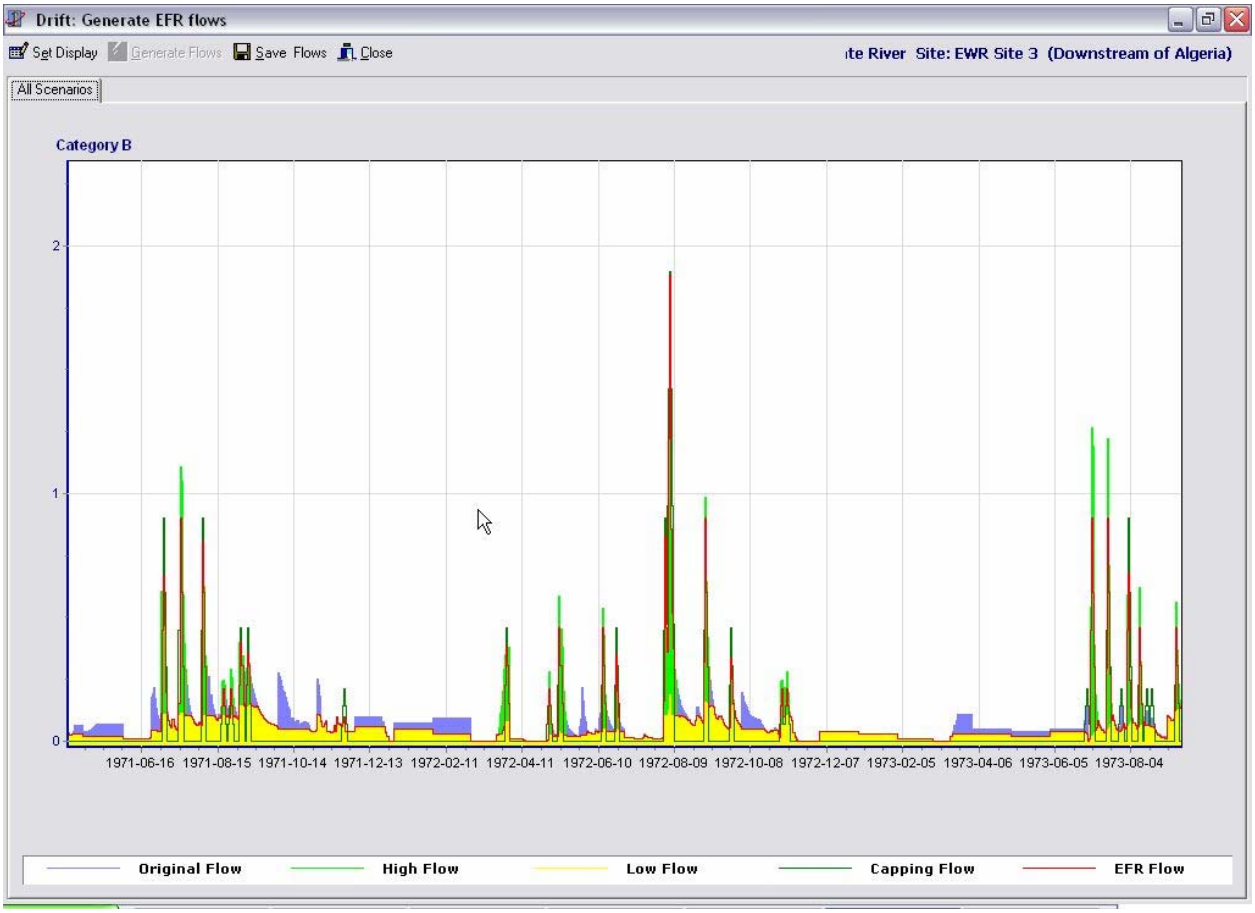


Figure 6.4 A portion of the modified flow regime for EWR Option 2 (AEC) at EWR Site 3.

Table 6.7 Water quantity for EWR Option 2 (AEC) at EWR Site 3 (Rondegat River downstream of Algeria). To be met at the pedestrian bridge at Algeria. MCM = million cubic metres.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 7.7 MCM. PD MAR = 7.3 MCM.														
EWR Ecostatus Category = C.														
MAINTENANCE														
CAPPING FLOWS	Not set												N/a	
LOW FLOWS Q m^3s^{-1}	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.06	0.1	0.1	1.15	15
FLOOD Class 1[50]: 0.32 m^3s^{-1}	0.5	1				1						0.5	0.05x3	2
FLOOD Class 2: 0.64 m^3s^{-1}									1				0.11x1	1
FLOOD Class 3: 1.28 m^3s^{-1}													-	-
FLOOD Class 4: 2.56 m^3s^{-1}													-	-
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												0.59	8
MAINTENANCE TOTAL (Volume)	**Annual[51]**												**2.00**	**26**
	Long-term average[52]												**2.17**	**28**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.004	0	0	0.004	0.004	0	0	0	0.01	0.01	0.01	0.01	0.14	2
FLOOD Peak[53] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***0.17***	***0.12***	***0.10***	***0.08***	***0.06***	***0.05***	***0.06***	***0.15***	***0.18***	***0.19***	***0.66***	***0.38***	**2.17**	**28**

[50] Daily average peak

[51] Calculated as the volume of water required to meet the full requirements.

[52] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.

[53] Daily average peak

Table 6.8 Summary of the flood requirements for EWR Site 3 – EWR Option 2 (AEC): Maintain a C-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	0.32	3	0.05	3	April - June September - November
Class 2	0.64	3	0.11	1	June- September
Class 3	1.28	4	0.22	0	Not applicable
Class 4	2.56	4	0.44	0	Not applicable
Inter-annual Class (return period given below)					
1:2	2.8	7	1.02	0	Not applicable
1:5	3.9	8	1.3	Present	Not stipulated
1:10	6.5	8	1.88	Present	Not stipulated
1:20	11.0	10	2.87	Present	Not stipulated

Table 6.9 Exceedence curves for the complete flow regime (floods and droughts included) required to meet Option 2 (AEC) for EWR Site 3. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	0.903	0.105	0.102	0.064	0.056	0.034	0.031	0.03	0.02	0.014	0.01	0	0	2.173
Jan	0.035	0.034	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0	0.076
Feb	0.032	0.032	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.013	0.01	0	0	0.064
Mar	0.055	0.022	0.021	0.021	0.02	0.02	0.02	0.02	0.01	0.01	0	0	0	0.05
Apr	0.213	0.021	0.021	0.02	0.02	0.02	0.02	0.02	0.011	0.01	0	0	0	0.056
May	1.423	0.191	0.015	0.014	0.012	0.012	0.011	0.011	0.011	0.01	0	0	0	0.145
Jun	1.186	0.06	0.036	0.034	0.032	0.031	0.031	0.031	0.03	0.021	0.01	0.01	0	0.175
Jul	0.516	0.072	0.068	0.066	0.065	0.063	0.063	0.062	0.06	0.051	0.02	0.01	0	0.19
Aug	4.196	1.017	0.107	0.105	0.103	0.103	0.103	0.102	0.096	0.076	0.045	0.011	0	0.657
Sep	1.423	0.458	0.111	0.102	0.102	0.101	0.101	0.101	0.1	0.091	0.058	0.041	0.02	0.379
Oct	0.458	0.064	0.062	0.061	0.061	0.061	0.06	0.06	0.06	0.04	0.02	0.01	0	0.168
Nov	0.306	0.142	0.044	0.043	0.042	0.042	0.042	0.041	0.04	0.032	0	0	0	0.119
Dec	0.306	0.034	0.031	0.031	0.031	0.031	0.03	0.03	0.03	0.021	0.01	0	0	0.097
Wet[54]	1.628	0.229	0.104	0.101	0.081	0.063	0.061	0.045	0.031	0.014	0.011	0.003	0	1.713
Dry[55]	0.213	0.043	0.042	0.031	0.03	0.03	0.03	0.021	0.02	0.013	0.002	0	0	0.461

[54] May-October.

[55] November-April.

Table 6.10 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 2 (AEC) for EWR Site 3. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	0.034	0.034	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0	0.075
Feb	0.032	0.032	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.013	0.01	0	0	0.061
Mar	0.022	0.022	0.021	0.021	0.02	0.02	0.02	0.02	0.01	0.01	0	0	0	0.041
Apr	0.023	0.021	0.021	0.02	0.02	0.02	0.02	0.02	0.011	0.01	0	0	0	0.039
May	0.015	0.014	0.014	0.013	0.012	0.012	0.011	0.011	0.011	0.01	0	0	0	0.027
Jun	0.042	0.036	0.036	0.034	0.032	0.031	0.031	0.031	0.03	0.02	0.01	0.01	0	0.072
Jul	0.072	0.069	0.068	0.066	0.064	0.063	0.063	0.062	0.06	0.051	0.02	0.01	0	0.148
Aug	0.107	0.106	0.105	0.104	0.103	0.103	0.103	0.101	0.094	0.073	0.04	0.01	0	0.235
Sep	0.111	0.102	0.102	0.102	0.101	0.101	0.101	0.101	0.1	0.09	0.057	0.04	0.02	0.239
Oct	0.032	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.03	0.022	0.012	0.01	0	0.07
Nov	0.031	0.031	0.031	0.031	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0	0	0.07
Dec	0.035	0.031	0.031	0.031	0.031	0.031	0.03	0.03	0.03	0.021	0.01	0	0	0.07
Wet[56]	0.107	0.103	0.102	0.101	0.068	0.061	0.033	0.031	0.03	0.013	0.011	0.003	0	0.792
Dry[57]	0.034	0.031	0.031	0.031	0.03	0.03	0.03	0.021	0.02	0.015	0.003	0	0	0.356

[56] May-October.

[57] November-April.

7. RESULTS FOR EWR SITE 4 (DORING RIVER UPSTREAM OF THE CONFLUENCE WITH THE BIEDOU RIVER)

KEY ISSUES AT EWR SITE 4:

- The Present Ecostatus is B/C-category.
- The Recommended Ecological Category (REC) is a B-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B-category) = 277 MCM per annum (i.e., 66% nMAR – incl. volume of inter-annual floods).
- Environmental Flow to support AEC (C-category) = 136 MCM per annum (i.e., 33% nMAR – incl. volume of inter-annual floods).
- The flows recommended for BOTH scenarios provided here represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation.
- At the time of this study, no data or models were available to assess the implications of flow changes on the unique water chemistry of the Doring River. It is thus, highly possible that the water quality implications of the changes in flow are underestimated.
- The invasion of biota into the Doring River, primarily *Nerium oleander*, is a major threat to the future ecostatus of this system.
- The physical presence (i.e., aside from influence on the flow regime) of a dam in the Doring or Groot River, i.e., upstream of EWR Site 4 or 5 would critically affect the geomorphological condition of the system (with knock-on effects on other aspects of the river ecosystem, e.g., geomorphology and water quality) mainly through the reduction in variability of the large to medium sized flood, and through the reduction of sediment supply/sediment transport capacity. It would also represent a barrier to fish and other fauna movement, and provide a safe haven for alien invaders, such as smallmouthed bass (see Brown *et al.* 2003).

7.1 RIVER REACH REPRESENTED BY EWR SITE 4

The Doring River is a tributary of the Olifants River. EWR Site 4 is representative of the section of the Doring River from Elandsvlei (the confluence with the Tankwa River) to Doringbos.

7.2 PRESENT ECOSTATUS

A summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 4 is presented in Figure 7.1.

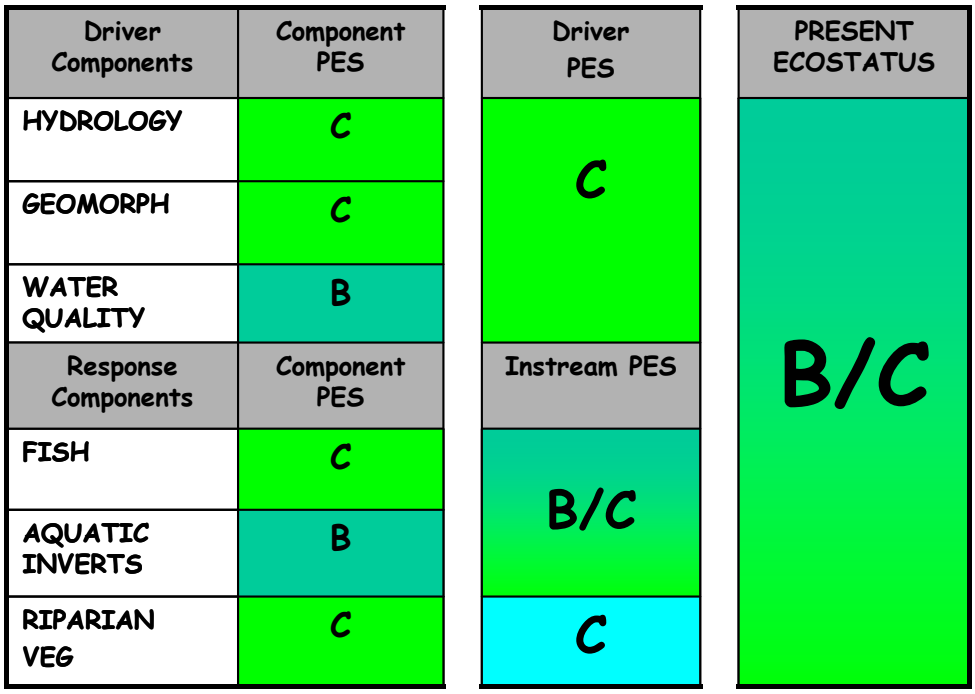


Figure 7.1 Summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 4.

Additional details for the PES assessments are provided in Riverine RDM report: Volume 1.

Table 7.1 Present Ecostatus, Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC) for EWR Site 4.

Component of the riverine ecosystem	PES		EIS	Recommended Ecological Category
	Category	Trajectory		
Hydrology	C	*Negative*	Very High	B[58]
Water quality	B	*Stable*		
Geomorphology	C	*Negative*		
Riparian vegetation	C	*Stable*		
Macroinvertebrates	B	*Stable*		
Fish	C	*Stable*		
PRESENT ECOSTATUS	**B/C**	***Negative***		

7.2.1 Major contributing factors to the Ecostatus

The major factors contributing to the Present Ecostatus for EWR Site 4 were:
- o reduced summer flows and long no-flow periods over the summer (flow related);
- o alien vegetation and plantations in catchment (non-flow related).

7.2.2 Change levels considered by the specialists

The change levels considered by the specialists for lowflows are provided below, while those for the floods are in Table 4.2.

[58] The high EIS for this site suggests that the REC should be for an improved condition.

Lowflows change levels were as follows:
Dry Season Lowflows:
Change Level 1: Reduction: Capped at the 10th percentile on the Present Day FDC.
Change Level 2: Reduction: Lengthen the duration of no-flow conditions in the dry season to the 10th percentile on the Present Day FDC.
Change Level 3: Increase: Shorten the Present Day dry season (i.e., move towards the natural duration of the dry season) by implementing a 0.03 m^3s^{-1} minimum flow in November and April.
Change Level 4: Increase: Constant 1 m^3s^{-1} flows during the dry season (e.g., irrigation releases).

Wet Season Lowflows:
Change Level 1: Reduction: Capped at the 20th percentile on the Present Day FDC.
Change Level 2: Reduction: Capped at the 40th percentile on the Present Day FDC.
Change Level 3: Reduction: Capped at the 60th percentile on the Present Day FDC.
Change Level 4: Reduction: Capped at the 90th percentile on the Present Day FDC.

Table 7.2 The change levels considered by the specialists for floods. Flood change levels consider changes in frequency of flood events within a magnitude class.

Flood Class	Frequency: Present Day	Change 1	Change 2	Change 3	Change 4
Class 1	6	Decrease (5)	Decrease (3)	Decrease (1)	Decrease (0)
Class 2	2	Decrease (1)	Decrease (0)	-	-
Class 3	2	Decrease (1)	Decrease (0)	-	-
Class 4	1	Decrease (0)	-	-	-

7.2 DRIFT CATEGORY OUTPUT FOR EWR SITE 4

The DRIFT CATEGORY output provides a summary view of the predicted changes in the condition of the river under study with changes in the percentage of the MAR assigned to the river, assuming that there are no limitations on the distribution of that water, i.e., it can be distributed over the year in the way most beneficial to the river ecosystem. The output allows the decision maker the opportunity to select points along the continuum where they would like more detailed information. These points are then used as the position of the more detailed options, which can also explore the consequences of not being able to make certain releases, such as floods, i.e., consequences of non-optimal distribution of flows.

The DRIFT CATEGORY output was generated by calculating the maximised Overall Integrity Scores for 18 different annual volumes of water, distributed in the least damaging manner. The output for EWR Site 4 is provided in Figure 7.2.

- The plot depicts river condition at the level of the whole ecosystem, relative to the current state of the system, and the volumes provided are the **maximum annual** volume linked to each scenario[59].
- The DRIFT reported volumes usually include the volume contained in the floods with a return period of 1:2, 1:5, 1:10 and 1:20 years or more. Results reported in the Building Block Methodology usually exclude some or all of the inter-annual floods as it is assumed that they will pass through the system, and cannot be managed[60].

[59] These volumes are revised for the selected detailed scenarios to produce the **average annual** volumes. As a general rule, the volumes given in DRIFT Category are higher than the final volumes that would be arrived at through detailed calculations for particular releases from a dam, when floods are capped and/or are not cued by climatic events.

[60] This is in fact not always the case, as large dams can and do severely attenuate floods with return periods of 1:2, 1:5 and 1:10 years.

- ECOSTATUS = Overall Integrity Score of zero (0).
- The coloured horizontal lines in Figure 7.2 depict the position at which river condition is expected to change from one category to the next, i.e., they estimate the position of the **threshold between categories**. For example, the Present Ecostatus of EWR Site 4 is B/C, and is represented by an Integrity Score of 0 in the figure. Improvement in the overall condition of the river, i.e., positive Overall Integrity would lead first to a B category (i.e., across the blue line). Any decline in the present condition (i.e., such as increased abstraction resulting in an extended dry season), will result in a decline to a C-category river. For this reason, the B-category scenario presented is situated just above the B/C 'threshold' (blue line).

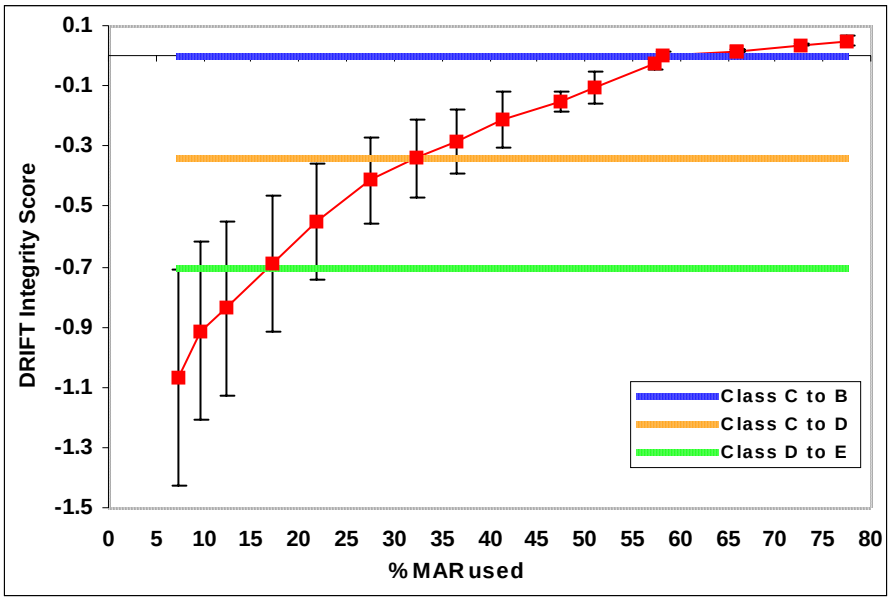


Figure 7.2 The DRIFT CATEGORY output for EWR Site 4. See notes above for explanation.

6.6 DETAILED EWR OPTION 1: MAINTAIN RECOMMENDED ECOLOGICAL CATEGORY (REC)

7.2.1 Overview of EWR Option 1

The following is a brief summary of EWR Option 1 (REC) for EWR Site 4.

TARGET ECOLOGICAL CATEGORY

Maintain Recommended Ecological Category (REC) = B.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume required for the river for EWR Option 1 (REC) – EWR Site 4:
Including the volume for the ≥ 1:5 year floods: 277 MCM a^{-1}
= 66% nMAR and 86% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[61]: 222 MCM a^{-1}
= 53% nMAR and 69 % present day MAR.

KEY CONSIDERATIONS

There is currently an 80% reduction at 70% exceedance, which effectively translates into an extended low-flow season, with extended periods of zero flow.

FLOW REDUCTION LEVELS USED

For EWR Option 1 (REC) at EWR Site 4, the following mix of change levels for the 10 components was selected for the Category B:

Wet season lowflows:	change level 3.
Dry season lowflows:	change level 3[62].
Class 1 Intra-annual floods:	present day.
Class 2 Intra-annual floods:	present day.
Class 3 Intra-annual floods:	present day.
Class 4 Intra-annual floods:	present day.
Inter-annual floods (1:2 year):	present day.
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 1 (REC) was specifically designed to limit possible impacts as a result of changes in the flow components that are deemed to threaten the overall Ecostatus.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 1 (REC) was assigned an **Overall Integrity Score of +0.015**, i.e., SLIGHT IMPROVEMENT in Present Ecostatus from a B/C to a B.

EXPECTED EC

Category B.

7.2.2 Scenario Hydrology

Figure 7.3 depicts an excerpt from the graphical time-series display for EWR Site 4, Option 1 (REC). Table 7.3 provides a breakdown of the flow regime required to meet EWR Option 1 (REC). The flood requirements for EWR Option 1 (REC) are given in detail in Table 7.4 and the rule curves are provided in Table 7.5.

[61] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the REC.

[62] I.e., only limited additional water is available for abstraction in the wet season, and some of the dry season lowflows should be reinstated.

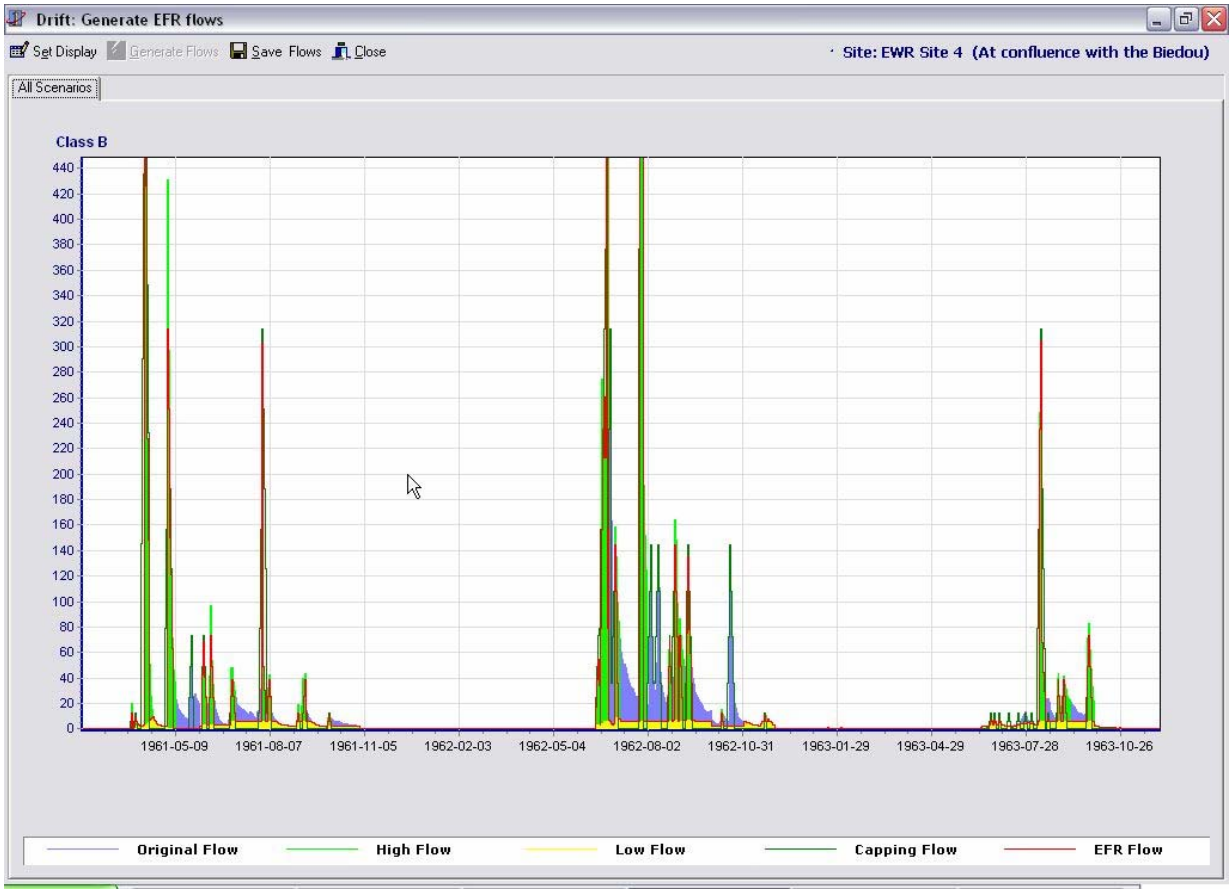


Figure 7.3 An excerpt from the graphical time-series display for EWR Site 4, Option 1 (REC). The blue line indicates the present day flow in the river, and the red line indicates the EWR flow requested.

Table 7.3 The EWR (quantity) requested for maintenance of a B-category at EWR Site 4 on the Doring River u/s Biedou, Western Cape.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 420 MCM. PD MAR =320 MCM														
EWR Ecostatus Category = B.														
MAINTENANCE														
CAPPING FLOWS	Not set	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	0 m^3s^{-1}	Not set					N/a	
LOW FLOWS Q m^3s^{-1}[63]	2.0	0.03	0	0	0	0	0.05	0.5	3.0	6.0	6.0	6.0	59.2	14
FLOOD Class 1[64]: 26 m^3s^{-1}	2	1				1		1				1	3.2x6	5
FLOOD Class 2: 52 m^3s^{-1}									1		1		11x2	5
FLOOD Class 3: 103 m^3s^{-1}									1		1		20.2x2	10
FLOOD Class 4: 209 m^3s^{-1}									1				45x1	11
FLOOD Class 5: 1:2 year													40	10
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												55	13
MAINTENANCE TOTAL (Volume)	**Annual[65]**												**277**	**66**
	Long-term average[66]												**199**	**47**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.15	0.03	0	0	0	0	0	0.01	0.01	0.02	1.03	0.09	3.6	1
FLOOD Peak[67] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***6.75***	***3.88***	***1.26***	***6.28***	***1.96***	***0.91***	***13.19***	***25.22***	***39.32***	***39.05***	***36.71***	***24.74***	**199**	**47**

[63] Figures rounded-off to the nearest one decimal place.
[64] Daily average peak.
[65] Calculated as the volume of water required to meet the full requirements.
[66] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
[67] Daily average peak.

Table 7.4 Summary of the flood requirements for EWR Site 4 – EWR Option 1 (REC): Maintain a B/C-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	26.09	2	3.2	6	September-June
Class 2	52.19	4	11	2	June-September
Class 3	103.38	4	20.27	2	June-September
Class 4	208.75	6	45.02	1	June-September
Inter-annual Class (return period given below)					
1:2	231.94	6	80.33	Present	Not stipulated
1:5	455.42	8	96.54	Present	Not stipulated
1:10	873.08	8	202.41	Present	Not stipulated
1:20	949.65	8	>202.41	Present	Not stipulated

Table 7.5 Exceedence curves for the complete flow regime (floods and droughts included) required to meet Option 1 (REC) for EWR Site 4. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	113.09	24.796	6.188	5.957	2.973	1.59	0.506	0.091	0.025	0	0	0	0	199.264
Jan	11.472	2.583	0.437	0.119	0.027	0	0	0	0	0	0	0	0	6.278
Feb	17.452	2.701	0.484	0.074	0.025	0	0	0	0	0	0	0	0	1.964
Mar	4.456	2.718	0.536	0.075	0.032	0.007	0	0	0	0	0	0	0	0.906
Apr	121.72	6.188	3.351	1.638	0.59	0.1	0.058	0.025	0.025	0.025	0.01	0.01[68]	0	13.189
May	238.23	60.558	6.188	0.571	0.534	0.515	0.5	0.38	0.061	0.01	0.01	0.01	0	25.221
Jun	213.28	78.525	40.634	7.095	3.139	3.075	3.036	3	1.824	0.494	0.035	0.01	0	39.319
Jul	144.19	49.158	32.848	6.261	6.133	6.08	6.057	6.018	4.916	3.229	1.573	0.17	0.08	39.051
Aug	178.05	51.031	25.585	6.195	6.081	6.055	6.04	6.003	5.085	3.212	1.702	1.03	0.19	36.71
Sep	125.64	35.649	12.792	6.183	6.081	6.053	6.017	5.431	4.046	2.843	1.614	0.92	0.18	24.735
Oct	38.377	6.188	2.147	2.051	2.037	2.025	2.002	1.565	1.032	0.616	0.28	0.15	0.02	6.751
Nov	18.203	6.254	3.051	1.039	0.34	0.1	0.03	0.03	0.03	0.03	0.03	0.03	0.01	3.878
Dec	7.719	4	0.77	0.12	0.01	0	0	0	0	0	0	0	0	1.262
Wet[69]	157.05	49.158	24.579	6.115	6.046	5.206	3.064	2.05	1.4	0.534	0.177	0	0	171.787
Dry[70]	16.39	4.042	1.753	0.288	0.07	0.03	0.025	0	0	0	0	0	0	27.477

[68] Adjusted slightly to remove the mismatch between the end of dry and start of wet seasons.
[69] May-October.
[70] November-April.

Table 7.6 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 1 (REC) for EWR Site 4. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	7.365	2.161	0.437	0.119	0.027	0	0	0	0	0	0	0	0	1.119
Feb	17.452	2.581	0.484	0.074	0.025	0	0	0	0	0	0	0	0	1.943
Mar	3.354	2.523	0.536	0.075	0.032	0.007	0	0	0	0	0	0	0	0.82
Apr	7.91	4.48	2.75	1.59	0.59	0.1	0.05	0.025	0.025	0.025	0.01	0.01[71]	0	2.429
May	0.639	0.606	0.575	0.55	0.528	0.512	0.5	0.37	0.061	0.01	0.01	0.01	0	0.639
Jun	4.296	3.221	3.15	3.105	3.071	3.042	3.022	2.89	1.824	0.494	0.035	0.01	0	4.296
Jul	6.32	6.189	6.146	6.102	6.075	6.059	6.033	6	4.916	3.229	1.573	0.17	0.08	6.32
Aug	6.643	6.226	6.136	6.082	6.062	6.045	6.029	6	5.085	3.212	1.702	1.03	0.19	6.643
Sep	6.861	6.195	6.158	6.077	6.056	6.034	6	5.28	4.046	2.843	1.614	0.92	0.18	6.861
Oct	2.182	2.134	2.07	2.047	2.031	2.02	2	1.54	1.032	0.616	0.28	0.15	0.02	2.182
Nov	11.11	5.56	2.78	0.99	0.34	0.1	0.03	0.03	0.03	0.03	0.03	0.03	0.01	2.483
Dec	7.719	4	0.77	0.12	0.01	0	0	0	0	0	0	0	0	1.262
Wet[72]	6.473	6.147	6.085	6.046	5.718	3.215	2.901	2.028	1.103	0.528	0.177	0	0	49.197
Dry[73]	9.536	3.43	1.668	0.288	0.069	0.03	0.025	0	0	0	0	0	0	10.056

7.3 DETAILED EWR OPTION 2: DROP TO A C-CATEGORY (AEC)

7.3.1 Overview of EWR Option 2

The following is a brief summary of EWR Option 2 (AEC) for EWR Site 4.

TARGET ECOLOGICAL CATEGORY

Maintain Alternate Ecological Category (AEC) = C.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume required for the river for EWR Option 2 (AEC) – EWR Site 4:

Including the volume for the ≥ 1:5 year floods: 136 MCM a^{-1}
= *c*. 32% nMAR and 43% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[74]: 87 MCM a^{-1}
= *c*. 21% nMAR and 28% present day MAR.

KEY CONSIDERATIONS

There is currently an 80% reduction at 70% exceedance, which effectively translates into an extended low-flow season, with extended periods of zero flow.

[71] Adjusted slightly to remove the mismatch between the end of dry and start of wet seasons.
[72] May-October.
[73] November-April.
[74] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the AEC.

FLOW REDUCTION LEVELS USED

For EWR Option 2 (AEC) at EWR Site 4, the following mix of change levels for the 10 components was selected – relative to Present Ecostatus:

Wet season lowflows:	change level 4.
Dry season lowflows:	change level 3[75].
Class 1 Intra-annual floods:	change level 2.
Class 2 Intra-annual floods:	present day.
Class 3 Intra-annual floods:	change level 2.
Class 4 Intra-annual floods:	present day.
Inter-annual floods (1:2 year):	change level 1.
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 2 (AEC) should result in a reduction in Present Ecostatus from a B/C-category to a C-category, with a risk of dropping to a C/D category.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 2 (AEC) was assigned an **Overall Integrity Score of –0.034**, i.e., REDUCTION in Present Ecostatus to a C-category[76].

EXPECTED EC

Category C.

7.3.2 Scenario Hydrology

Figure 7.4 depicts an excerpt from the graphical time-series display for EWR Site 4, Option 2 (AEC). Table 7.7 provides a breakdown of the flow regime required to meet EWR Option 2 (AEC). The flood requirements for EWR Option 2 (AEC) are given in detail in Table 7.8 and the exceedance curves are provided in Tables 7.9 (whole flow regime) and 7.10 (lowflows only).

[75] Note: This represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation (see PES assessment: hydrology; Section 8.2).

[76] This is very close to the threshold for a C/D-category, but was adjusted in line with EWR Site 5.

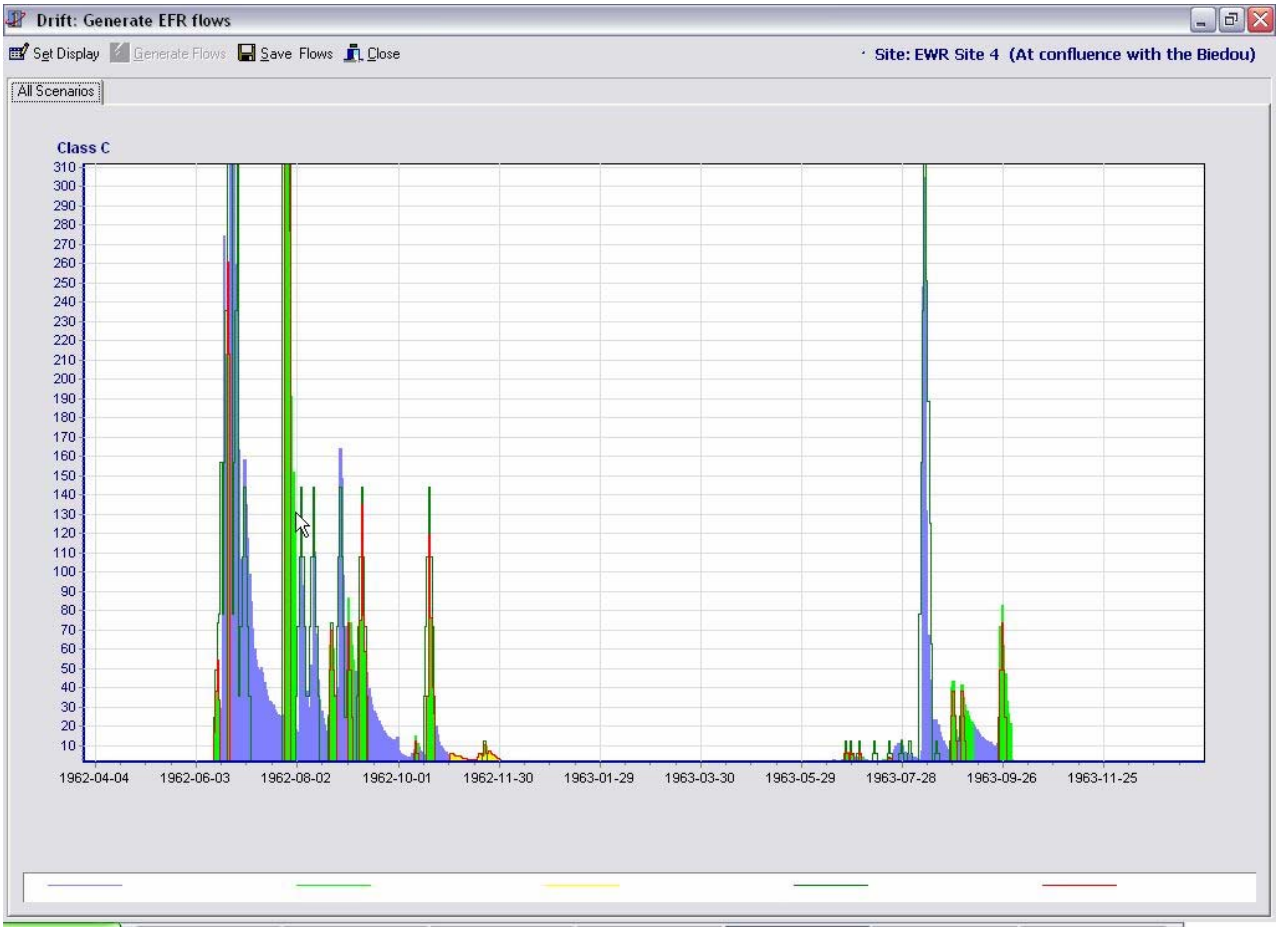


Figure 7.4 An excerpt from the graphical time-series display for EWR Site 4, Option 2 (AEC). The blue line indicates the present day flow in the river, and the red line indicates the EWR flow requested.

Table 7.7 The EWR (quantity) requested for maintenance of a C-category at EWR Site 4 on the Doring River u/s Biedou, Western Cape.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 420 MCM. PD MAR =320 MCM														
EWR Ecostatus Category = C.														
MAINTENANCE														
CAPPING FLOWS	Not set	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	0 m^3s^{-1}	Not set					N/a	
LOW FLOWS Q m^3s^{-1}[77]	2.0	0.03	0	0	0	0	0.05	0.5	3.0	6.0	6.0	6.0	26.6	6
FLOOD Class 1[78]: 26 m^3s^{-1}	2	1				1		1				1	3.2x5	5
FLOOD Class 2: 52 m^3s^{-1}									1		1		11x2	5
FLOOD Class 3: 103 m^3s^{-1}									1				20.2x1	5
FLOOD Class 4: 209 m^3s^{-1}									-				-	-
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												50	12
MAINTENANCE TOTAL (Volume)	**Annual[79]**												**136**	**32**
	Long-term average[80]												**120**	**29**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.15	0.03	0	0	0	0	0	0.01	0.01	0.02	1.03	0.09	3.6	1
FLOOD Peak[81] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***4.42***	***2.57***	***1.29***	***6.124***	***1.951***	***0.867***	***8.124***	***9423***	***20.61***	***29.31***	***22.21***	***13.83***	**120**	**29**

[77] Figures rounded-off to the nearest one decimal place.
[78] Daily average peak.
[79] Calculated as the volume of water required to meet the full requirements.
[80] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
[81] Daily average peak

Table 7.8 Summary of the flood requirements for EWR Site 4 – EWR Option 2 (AEC): Maintain a C-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	26.09	2	3.2	5	September-June
Class 2	52.19	4	11	2	June-September
Class 3	103.38	4	20.27	1	June-September
Class 4	208.75	6	45.02	0	June-September
Inter-annual Class (return period given below)					
1:2	231.94	6	80.33	absent	Not applicable
1:5	455.42	8	96.54	present	Not stipulated
1:10	873.08	8	202.41	present	Not stipulated
1:20	949.65	8	>202.41	present	Not stipulated

Table 7.9 Exceedence curves for the complete flow regime (floods and droughts included) required to meet Option 2 (AEC) for EWR Site 4. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	72.094	12.375	2.475	2.011	1.511	0.515	0.263	0.089	0.025	0	0	0	0	120.752
Jan	8.409	2.326	0.437	0.119	0.027	0	0	0	0	0	0	0	0	6.124
Feb	17.452	2.581	0.484	0.074	0.025	0	0	0	0	0	0	0	0	1.951
Mar	3.733	2.604	0.536	0.075	0.032	0.007	0	0	0	0	0	0	0	0.867
Apr	42.454	5.661	3.145	1.59	0.59	0.1	0.05	0.025	0.025	0.025	0.025	0.025	0.025	8.124
May	98.07	6.498	0.127	0.117	0.111	0.107	0.105	0.102	0.06	0	0	0	0	9.423
Jun	144.19	49.158	24.579	0.689	0.537	0.523	0.515	0.511	0.507	0.467	0.03	0	0	20.605
Jul	179.1	49.158	25.585	1.673	1.554	1.54	1.529	1.521	1.515	1.508	1.5	0.17	0.08	29.341
Aug	146.95	37.649	14.508	2.093	2.038	2.028	2.023	2.016	2.012	2.003	1.701	1.03	0.19	22.214
Sep	73.737	25.585	7.685	2.06	2.046	2.028	2.02	2.016	2.009	2	1.6	0.92	0.18	13.825
Oct	43.601	6.188	0.537	0.52	0.515	0.512	0.51	0.507	0.504	0.5	0.28	0.15	0.02	4.422
Nov	11.11	6.034	2.861	1.021	0.34	0.1	0.03	0.03	0.03	0.03	0.03	0.03	0.03	2.567
Dec	7.72	4	0.77	0.12	0.01	0	0	0	0	0	0	0	0	1.288
Wet[82]	108.14	31.905	6.811	2.032	2.013	1.557	1.503	0.52	0.508	0.167	0.102	0	0	99.83
Dry[83]	11.609	3.832	1.753	0.288	0.07	0.03	0.025	0	0	0	0	0	0	20.922

[82] May-October.

[83] November-April.

Table 7.10 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 2 (AEC) for EWR Site 4. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	7.365	2.161	0.437	0.119	0.027	0	0	0	0	0	0	0	0	1.119
Feb	17.452	2.581	0.484	0.074	0.025	0	0	0	0	0	0	0	0	1.943
Mar	3.354	2.523	0.536	0.075	0.032	0.007	0	0	0	0	0	0	0	0.82
Apr	7.91	4.48	2.75	1.59	0.59	0.1	0.05	0.025	0.025	0.025	0.01	0.01[84]	0	2.429
May	0.134	0.127	0.126	0.114	0.109	0.107	0.104	0.102	0.06	0	0	0	0	0.214
Jun	0.716	0.667	0.588	0.531	0.522	0.515	0.512	0.509	0.505	0.46	0.03	0	0	1.167
Jul	1.704	1.655	1.575	1.548	1.536	1.529	1.521	1.517	1.513	1.507	1.49	0.17	0.08	3.838
Aug	2.214	2.103	2.077	2.038	2.028	2.024	2.018	2.015	2.01	2.002	1.7	1.03	0.19	5.134
Sep	2.287	2.065	2.058	2.046	2.029	2.021	2.018	2.014	2.008	2	1.6	0.92	0.18	4.925
Oct	0.546	0.535	0.53	0.519	0.513	0.512	0.509	0.507	0.504	0.5	0.28	0.15	0.02	1.248
Nov	11.11	5.56	2.78	0.99	0.34	0.1	0.03	0.03	0.03	0.03	0.03	0.03	0.01	2.483
Dec	7.719	4	0.77	0.12	0.01	0	0	0	0	0	0	0	0	1.262
Wet[85]	2.126	2.054	2.028	2.014	1.696	1.517	0.557	0.514	0.506	0.128	0.102	0	0	16.527
Dry[86]	9.536	3.43	1.668	0.288	0.069	0.03	0.025	0	0	0	0	0	0	10.056

[84] Adjusted slightly to remove the mismatch between the end of dry and start of wet seasons.

[85] May-October.

[86] November-April.

8. RESULTS FOR EWR SITE 5 (DORING RIVER AT OU DRIF)

KEY ISSUES AT EWR SITE 5:

- The Present Ecostatus is B-category.
- The Recommended Ecological Category (REC) is a B-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B-category) = 310 MCM per annum (i.e., 61% nMAR – incl. volume of inter-annual floods).
- Environmental Flow to support AEC (C-category) = 185 MCM per annum (i.e., 36% nMAR – incl. volume of inter-annual floods).
- The flows recommended for BOTH scenarios provided here represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation.
- At the time of this study, no data or models were available to assess the implications of flow changes on the unique water chemistry of the Doring River. It is thus highly possible that the water quality implications of the changes in flow are underestimated.
- The invasion of biota into the Doring River, primarily *Nerium oleander*, is a major threat to the future ecostatus of this system.
- The physical presence (i.e., aside from influence on the flow regime) of a dam in the Doring or Groot River, i.e., upstream of EWR Site 5 would critically affect the geomorphological condition of the system (with knock-on effects on other aspects of the river ecosystem, e.g., geomorphology and water quality) mainly through the reduction in variability of the large to medium sized flood, and through the reduction of sediment supply/sediment transport capacity. It would also represent a barrier to fish, and other fauna, movement, and provide a safe haven for alien invaders, such as smallmouthed bass (see Brown *et al.* 2003).

8.1 RIVER REACH REPRESENTED BY EWR SITE 5

The Doring River is a tributary of the Olifants River. EWR Site 5 is representative of the section of the Doring River from Doringbos to the confluence with the Olifants River.

8.2 PRESENT ECOSTATUS

A summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 5 is presented in Figure 8.1.

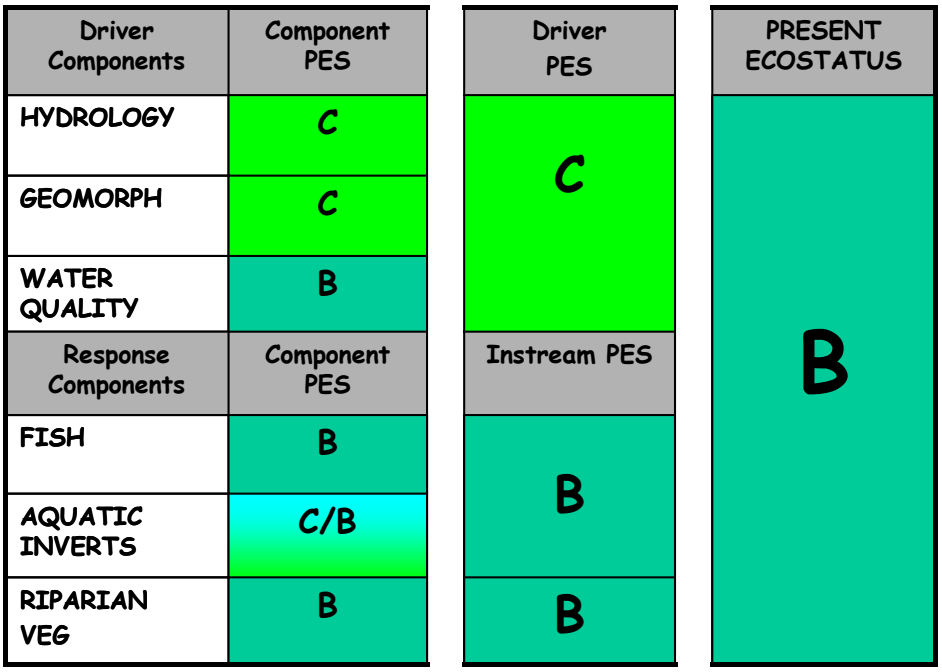


Figure 8.1 Summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 5.

Additional details for the PES assessments are provided in Riverine RDM report: Volume 1.

Table 8.1 Present Ecostatus, Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC) for EWR Site 5.

Component of the riverine ecosystem	PES		EIS	Recommended Ecological Category
	Category	Trajectory		
Hydrology	C	*Negative*	Very High	B
Water quality	B	*Stable*		
Geomorphology	C	*Negative*		
Riparian vegetation	B	*Negative*[87]		
Macroinvertebrates	C/B	*Stable*		
Fish	B	*Stable*		
PRESENT ECOSTATUS	**B**	***Negative***		

8.2.1 Major contributing factors to the Ecostatus

The major factors contributing to the Ecostatus for EWR Site 5 were:
- reduced summer flows and long no-flow periods over the summer (flow related);
- alien vegetation and plantations in the catchment (non-flow related).

8.2.2 Change levels considered by the specialists

The change levels considered by the specialists for lowflows are provided below, while those for the floods are in Table 8.2.

[87] Mainly as a result of non-flow related factors such as invasion by *Oleander* sp.

Lowflows change levels were as follows:
Dry Season Lowflows:
Change Level 1: Reduction: Capped at the 10th percentile on the Present Day FDC.
Change Level 2: Reduction: Lengthen the duration of no-flow conditions in the dry season to the 10th percentile on the Present Day FDC.
Change Level 3: Increase: Shorten the Present Day dry season (i.e., move towards the natural duration of the dry season) by implementing a 0.03 m^3s^{-1} minimum flow in November and April.
Change Level 4: Increase: Constant 1 m^3s^{-1} flows during the dry season, excl. April (e.g., irrigation releases).

Wet Season Lowflows:
Change Level 1: Reduction: Capped at the 20th percentile on the Present Day FDC.
Change Level 2: Reduction: Capped at the 40th percentile on the Present Day FDC.
Change Level 3: Reduction: Capped at the 60th percentile on the Present Day FDC.
Change Level 4: Reduction: Capped at the 90th percentile on the Present Day FDC.

Table 8.2 The change levels considered by the specialists for floods. Flood change levels consider changes in frequency of flood events within a magnitude class.

Flood Class	Frequency: Present Day	Change 1	Change 2	Change 3	Change 4
Class 1	6	Decrease (5)	Decrease (3)	Decrease (1)	Decrease (0)
Class 2	2	Decrease (1)	Decrease (0)	-	-
Class 3	2	Decrease (1)	Decrease (0)	-	-
Class 4	1	Decrease (0)	-	-	-

8.3 DRIFT CATEGORY OUTPUT FOR EWR SITE 5

The DRIFT CATEGORY output provides a summary view of the predicted changes in the condition of the river under study with changes in the percentage of the MAR assigned to the river, assuming that there are no limitations on the distribution of that water, i.e., it can be distributed over the year in the way most beneficial to the river ecosystem. The output allows the decision maker the opportunity to select points along the continuum where they would like more detailed information. These points are then used as the position of the more detailed options, which can also explore the consequences of not being able to make certain releases, such as floods, i.e., consequences of non-optimal distribution of flows.

The DRIFT CATEGORY output was generated by calculating the maximised Overall Integrity Scores for 18 different annual volumes of water, distributed in the least damaging manner. The output for EWR Site 5 is provided in Figure 8.2.

- The plot depicts river condition at the level of the whole ecosystem, relative to the current state of the system, and the volumes provided are the **maximum annual** volume linked to each scenario[88].
- The DRIFT reported volumes usually include the volume contained in the floods with a return period of 1:2, 1:5, 1:10 and 1:20 years or more. Results reported in the Building Block Methodology usually exclude some or all of the inter-annual floods as it is assumed that they will pass through the system, and cannot be managed[89].

[88] These volumes are revised for the selected detailed scenarios to produce the **average annual** volumes. As a general rule, the volumes given in DRIFT Category are higher than the final volumes that would be arrived at through detailed calculations for particular releases from a dam, when floods are capped and/or are not cued by climatic events.

[89] This is in fact not always the case, as large dams can and do severely attenuate floods with return periods of 1:2, 1:5 and 1:10 years.

- ECOSTATUS = Overall Integrity Score of zero (0).
- The coloured horizontal lines in Figure 8.2 depict the position at which river condition is expected to change from one category to the next, i.e., they estimate the position of the **threshold between categories**. For example, the Present Ecostatus of EWR Site 5 is B, and is represented by an Integrity Score of 0 in the figure. Should the condition drop below the blue line, the ecostatus is expected to be a C-category. Overall improvement in the overall condition of the river is possible, through reversal of the trend towards lengthened dry seasons, i.e., positive Overall Integrity[90], and maintaining the present day wet season characteristics (floods and lowflows).

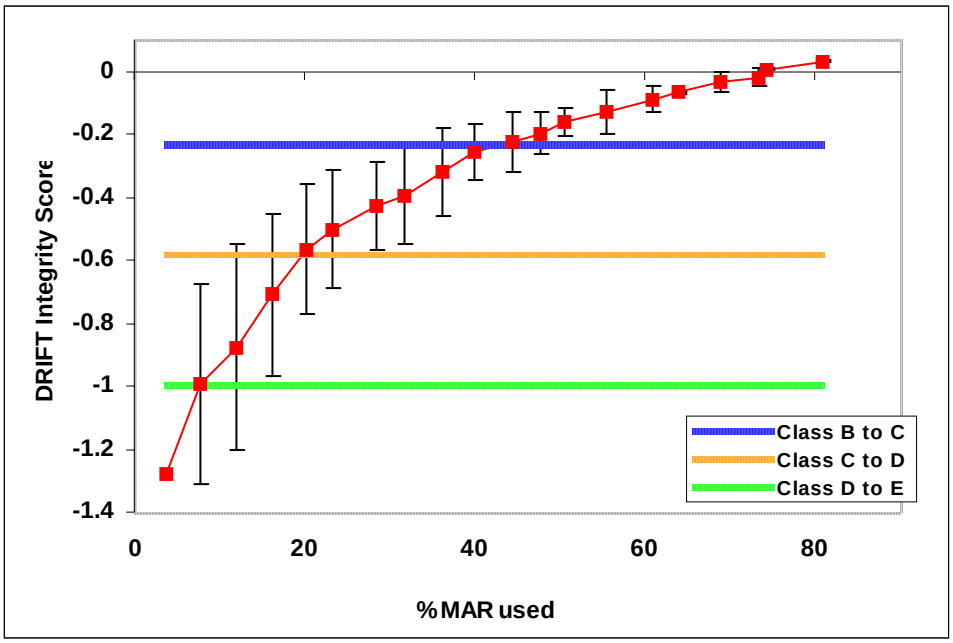


Figure 8.2 The DRIFT CATEGORY output for EWR Site 5. See notes above for explanation.

8.4 DETAILED EWR OPTION 1: MAINTAIN RECOMMENDED ECOLOGICAL CATEGORY (REC)

8.4.1 Overview of EWR Option 1

The following is a brief summary of EWR Option 1 (REC) for EWR Site 5.

TARGET ECOLOGICAL CATEGORY

Maintain Recommended Ecological Category (REC) = B.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume requested for the river for EWR Option 1 (REC) – EWR Site 5:

[90] There is also a improvement in condition with irrigation releases of 1 cumec in the summer, but the 'benefit' of these is of course offset by the fact that the summer releases have to be removed from the system (barrage) or stored in a dam during the winter months.

Including the volume for the ≥ 1:5 year floods: 310 MCM a^{-1}
= *c*. 61% nMAR and 77% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[91]: 245 MCM a^{-1}
= *c*. 47% nMAR and 61% present day MAR.

Note: The volume requested is generally higher than the longterm average amount received by the river, as events and lowflows are cued by natural climatic events.

KEY CONSIDERATIONS

This represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation (see PES assessment: hydrology; Section 8.2).

FLOW REDUCTION LEVELS USED

For EWR Option 1 (REC) at EWR Site 5, the following mix of change levels for the 10 components was selected for the Minimum Degradation Scenario – relative to Present Day:

Wet season lowflows:	change level 3.
Dry season lowflows:	change level 3[92].
Class 1 Intra-annual floods:	present day.
Class 2 Intra-annual floods:	present day.
Class 3 Intra-annual floods:	present day.
Class 4 Intra-annual floods:	present day.
Inter-annual floods (1:2 year):	change level 1.
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 1 (REC) was specifically designed to limit possible impacts as a result of changes in the flow components that are deemed to threaten the Present Ecostatus. The Ecostatus would, however, still be threatened should the distribution of the flows differ significantly from those suggested. Of particular importance in this regard is the retention of the small to medium size floods (i.e., flow variability) and the reinstatement of some of the flows in the early and late dry season. At present, abstraction (mainly in the upper reaches of the Groot River) has resulted in a 90% reduction at 70% exceedence for lowflows. This has effectively extended the dry season/no-flow periods in the river, thereby increasing the stress for biota during that time[93].

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 1 (REC) was assigned an **Overall Integrity Score of –0.088**, i.e., SLIGHT REDUCTION in Present Ecostatus. Although the overall integrity score has been reduced slightly, no reduction in overall Ecostatus is envisaged.

EXPECTED EC

Category B.

[91] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the REC.

[92] Note: This represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation (see PES assessment: hydrology; Section 8.2).

[93] It is possible that some of the lowflow impacts are related to climate change – but this could not be verified with the data available for this study.

8.4.2 Scenario Hydrology

Figure 8.3 depicts an excerpt from the graphical time-series display for EWR Site 5, Option 1 (REC). Table 8.3 provides a breakdown of the flow regime required to meet EWR Option 1 (REC). The flood requirements for EWR Option 1 (REC) are given in detail in Table 8.4 and the rule curves are provided in Tables 8.5 (whole flow regime) and 8.6 (lowflows only).

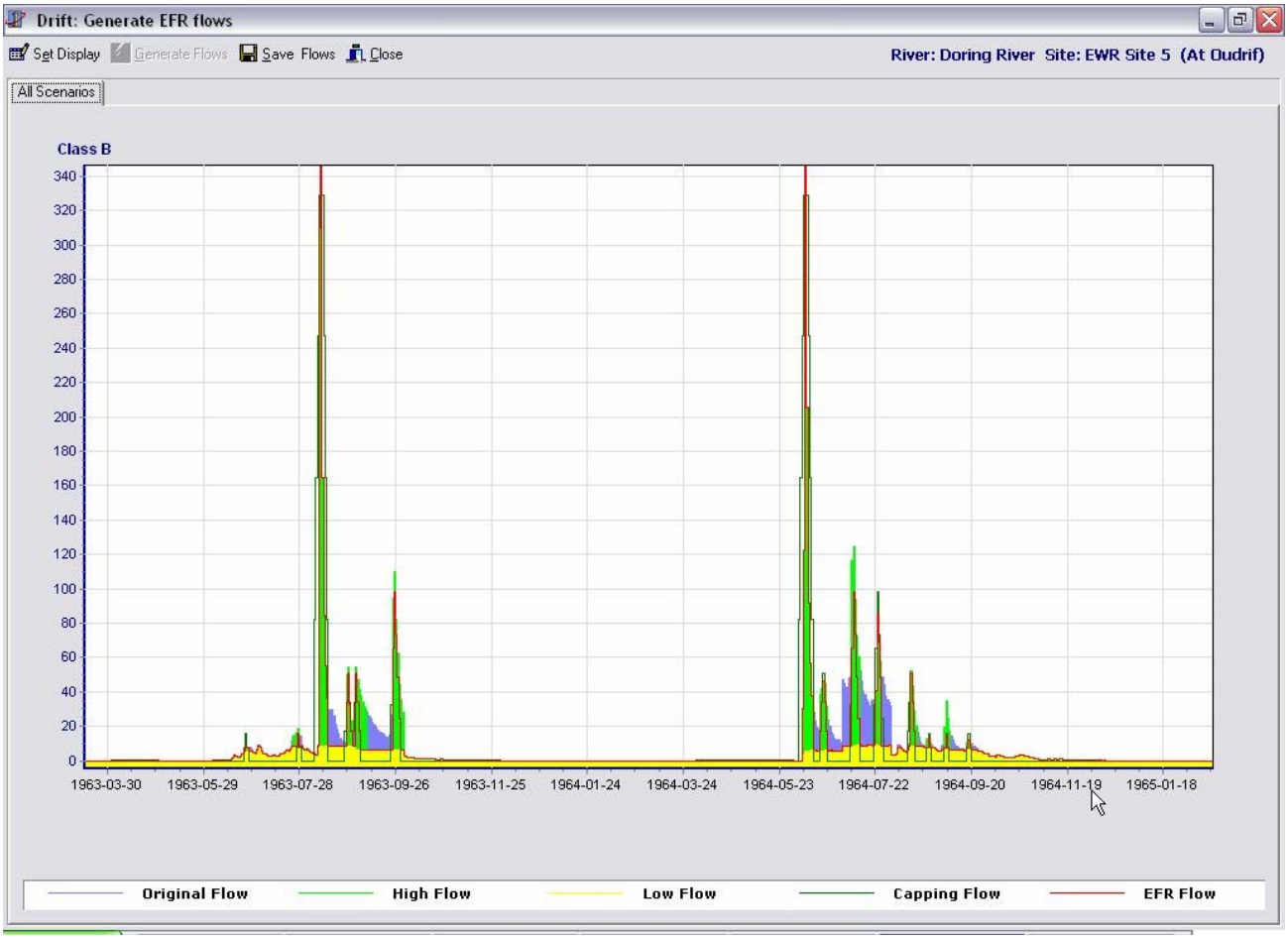


Figure 8.3 An excerpt from the graphical time-series display for EWR Site 5, Option 1 (REC). The blue line indicates the present day flow in the river, and the red line indicates the EWR flow requested.

Table 8.3 The EWR (quantity) requested for maintenance of a B-category at EWR Site 5 on the Doring River at Ou Drif, Western Cape.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 511 MCM. PD MAR = 401 MCM														
EWR Ecostatus Category = B.														
MAINTENANCE														
CAPPING FLOWS	Not set	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	0 m^3s^{-1}	Not set					N/a	
LOW FLOWS Q m^3s^{-1}[94]	2.29	0.03	0	0	0	0	0.05	0.82	5.00	8.30	8.00	6.00	78	15
FLOOD Class 1[95]: 35.05 m^3s^{-1}	2	1				1		1				1	4x6	6
FLOOD Class 2: 70.11 m^3s^{-1}									1		1		15x2	6
FLOOD Class 3: 140.22 m^3s^{-1}									1		1		27x2	10
FLOOD Class 4: 280 m^3s^{-1}									1				59x1	12
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												65	13
MAINTENANCE TOTAL (Volume)	**Annual[96]**												**310**	**61**
	Long-term average[97]												**234.39**	**46**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.03	0.03	0	0	0	0	0	0	0	0.06	0.19	0.18	15	3
FLOOD Peak[98] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***6.7***	***1.9***	***1.0***	***18.2***	***24.4***	***52.1***	***47.7***	***44.9***	***21.1***	***8.9***	***4.3***	***3.2***	**234.39**	**46**

[94] Figures rounded-off to the nearest one decimal place.
[95] Daily average peak
[96] Calculated as the volume of water required to meet the full requirements.
[97] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
[98] Daily average peak

Table 8.4 Summary of the flood requirements for EWR Site 5 – EWR Option 1 (REC): Maintain a B-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	35.05	2	4	6	September-June
Class 2	70.11	4	15	2	June-September
Class 3	140.22	5	27	2	June-September
Class 4	280.43	6	59	1	June-September
Inter-annual Class (return period given below)					
1:2	311.59	7	136.88	Absent	Not applicable
1:5	535.57	8	140.46	Present	Not stipulated
1:10	1057.70	8	234.56	Present	Not stipulated
1:20	1396.40	8	284.65	Present	Not stipulated

Table 8.5 Exceedence curves for the complete flow regime (floods and droughts included) required to meet Option 1 (REC) for EWR Site 5. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	131.27	31.479	8.577	6.123	3.538	2.031	0.59	0.088	0.03	0	0	0	0	234.385
Jan	15.888	2.538	0.44	0.12	0.03	0	0	0	0	0	0	0	0	6.728
Feb	25.72	2.027	0.484	0.074	0.021	0	0	0	0	0	0	0	0	1.921
Mar	6.669	2.788	0.536	0.075	0.03	0.007	0	0	0	0	0	0	0	1.037
Apr	192.17	7.95	4.098	1.717	0.59	0.1	0.051	0.03	0.03	0.03	0.03	0.03	0.03	18.165
May	246.9	34.549	3.687	3.282	2.169	1.577	0.835	0.348	0.061	0	0	0	0	24.389
Jun	313.62	97.856	50.697	8.188	5.887	5.755	5.407	3.843	2.197	0.59	0.05	0	0	52.057
Jul	192.17	73.392	47.984	15.888	8.724	8.521	8.398	8.214	6.081	3.892	1.689	0.17	0.08	47.77
Aug	246.9	60.542	33.798	8.901	8.372	8.224	8.11	7.43	5.823	3.834	1.848	1.04	0.19	44.838
Sep	93.251	24.464	8.318	6.371	6.154	6.109	6.057	5.706	4.324	2.926	1.627	0.92	0.18	21.08
Oct	48.397	7.944	3.268	3.075	3.052	3.004	2.346	1.605	1.047	0.617	0.29	0.15	0.03	8.864
Nov	19.209	6.782	3.17	1.06	0.324	0.09	0.03	0.03	0.03	0.03	0.03	0.03	0.03	4.313
Dec	30.318	6.614	0.858	0.123	0.007	0	0	0	0	0	0	0	0	3.224
Wet[99]	192.17	50.697	20.349	8.398	7.254	5.899	4.173	3.058	2.06	0.953	0.179	0	0	198.998
Dry[100]	32.061	4.677	1.737	0.273	0.067	0.03	0.03	0	0	0	0	0	0	35.387

[99] May-October.
[100] November-April.

Table 8.6 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 1 (REC) for EWR Site 5. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	6.49	1.9	0.44	0.12	0.03	0	0	0	0	0	0	0	0	1.024
Feb	17.113	1.887	0.484	0.074	0.021	0	0	0	0	0	0	0	0	1.598
Mar	3.116	2.344	0.536	0.075	0.028	0.007	0	0	0	0	0	0	0	0.781
Apr	10.35	5.12	3.11	1.59	0.59	0.1	0.05	0.03	0.03	0.03	0.03	0.03	0.03	2.786
May	3.934	3.636	3.535	2.621	2	1.51	0.82	0.33	0.06	0	0	0	0	3.549
Jun	13.846	6.156	6.003	5.862	5.768	5.575	5	3.53	1.84	0.55	0.04	0	0	10.17
Jul	9.366	8.823	8.749	8.604	8.506	8.408	8.298	8	5.37	3.56	1.57	0.17	0.08	17.607
Aug	9.489	8.718	8.638	8.375	8.25	8.137	8	6.89	5.52	3.54	1.83	1.04	0.19	17.164
Sep	7.974	6.384	6.329	6.149	6.123	6.077	6	5.55	4.14	2.79	1.6	0.92	0.18	12.625
Oct	3.32	3.261	3.092	3.068	3.045	3	2.29	1.58	1.04	0.61	0.29	0.15	0.03	5.301
Nov	12.87	5.55	2.86	1.05	0.32	0.09	0.03	0.03	0.03	0.03	0.03	0.03	0.03	2.608
Dec	26.273	5.577	0.851	0.123	0.007	0	0	0	0	0	0	0	0	2.505
Wet[101]	9.279	8.633	8.414	7.839	6.081	5.564	3.596	3.021	1.968	0.936	0.179	0	0	66.415
Dry[102]	11.617	3.618	1.682	0.273	0.067	0.03	0.03	0	0	0	0	0	0	11.303

8.5 DETAILED EWR OPTION 2: DROP ONE CATEGORY TO A C-CATEGORY (AEC)

8.5.1 Overview of EWR Option 2

The following is a brief summary of EWR Option 2 (AEC) for EWR Site 5.

TARGET ECOLOGICAL CATEGORY

Maintain Alternate Ecological Category (AEC) = C.

ECOLOGICAL WATER REQUIREMENTS[103]

Mean annual volume required for the river for EWR Option 2 – EWR Site 5:

Including the volume for the ≥ 1:5 year floods: 185 MCM a^{-1}
= *c*. 36% nMAR and 46% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[104]: 119 MCM a^{-1}
= *c*. 23% nMAR and 30% present day MAR.

KEY CONSIDERATIONS

As was the case with Option 1 (REC) the flow regime for Option 2 (AEC) represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation (see explanations in Sections 8.2 and 8.4). This means that the additional water 'made available' by this scenario is only available in the wet, winter months.

[101] May-October.
[102] November-April.
[103] See explanation re. Volumes without inter-annual floods in Section 8.4.
[104] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the AEC.

FLOW REDUCTION LEVELS USED

For EWR Option 2 (AEC) at EWR Site 5, the following mix of change levels for the 10 components was selected for a REDUCTION in Present Ecostatus from a B-category to a C-category river. The precautionary principle has been applied and a flow regime selected that is immediately below the C/B-category theoretical threshold. Clearly some scope exists for further reduction, while maintaining a C-category, however, this would be accompanied by an increased risk of not meeting a C-category.

Wet season lowflows:	change level 4.
Dry season lowflows:	change level 3[105].
Class 1 Intra-annual floods:	change level 1.
Class 2 Intra-annual floods:	change level 1.
Class 3 Intra-annual floods:	change level 2.
Class 4 Intra-annual floods:	present day.
Inter-annual floods (1:2 year):	change level 1.
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 2 (AEC) was designed to limit the impacts of changes in the flow components to those that will result in a one-category drop in Present Ecostatus. This Ecostatus would, however, be threatened should the distribution of the flows differ significantly from those suggested. Of particular importance in this regard is the reinstatement of some of the flows in the early and late dry season.

Equally important, however, is the likely effect of reduced flood flows on the spread of *Nerium oleander* in the Doring River. This is already a problem and is likely to be exacerbated by decreased flows, hence maintenance of the C-category will be dependent on an effective management strategy for the control of the *Nerium oleander*.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 2 (AEC) was assigned an **Overall Integrity Score of –0.320**, i.e., DECREASE BY ONE CATEGORY TO A C-CATEGORY (relative to Present Ecostatus).

EXPECTED EC

Category C.

8.5.2 Scenario Hydrology

Figure 8.4 depicts an excerpt from the graphical time-series display for EWR Site 5, Option 2 (AEC). Table 8.7 provides a breakdown of the flow regime required to meet EWR Option 2 (AEC). The flood requirements for EWR Option 2 (AEC) are given in detail in Table 8.8 and the rule curves are provided in Table 8.9 (whole flow regime) and 8.10 (lowflows only).

[105] Note: This represents a slight INCREASE in dry season lowflow volumes as it seeks to reduce the length of the dry season back towards a more natural situation (see PES assessment: hydrology; Section 8.2).

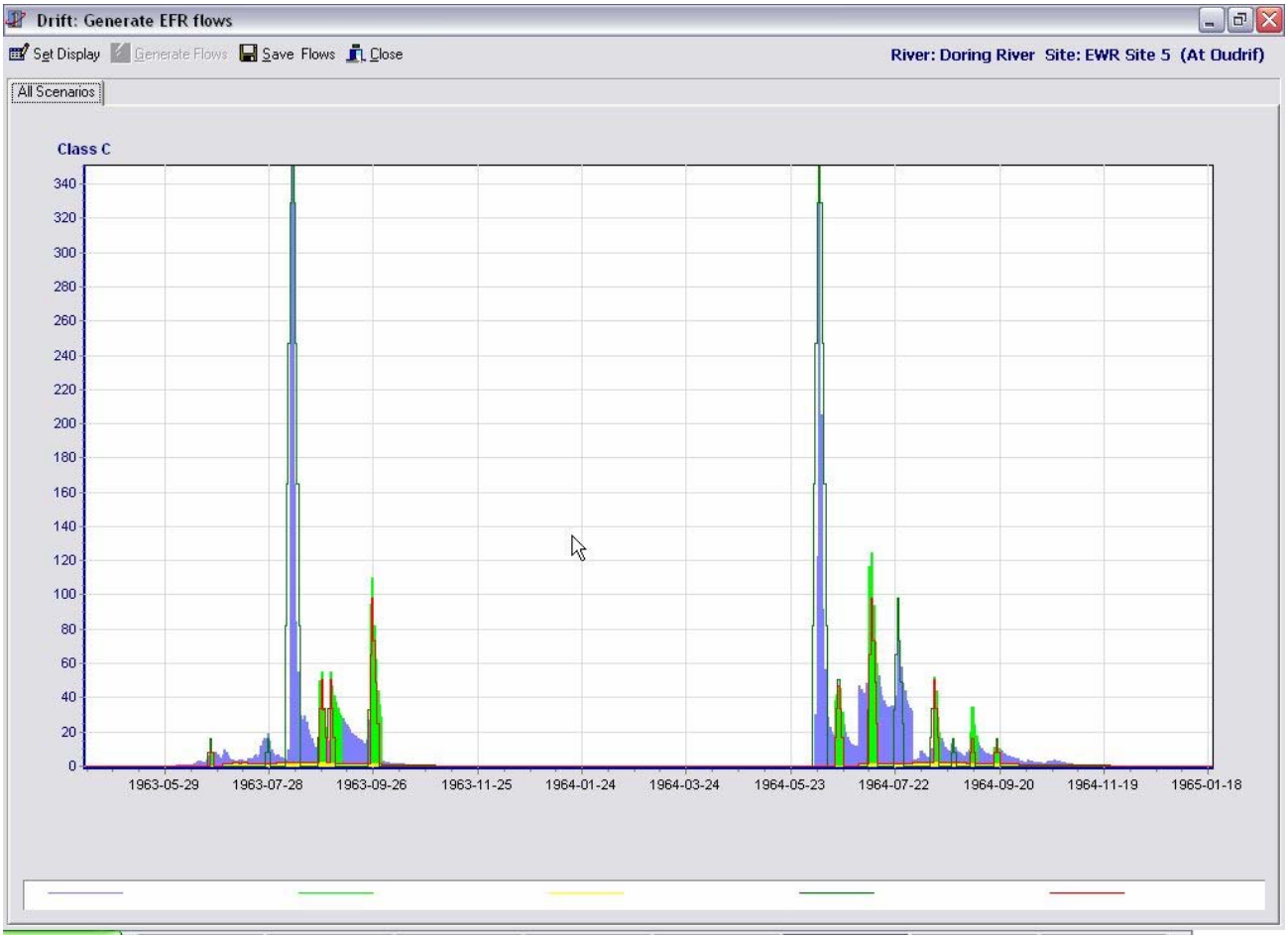


Figure 8.4 An excerpt from the graphical time-series display for EWR Site 5, Option 2 (AEC). The blue line indicates the present day flow in the river, and the red line indicates the EWR flow requested.

Table 8.7 The EWR (quantity) requested for maintenance of a C-category at EWR Site 5 on the Doring River at Ou Drif, Western Cape.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 511 MCM. PD MAR = 401 MCM														
EWR Ecostatus Category = C.														
MAINTENANCE														
CAPPING FLOWS	Not set	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	1 m^3s^{-1}	0 m^3s^{-1}	Not set					N/a	
LOW FLOWS Q m^3s^{-1}[106]	0.03	0.03	0	0	0	0	0.05	0.11	0.11	1.63	1.92	1.62	25	5
FLOOD Class 1[107]: 35.05 m^3s^{-1}	1	1				1		1				1	4x5	4
FLOOD Class 2: 70.11 m^3s^{-1}									1				15x1	3
FLOOD Class 3: 140.22 m^3s^{-1}									-				-	-
FLOOD Class 4: 280 m^3s^{-1}									1				59X1	12
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												61	12
MAINTENANCE TOTAL (Volume)	**Annual[108]**												**185**	**36**
	Long-term average[109]												**133.60**	**26**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.03	0.03	0	0	0	0	0	0	0	0.06	0.19	0.18	15	3
FLOOD Peak[110] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***4.87***	***2.71***	***2.56***	***5.74****	***1.69***	***1.00***	***16.38***	***19.59***	***11.13****	***32.05***	***22.11***	***13.82***	**133.60**	**26**

*Discrepancies relate to flood events occurring in some months and not in others.

[106] Figures rounded-off to the nearest one decimal place.
[107] Daily average peak.
[108] Calculated as the volume of water required to meet the full requirements.
[109] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
[110] Daily average peak.

Table 8.8 Summary of the flood requirements for EWR Site 5 – EWR Option 2 (AEC): Drop to a C-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	35.05	2	4	5	April-December
Class 2	70.11	4	15	1	June-September
Class 3	140.22	5	27	Absent	Not applicable
Class 4	280.43	6	59	1	June-September
Inter-annual Class (return period given below)					
1:2	311.59	7	136.88	Absent	Not applicable
1:5	535.57	8	140.46	Present	Not stipulated
1:10	1057.70	8	234.56	Present	Not stipulated
1:20	1396.40	8	284.65	Present	Not stipulated

Table 8.9 Exceedence curves for the complete flow regime (floods and droughts included) required to meet EWR Option 2 (AEC) for EWR Site 5. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	7.944	2.166	0.44	0.12	0.03	0	0	0	0	0	0	0	0	133.602
Jan	17.113	2.372	0.484	0.074	0.021	0	0	0	0	0	0	0	0	5.739
Feb	5.039	2.788	0.536	0.075	0.029	0.007	0	0	0	0	0	0	0	1.688
Mar	137.37	7.944	4.028	1.717	0.59	0.1	0.051	0.03	0.03	0.03	0.03	0.03	0.03	0.955
Apr	233.07	29.979	0.126	0.12	0.112	0.109	0.106	0.102	0.061	0.03	0.03	0.03	0.03	16.382
May	83.026	24.464	0.167	0.133	0.11	0.106	0.104	0.103	0.102	0.101	0.04	0.03	0.03	19.594
Jun	229.2	48.928	16.899	1.703	1.659	1.643	1.633	1.627	1.62	1.612	1.591	0.17	0.08	11.129
Jul	185.17	33.798	2.056	1.987	1.955	1.928	1.923	1.919	1.913	1.906	1.83	1.04	0.19	32.054
Aug	97.856	16.899	7.944	1.714	1.652	1.634	1.624	1.619	1.615	1.607	1.6	0.92	0.18	22.11
Sep	48.397	7.944	0.332	0.32	0.312	0.309	0.307	0.305	0.304	0.302	0.29	0.16	0.03	13.815
Oct	12.87	6.079	2.933	1.05	0.32	0.09	0.03	0.03	0.03	0.03	0.03	0.03	0.03	4.865
Nov	26.273	6.015	0.858	0.123	0.007	0	0	0	0	0	0	0	0	2.706
Dec	7.944	2.166	0.44	0.12	0.03	0	0	0	0	0	0	0	0	2.564
Wet[111]	99.98	31.167	2.062	1.915	1.655	1.622	1.399	0.307	0.135	0.107	0.101	0.03	0	103.569
Dry[112]	17.113	4.251	1.717	0.273	0.067	0.03	0.03	0	0	0	0	0	0	30.034

[111] May-October.
[112] November-April.

Table 8.10 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 2 (AEC) for EWR Site 5. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	6.49	1.9	0.44	0.12	0.03	0	0	0	0	0	0	0	0	1.024
Feb	17.113	1.887	0.484	0.074	0.021	0	0	0	0	0	0	0	0	1.598
Mar	3.116	2.344	0.536	0.075	0.028	0.007	0	0	0	0	0	0	0	0.781
Apr	10.35	5.12	3.11	1.59	0.59	0.1	0.05	0.03	0.03	0.03	0.03	0.03	0.03	2.786
May	0.127	0.124	0.121	0.116	0.11	0.109	0.105	0.102	0.06	0	0	0	0	0.215
Jun	0.164	0.14	0.134	0.111	0.107	0.104	0.104	0.103	0.102	0.101	0.04	0	0	0.255
Jul	1.864	1.819	1.682	1.659	1.644	1.634	1.628	1.624	1.617	1.61	1.58	0.17	0.08	4.123
Aug	2.063	2.032	1.994	1.971	1.936	1.927	1.922	1.918	1.912	1.905	1.83	1.04	0.19	4.959
Sep	1.932	1.727	1.679	1.649	1.634	1.625	1.621	1.616	1.612	1.606	1.6	0.92	0.18	4.052
Oct	0.337	0.331	0.325	0.315	0.31	0.308	0.307	0.305	0.304	0.302	0.29	0.16	0.03	0.792
Nov	12.87	5.55	2.86	1.05	0.32	0.09	0.03	0.03	0.03	0.03	0.03	0.03	0.03	2.608
Dec	26.273	5.577	0.851	0.123	0.007	0	0	0	0	0	0	0	0	2.505
Wet[113]	2.031	1.937	1.919	1.664	1.628	1.612	0.326	0.304	0.12	0.105	0.101	0	0	14.396
Dry[114]	11.617	3.618	1.682	0.273	0.067	0.03	0.03	0	0	0	0	0	0	11.303

[113] May-October.

[114] November-April.

9. RESULTS FOR EWR SITE 6 (GROOT RIVER AT MOUNT CEDAR)

KEY ISSUES AT EWR SITE 6:

- The Present Ecostatus is B/C-category.
- The Recommended Ecological Category (REC) is a B/C-category.
- The Alternative Recommended Category (AEC) is a C-category.
- Environmental Flow to support REC (B/C-category) = 79 MCM per annum (i.e., 57% nMAR – incl. volume of ≥ 1:5 return period floods). Long-term Average = 63 MCM (i.e., 46% nMAR).
- Environmental Flow to support AEC (C-category) = 56 MCM per annum (i.e., 41% nMAR – incl. volume of inter-annual floods). Long-term Average = 53 (i.e., 38% nMAR).

9.1 RIVER REACH REPRESENTED BY EWR SITE 6

The Groot River is a tributary of the Doring River. EWR Site 6 is representative of Resource Unit 2, the length of the Groot River gorge. It was also included as a tributary for which EWR assessment data could be extrapolated to the Riet, Matjies and possibly Tra-Tra Rivers.

9.2 PRESENT ECOSTATUS

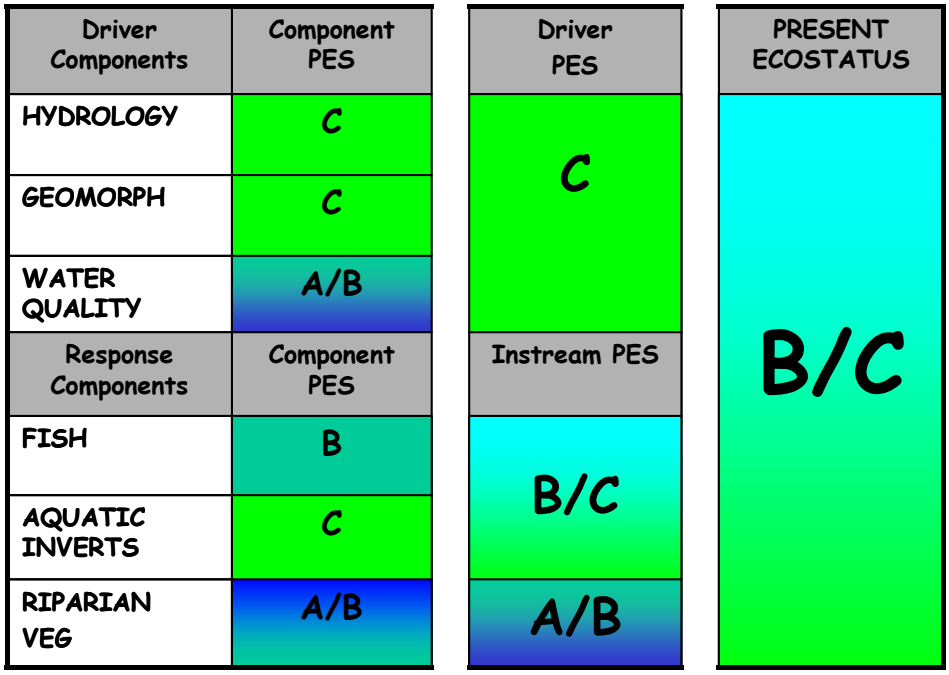


Figure 9.1 Summary of the individual PES assessments comprising the Present Ecostatus for EWR Site 6.

Table 9.1 Present Ecostatus, Ecological Importance and Sensitivity (EIS) and **Recommended Ecological Category** (REC) for EWR Site 6.

Component of the riverine ecosystem	PES		EIS	Recommended Ecological Category
	Category	Trajectory		
Hydrology	C	*Negative*	Very high	**B/C**
Water quality	A/B	*Negative*		
Geomorphology	C	*Negative*		
Riparian vegetation	A/B	*Stable*		
Macroinvertebrates	C	*Negative*		
Fish	B	*Stable*		
PRESENT ECOSTATUS	**B/C**	***Negative***		

9.2.1 Major contributing factors to the Present Ecostatus

The major factors contributing to the Present Ecostatus for EWR Site 6 were:
- reduced summer flows and longer no-flow periods over the summer (flow related);
- water quality deterioration, as evidenced by the poor macroinvertebrate scores (flow related)[115].

9.2.2 Change levels considered by the specialists

The change levels considered by the specialists for lowflows are provided below, while those for the floods are in Table 9.2.

Lowflows change levels were as follows:
Dry Season Lowflows:
Change Level 1: Reduction: Capped at 1 cumecs on the Present Day FDC (on the seasonal FDC, not monthly).
Change Level 2: Reduction: Capped at 0.5 cumecs on the Present Day FDC (on the seasonal FDC, not monthly).
Change Level 3: Reduction: Capped at *c.* 0.08 cumecs on the Present Day FDC (on the seasonal FDC, not monthly).
Change Level 4: None.

Wet Season Lowflows:
Change Level 1: Reduction: Capped at the 10th percentile on the Present Day FDC.
Change Level 2: Reduction: Capped at the 30th percentile on the Present Day FDC.
Change Level 3: Reduction: Capped at the 60th percentile on the Present Day FDC.
Change Level 4: Reduction: Capped at the 90th percentile on the Present Day FDC.

[115] Note: Very few water quality data are available for this site, and this assessment of water quality is from the macroinvertebrate (SASS) scores.

Table 9.2 The change levels considered by the specialists for floods. Flood change levels consider changes in frequency of flood events within a magnitude class.

Flood Class	Frequency: Present Day	Change 1	Change 2	Change 3	Change 4
Class 1	9[116]	Decrease (6)	Decrease (3)	Decrease (1)	Decrease (0)
Class 2	3	Decrease (2)	Decrease (1)	Decrease (0)	-
Class 3	2	Decrease (1)	Decrease (0)	-	-
Class 4	2	Decrease (1)	Decrease (0)	-	-

9.3 DRIFT CATEGORY OUTPUT FOR EWR SITE 6

The DRIFT CATEGORY output provides a summary view of the predicted changes in the condition of the river with changes in the percentage of the MAR assigned to the river, assuming that it can be distributed over the year in the way most beneficial to the river ecosystem. These points are then used as the position of the more detailed options, which can also explore the consequences of not being able to make certain releases, such as floods, i.e., consequences of non-optimal distribution of flows.

The output for EWR Site 6 is provided in Figure 9.2.

- The plot depicts the river condition at the level of the whole ecosystem, relative to the current state of the system, and the volumes provided are the **maximum annual** volume linked to each scenario[117].
- The DRIFT reported volumes usually include the volume contained in the floods with a return period of 1:2, 1:5, 1:10 and 1:20 years or more. Results reported in the Building Block Methodology usually exclude some or all of the inter-annual floods as it is assumed that they will pass through the system, and cannot be managed[118].
- ECOSTATUS = Overall Integrity Score of zero (0).
- The coloured horizontal lines in Figure 9.2 depict the position at which river condition is expected to change from one category to the next, i.e., they estimate the position of the **threshold between categories**. For example, the Present Ecostatus of EWR Site 6 is B/C, and is represented by an Integrity Score of 0 in the figure. Improvement in the overall condition of the river, i.e., positive Overall Integrity would lead first to a B category (green line). Any decline in the present condition (i.e., such as increased abstraction resulting in an extended dry season), will result in a decline to a C category river. However, the gradient of the slope below the blue line is very gentle initially, and we have selected a point just below the blue line for maintenance of a B/C-category. Accordingly, we have selected a point immediately above the C/D category threshold for maintenance of a C-category[119].

[116] Rounded down to be more in line with natural and EWR Sites 4 and 5, which are downstream.

[117] These volumes are revised for the selected detailed scenarios to produce the **average annual** volumes.

[118] This is in fact not always the case, as large dams can and do severely attenuate floods with return periods of 1:2, 1:5 and 1:10 years.

[119] This is partly because the main impact on PES at this site is water quality (which is reflected in the macroinvertebrate communities), probably as a result of agricultural runoff from upstream.

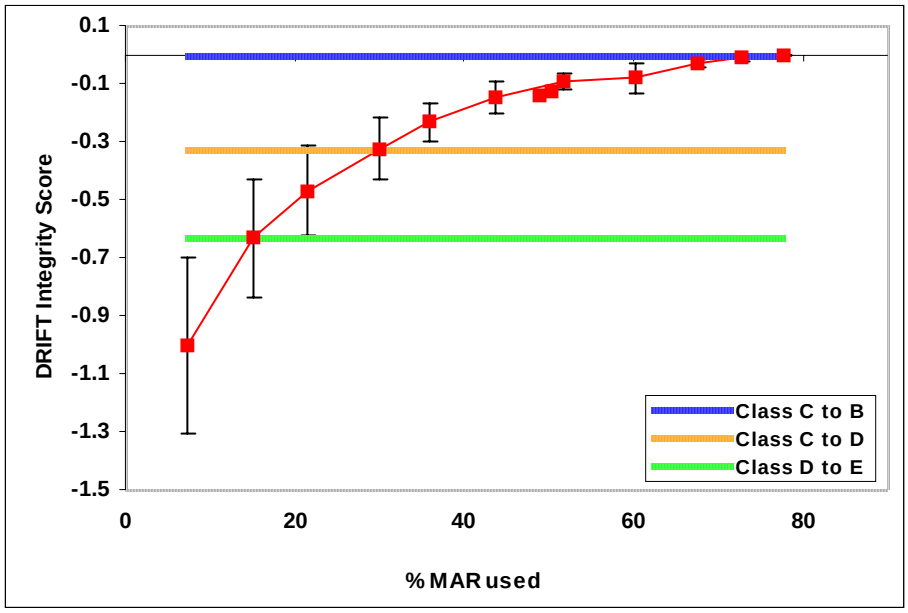


Figure 9.2 The DRIFT CATEGORY output for EWR Site 6. See notes above for explanation.

9.4 DETAILED EWR OPTION 1: MAINTAIN RECOMMENDED ECOLOGICAL CATEGORY (REC)

9.4.1 Overview of EWR Option 1

The following is a brief summary of EWR Option 1 (REC) for EWR Site 6.

TARGET ECOLOGICAL CATEGORY

Maintain Recommended Ecological Category (REC) = B/C.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume required for the river for EWR Option 1 (REC) – EWR Site 6:

Including the volume for the ≥ 1:5 year floods: 79 MCM a^{-1}
= *c*. 57% nMAR and 76% present day MAR.

Excluding the volume for the ≥ 1:5 year floods[120]: 66 MCM a^{-1}
= *c*. 48% nMAR and 63% present day MAR.

KEY CONSIDERATIONS

The two aspects of the flow regime that were identified as having some scope for reduction were the winter lowflows and the Class 2 floods. Additional dry season, run-of-river abstractions will exacerbate the water quality issues in the river, and lead to a reduction in condition. Note: Even for maintenance of a C-category (Section 9.4.2), only additional wet season abstractions are allowed.

[120] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the REC.

FLOW REDUCTION LEVELS USED

For EWR Option 1 (REC) at EWR Site 6, the following mix of change levels for the 10 components was selected for the Minimum Degradation Scenario – relative to Present Day:

Wet season lowflows:	change level 3.
Dry season lowflows:	present day.
Class 1 Intra-annual floods:	present day.
Class 2 Intra-annual floods:	change level 1.
Class 3 Intra-annual floods:	present day.
Class 4 Intra-annual floods:	present day.
Inter-annual floods (1:2 year):	present day.
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 1 (REC) was specifically designed to limit possible impacts as a result of changes in the flow components that are deemed to threaten the overall Ecostatus. This Ecostatus would, however, be threatened should the non-flow related factors contributing to the poor condition of the river, such as reduced water quality (probably as a result of agricultural runoff), continue unabated. Indeed, **if the water quality in the river were improved, then the river would be expected to be maintained in a B-category with this flow**.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 1 (REC) was assigned an **Overall Integrity Score of –0.08**, i.e., SLIGHT REDUCTION in Present Ecostatus. The overall integrity score has been reduced slightly, which is expected to maintain a high C (B/C).

EXPECTED EC

Category B/C.

9.4.2 Scenario Hydrology

Figure 9.3 depicts an excerpt from the graphical time-series display for EWR Site 6, Option 2. Table 9.3 provides a breakdown of the flow regime required to meet EWR Option 1 (REC). The flood requirements for EWR Option 2 are given in detail in Table 9.4 and the rule curves are provided in Table 9.5 (whole flow regime) and 9.6 (lowflows only).

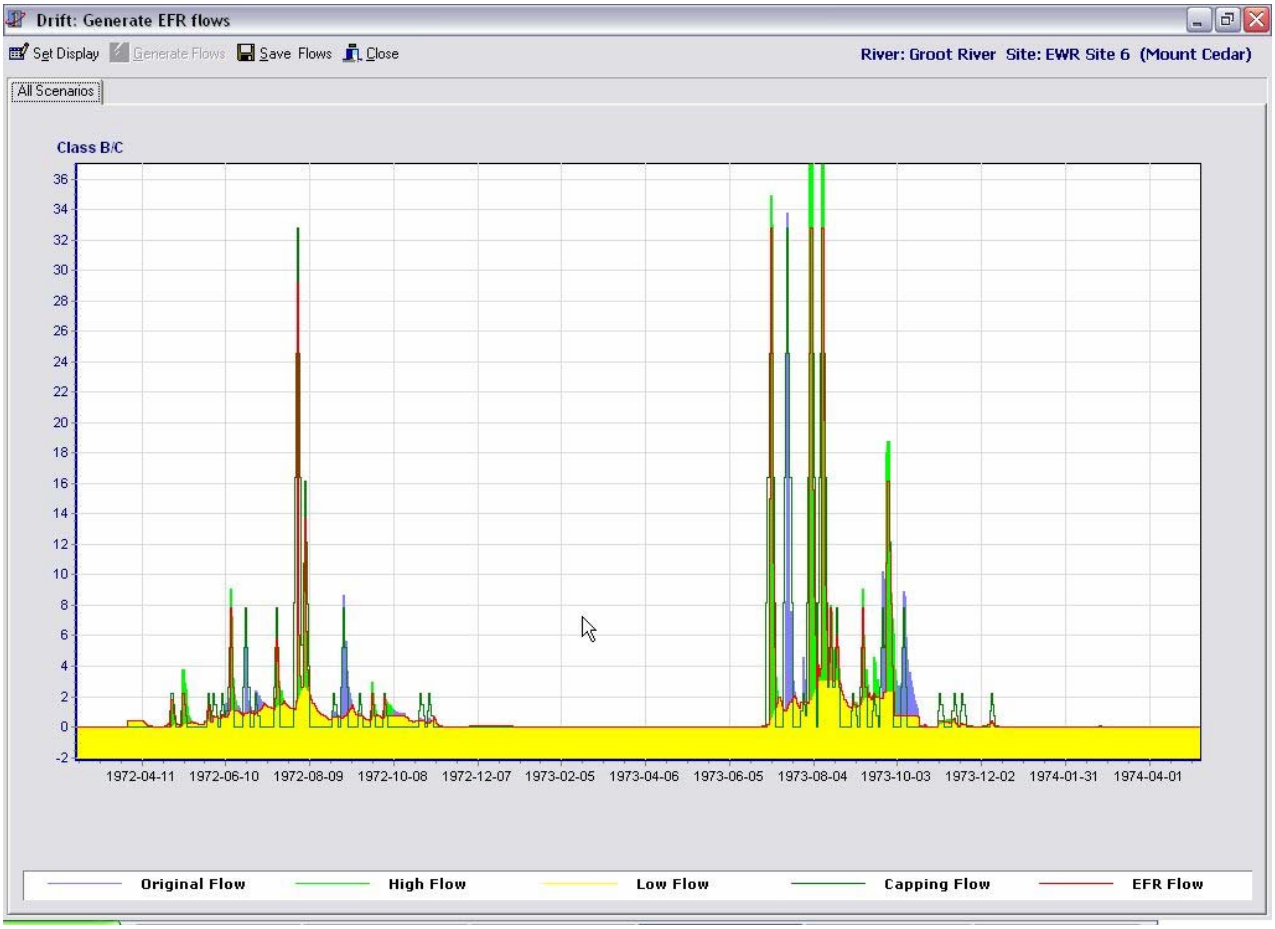


Figure 9.3 An excerpt from the graphical time-series display for EWR Site 6, Option 1 (REC). The blue line indicates the present day flow in the river, and the red line indicates the EWR flow requested.

Table 9.3 The EWR (quantity) requested for maintenance of a B/C-category at EWR Site 6 on the Groot River at Mount Cedar, Western Cape.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 138 MCM. PD MAR = 104 MCM														
EWR Ecostatus Category = B/C.														
MAINTENANCE														
CAPPING FLOWS	Not set													
LOW FLOWS Q m^3s^{-1}	0.726	0.18	0.04	0.011	0.01	0.02	0.06	0.23	1.055	2.012	3.00	2.228	22	17
FLOOD Class 1[121]: 5.5 m^3s^{-1}	1					1		3				2	7x1	5
FLOOD Class 2: 11 m^3s^{-1}									2				2x2	3
FLOOD Class 3: 22 m^3s^{-1}									2				2x4	6
FLOOD Class 4: 44 m^3s^{-1}									2				2x11	16
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												16	12
MAINTENANCE TOTAL (Volume)	**Annual[122]**												**79**	**57**
	Long-term average[123]												**63**	**46**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.04	0.01	0.001	0.001	0.001	0.001	0.001	0.01	0.04	0.15	0.42	0.54	3.2	2
FLOOD Peak m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)	***2.699***	***2.085***	***0.725***	***0.296***	***0.127***	***0.261***	***0.764***	***5.756***	***8.713***	***13.148***	***17.681***	***11.168***	**63**	**46**

*Discrepancies relate to flood events occurring in some months and not in others.

[121] Daily average peak.
[122] Calculated as the volume of water required to meet the full requirements.
[123] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.

Table 9.4 Summary of the flood requirements for EWR Site 6 – EWR Option 1 (REC): Maintain a B/C-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	5.51	3	1.0	7[124]	September-June
Class 2	11.02	5	2.0	2	June - September
Class 3	22.03	5	4.0	2	June - September
Class 4	44.06	7	11.0	2	June - September
Inter-annual Class (return period given below)					
1:2	48.96		15.5	Present	Not stipulated
1:5	66.26		29.5	Present	Not stipulated
1:10	77.89		33.7	Present	Not stipulated
1:20	162.55		43.2	Present	Not stipulated

Table 9.5 Exceedence curves for the complete flow regime (floods and droughts included) required to meet EWR Option 1 (REC) for EWR Site 6. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	32.756	9.196	3.194	2.068	1.019	0.61	0.273	0.103	0.04	0.013	0.001	0.001	0.001	62.713
Jan	1.11	1	0.09	0.03	0.02	0.02	0.011	0.01	0.001	0.001	0.001	0.001	0.001	0.228
Feb	0.189	0.137	0.11	0.03	0.011	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.071
Mar	0.458	0.4	0.34	0.11	0.05	0.021	0.02	0.01	0.001	0.001	0.001	0.001	0.001	0.204
Apr	1.463	0.71	0.685	0.451	0.325	0.133	0.06	0.03	0.011	0.01	0.001	0.001	0.001	0.708
May	48.721	10.015	2.194	0.623	0.44	0.335	0.267	0.154	0.053	0.03	0.012	0.01	0.01	5.776
Jun	49.53	16.162	7.862	2.621	1.26	1.094	1.066	1.05	0.747	0.32	0.082	0.04	0.01	8.733
Jul	32.756	24.567	12.985	5.957	2.621	2.13	2.108	2.01	1.712	1.38	0.8	0.164	0.01	13.17
Aug	58.074	31.305	16.162	8.081	3.534	3.081	3.041	2.974	2.103	1.338	0.73	0.42	0.01	17.696
Sep	35.941	16.826	10.687	5.139	2.274	2.261	2.234	2.222	1.879	1.394	0.85	0.564	0.15	11.179
Oct	10.775	2.194	1.097	0.753	0.744	0.74	0.73	0.721	0.606	0.419	0.213	0.041	0.02	2.718
Nov	13.892	0.881	0.681	0.508	0.316	0.257	0.195	0.137	0.097	0.061	0.021	0.001	0.001	1.878
Dec	0.63	0.296	0.206	0.11	0.071	0.05	0.041	0.04	0.03	0.02	0.01	0.001	0	0.352
Wet[125]	43.834	16.378	8.42	3.1	2.26	1.986	1.259	0.855	0.723	0.387	0.078	0.025	0.01	59.271
Dry[126]	1.318	0.663	0.419	0.189	0.104	0.048	0.028	0.018	0.01	0.001	0.001	0.001	0	3.442

[124] This is highlighting the perceived need for variability in flow in the Groot River.
[125] May-October.
[126] November-April.

Table 9.6 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 1 (REC) for EWR Site 6. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	1.11	1	0.09	0.03	0.02	0.02	0.011	0.01	0.001	0.001	0.001	0.001	0.001	0.228
Feb	0.189	0.137	0.11	0.03	0.011	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.063
Mar	0.458	0.4	0.34	0.11	0.05	0.021	0.02	0.01	0.001	0.001	0.001	0.001	0.001	0.204
Apr	0.747	0.702	0.67	0.43	0.31	0.13	0.06	0.03	0.011	0.01	0.001	0.001	0.001	0.54
May	0.651	0.624	0.602	0.443	0.341	0.3	0.23	0.11	0.05	0.03	0.012	0.01	0.01	0.669
Jun	1.46	1.327	1.26	1.134	1.069	1.066	1.055	1	0.62	0.26	0.07	0.04	0.01	2.168
Jul	2.837	2.377	2.204	2.13	2.117	2.102	2.012	1.9	1.61	1.3	0.76	0.15	0.01	4.69
Aug	3.622	3.358	3.199	3.069	3.043	3.039	3	2.57	1.86	1.25	0.68	0.42	0.01	6.341
Sep	2.876	2.329	2.274	2.269	2.259	2.235	2.228	2.2	1.71	1.25	0.78	0.54	0.15	4.824
Oct	0.772	0.762	0.753	0.745	0.741	0.735	0.726	0.7	0.56	0.41	0.2	0.04	0.02	1.598
Nov	0.88	0.708	0.6	0.48	0.3	0.24	0.18	0.13	0.09	0.06	0.02	0.001	0.001	0.654
Dec	0.405	0.261	0.19	0.11	0.07	0.05	0.04	0.04	0.03	0.02	0.01	0	0	0.194
Wet[127]	3.351	3.048	2.817	2.23	2.029	1.343	1.055	0.744	0.614	0.341	0.068	0.025	0.01	20.289
Dry[128]	0.953	0.595	0.4	0.186	0.099	0.048	0.027	0.018	0.01	0.001	0.001	0.001	0	1.883

9.5 DETAILED EWR OPTION 2: DROP TO A C-CATEGORY (AEC)

9.5.1 Overview of EWR Option 2

The following is a brief summary of EWR Option 2 for EWR Site 6.

TARGET ECOLOGICAL CATEGORY

Maintain Alternative Ecological Category (AEC) = C.

ECOLOGICAL WATER REQUIREMENTS

In South Africa EWR results are traditionally reported without including the volume of water required to meet the inter-annual floods (i.e., ≥ 1:5 year return period). Thus, to facilitate the comparison between the results obtained using DRIFT and those obtained using other methods, the DRIFT volumes are reported both including and excluding the volumes of the ≥ 1:5 year return period flood.

Mean annual volume required for the river for EWR Option 2 (AEC) – EWR Site 6:
Including the volume for the ≥ 1:5 year floods: 56 MCM a^{-1}
= *c*. 41% nMAR and 54% present day MAR.
Excluding the volume for the ≥ 1:5 year floods[129]: 40 MCM a^{-1}
= *c*. 29% nMAR and 38% present day MAR.

KEY CONSIDERATIONS

As with Option 1, the two aspects of the flow regime that were identified as having some scope for reduction were the winter lowflows and the Class 2 floods. Any additional dry season, run-of-river abstractions will exacerbate the water quality issues in the river, and lead to a reduction in condition.

[127] May-October.
[128] November-April.
[129] It is however **vital** for the ≥ 1:5 year return period floods to come through to meet the AEC.

FLOW REDUCTION LEVELS USED

For EWR Option 2 (AEC) at EWR Site 6, the following mix of change levels for the 10 components was selected – relative to Present Ecostatus:

Wet season lowflows:	change level 4.
Dry season lowflows:	present day
Class 1 Intra-annual floods:	present day.
Class 2 Intra-annual floods:	present day.
Class 3 Intra-annual floods:	present day.
Class 4 Intra-annual floods:	change level 1.
Inter-annual floods (1:2 year):	present day.
Inter-annual floods (1:5 year):	present day.
Inter-annual floods (1:10 year):	present day.
Inter-annual floods (1:20 year):	present day.

GENERAL OVERVIEW OF THE EXPECTED CONDITION OF THE RIVER

The flow regime presented in EWR Option 2 (AEC) is expected to result in a drop in ecological condition from a B/C to a C. In all likelihood, this will be accompanied by a reduction in water quality as a result of increased irrigation return flows from upstream.

OVERALL EWR OPTION INTEGRITY SCORE

EWR Option 2 (AEC) was assigned an **Overall Integrity Score of –0.015**, i.e., SLIGHT REDUCTION in present Ecostatus. The overall integrity score has been reduced and is expected to result in a C-category[130].

EXPECTED EC

Category C.

9.5.2 Scenario Hydrology

Figure 9.4 depicts an excerpt from the graphical time-series display for EWR Site 5, Option 2 (AEC). Table 9.7 provides a breakdown of the flow regime required to meet EWR Option 2 (AEC). The flood requirements for EWR Option 2 (AEC) are given in detail in Table 9.8 and the rule curves are provided in Table 9.9 (whole flow regime) and 9.10 (lowflows only).

[130] Note: The difference in the DRIFT Integrity Scores between the two categories presented is lower here than for other sites in this study because the difference in condition described is smaller, *viz*. B to C will result in a greater difference in Integrity Scores than B/C to C.

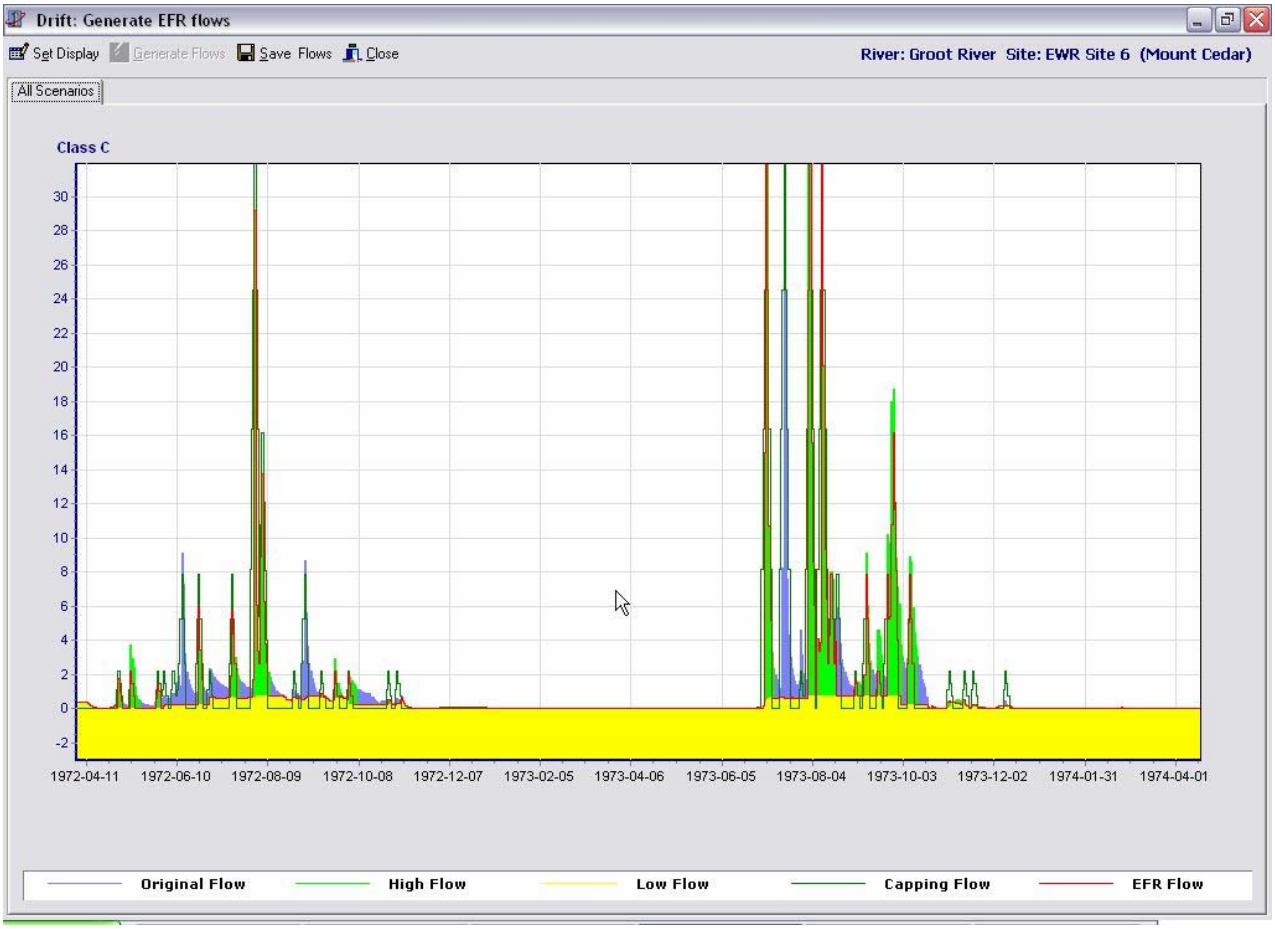


Figure 9.4 An excerpt from the graphical time-series display for EWR Site 6, Option 2 (AEC). The blue line indicates the present day flow in the river, and the red line indicates the EWR flow requested.

Table 9.7 The EWR (quantity) requested for maintenance of a C-category at EWR Site 6 on the Groot River at Mount Cedar, Western Cape.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	VOL (MCM)	nMAR %
N MAR = 138 MCM. PD MAR = 104 MCM														
EWR Ecostatus Category = C.														
MAINTENANCE														
CAPPING FLOWS	Not set													
LOW FLOWS Q m^3s^{-1}	0.20	0.18	0.04	0.011	0.01	0.02	0.06	0.04	0.22	0.64	0.74	0.71	8.36	6
FLOOD Class 1[131]: 5.5 m^3s^{-1}	1					2		3				2	7x1	5
FLOOD Class 2: 11 m^3s^{-1}									3				3x2	4
FLOOD Class 3: 22 m^3s^{-1}									2				2x4	6
FLOOD Class 4: 44 m^3s^{-1}									1				1x11	8
Inter-annual floods	Estimated annual volume (1:5; 1;10 and 1:20 year floods)												16	12
MAINTENANCE TOTAL (Volume)	**Annual[132]**												**56**	**41**
	Long-term average[133]												**53**	**38**
DROUGHT														
LOW FLOWS m^3s^{-1}	0.04	0.01	0.001	0.001	0.001	0.001	0.001	0.01	0.04	0.15	0.42	0.54	3.2	2
FLOOD Peak[134] m^3s^{-1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL FLOWS (MCM)													**53**	**38**

*Discrepancies relate to flood events occurring in some months and not in others.

[131] Daily average peak.
[132] Calculated as the volume of water required to meet the full requirements.
[133] Calculated using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
[134] Daily average peak.

Table 9.8 Summary of the flood requirements for EWR Site 6 – EWR Option 2 (AEC): Maintain a C-category river.

Flood type	Daily average peak (m^3s^{-1})	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	5.51	3	1.0	7[135]	September-June
Class 2	11.02	5	2.0	3	June - September
Class 3	22.03	5	4.0	2	June - September
Class 4	44.06	7	11.0	1	June - September
Inter-annual Class (return period given below)					
1:2	48.96		15.5	Present	Not stipulated
1:5	66.26		29.5	Present	Not stipulated
1:10	77.89		33.7	Present	Not stipulated
1:20	162.55		43.2	Present	Not stipulated

Table 9.9 Exceedence curves for the complete flow regime (floods and droughts included) required to meet EWR Option 2 (AEC) for EWR Site 6. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
All	32.756	9.153	2.621	0.724	0.624	0.222	0.183	0.062	0.038	0.015	0.001	0.001	0.001	52.821
Jan	1.11	1	0.09	0.03	0.02	0.02	0.011	0.01	0.001	0.001	0.001	0.001	0.001	0.228
Feb	0.189	0.137	0.11	0.03	0.011	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.071
Mar	0.458	0.4	0.34	0.11	0.05	0.021	0.02	0.01	0.001	0.001	0.001	0.001	0.001	0.204
Apr	0.75	0.703	0.671	0.43	0.32	0.133	0.06	0.03	0.011	0.01	0.001	0.001	0.001	0.545
May	46.773	9.177	2.194	0.101	0.052	0.045	0.044	0.042	0.033	0.03	0.013	0.01	0	4.78
Jun	36.254	15.397	7.862	2.492	0.25	0.228	0.221	0.217	0.213	0.145	0.071	0.04	0.01	6.704
Jul	38.396	24.567	14.988	7.809	3.555	0.674	0.649	0.644	0.634	0.626	0.613	0.163	0.1	12.545
Aug	58.074	31.305	16.162	7.862	0.836	0.761	0.748	0.738	0.734	0.731	0.713	0.464	0.1	14.6
Sep	35.941	16.287	8.189	3.871	1.099	0.731	0.719	0.716	0.713	0.708	0.705	0.572	0.15	8.587
Oct	16.162	5.241	1.821	0.225	0.207	0.205	0.204	0.203	0.203	0.201	0.2	0.04	0.02	2.398
Nov	13.892	0.767	0.643	0.493	0.313	0.256	0.191	0.134	0.097	0.06	0.021	0.001	0.001	1.827
Dec	0.405	0.261	0.19	0.11	0.07	0.05	0.04	0.04	0.03	0.02	0.01	0	0	0.331
Wet[136]	39.245	16.378	8.28	2.621	0.741	0.716	0.645	0.234	0.205	0.15	0.044	0.032	0.01	49.613
Dry[137]	1.102	0.619	0.41	0.189	0.102	0.048	0.027	0.018	0.01	0.001	0.001	0.001	0	3.208

[135] This is highlighting the perceived need for variability in flow in the Groot River.
[136] May-October.
[137] November-April.

Table 9.10 Exceedence curves for the lowflow component of the flow regime (droughts included) required to meet Option 2 (AEC) for EWR Site 6. MCM = million cubic metres.

Month	Percentiles (data are in m^3s^{-1})													MAR [MCM]
	1	5	10	20	30	40	50	60	70	80	90	95	99	
Jan	1.11	1	0.09	0.03	0.02	0.02	0.011	0.01	0.001	0.001	0.001	0.001	0.001	0.228
Feb	0.189	0.137	0.11	0.03	0.011	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.063
Mar	0.458	0.4	0.34	0.11	0.05	0.021	0.02	0.01	0.001	0.001	0.001	0.001	0.001	0.204
Apr	0.747	0.702	0.67	0.43	0.31	0.13	0.06	0.03	0.011	0.01	0.001	0.001	0.001	0.54
May	0.062	0.061	0.058	0.052	0.045	0.044	0.043	0.041	0.032	0.03	0.012	0.01	0	0.106
Jun	0.275	0.256	0.25	0.234	0.224	0.221	0.218	0.216	0.2	0.129	0.07	0.04	0.01	0.502
Jul	0.845	0.725	0.678	0.654	0.65	0.646	0.643	0.638	0.63	0.626	0.6	0.15	0.1	1.649
Aug	0.846	0.796	0.773	0.76	0.749	0.742	0.737	0.735	0.733	0.73	0.68	0.42	0.1	1.906
Sep	0.853	0.743	0.739	0.723	0.718	0.716	0.714	0.711	0.708	0.707	0.7	0.54	0.15	1.801
Oct	0.227	0.219	0.208	0.206	0.205	0.204	0.203	0.203	0.202	0.201	0.2	0.04	0.02	0.514
Nov	0.88	0.708	0.6	0.48	0.3	0.24	0.18	0.13	0.09	0.06	0.02	0.001	0.001	0.654
Dec	0.405	0.261	0.19	0.11	0.07	0.05	0.04	0.04	0.03	0.02	0.01	0.001	0	0.194
Wet[138]	0.83	0.759	0.739	0.72	0.706	0.64	0.249	0.213	0.203	0.093	0.043	0.031	0.01	6.478
Dry[139]	0.953	0.595	0.4	0.186	0.099	0.048	0.027	0.018	0.01	0.001	0.001	0.001	0	1.883

[138] May-October.

[139] November-April.

10. DISCUSSION

The EWR assessments on the Olifants and Doring Rivers have highlighted several important aspects pertaining to the rivers, as well as the need for careful consideration and management into the future, if the value and beauty of these riverine ecosystems are to be protected. Apart from the possibility of supporting irrigation and development in the region, both the Olifants and Doring Rivers are important from an ecological perspective. Both contain several species of endemic fish, some of which are critically endangered. The Doring River in particular has an exceptionally high conservation status, and is one of the last remaining large rivers in the country that is relatively unimpacted by humans[140].

The condition of the different river reaches bears testimony to the type and extent of developments that have taken place in their immediate and upstream catchments. In the case of the main stem of the Olifants River (EWR Site 1 and 2; Figure 10.1), many of the impacts on the river are non-flow related and include cultivation of the floodplain, bulldozing of the riverbed and the creation of levees.

In EWR Reach 1 it is clear that there are some opportunities for further abstractions from the river while still maintaining a D-category river BUT only if some of the summer flows are reinstated. Furthermore, opportunities for additional abstraction are limited by the fact that hydrology is presently supporting the D-category condition of the river, whereas other 'drivers' of river condition, such as geomorphology, are in an E. If the hydrological regime is further restricted, without implementation of basic river restoration measures aimed at reducing some of the non-flow related impacts of the system, this will result in the river falling to an E category.

In EWR Reach 2, downstream of Bulshoek to the confluence with the Doring River (EWR Reach 2), the Present Ecostatus (E) is lower than the minimum D-category recommended by the RDM:Directorate's policy (Figure 10.1). The EWR assessment for that reach indicates that, with Bulshoek Barrage and Clanwilliam Dam in place, there is little likelihood of achieving a D-category through the use of flow. However, it is worth noting that the assessments were undertaken prior to the recent repairs to the barrage to reduce leakages, and it is possible that the condition could worsen if there is no flow in that section for most of the year. A 'reduced' EWR, in the region of 10-17% of the nMAR, on the other hand, would result in an improvement in Present Ecostatus in the reach represented by EWR Site 2, albeit not to a D-category.

EWR Site	Present Ecostatus	REC	AEC
Site 1	D	D	None
Site 2	E	D	None
Site 3	B	B	C
Site 4	B/C	B	C
Site 5	B	B	C
Site 6	B/C	B/C	C

Figure 10.1 Summary of the Present Ecostatus, Recommended Ecological Category (REC) and Alternative Ecological Category (AEC) for the six EWR sites.

[140] Similarly the Olifants River estuary is ecologically important and sensitive.

The EWRs for the lower reaches of the Olifants River were not assessed as part of the river assessments, mainly because the requirements for the estuary are likely to dominate flow in the lower Olifants[141]. It is worth noting, however, that the Doring River provides the bulk of the winter flow in the lower Olifants River, and its estuary, at present.

The mainstem Doring River remains in a fairly good condition (EWR Site 4 and 5; Figure 10.1). There is very little development alongside the Doring River (Figure 10.2), and the most prevalent impacts on the river are from upstream developments, namely the spread of the ubiquitous *Nerium oleander*, which is seriously threatening the structure of the river channel in parts, and water abstraction leading to a progressive lengthening of the no-flow conditions in the river, and thereby increasing the stress for biota over-summering in the system.

Figure 10.2 Satellite image of the confluence between the Olifants and Doring Rivers (the confluence is in the bottom left hand of the image).

The EWR assessments at both EWR Reach 4 and 5 indicated that there is a little scope for additional abstraction without resulting in a decline in condition of the river ecosystem. However, reintroducing some of the flow at the beginning and end of the dry season, thereby reinstating a more natural duration for the no-flow period in the river, is part and parcel of any EWR recommended for that system. The sensitivity of the Doring River to flow manipulations has long been of concern to river ecologists, and was highlighted again in the EWR assessments done here. The reasons for this lie in the unique location of the river, which receives clear acidic water from the Kouebokkeveld and the Cedarberg Mountains, and sediment-laden, salty water from the Karoo; combined with the high evaporation rates during the summer, when the river ceases to flow.

The contributions of tributaries are of paramount importance in supporting ecological character and function in the mainstem rivers. They contribute water, flow variability, seeds and refuges for a variety of fauna. Both the Rondegat (in the Olifants River catchment) and the Groot (in the Doring catchment) are in relatively good condition. The EWR assessments done for these rivers will be used to calibrate the Desktop Model (DWAF 1999) to allow rapid estimates of EWRs for many of the other

[141] These will be outlined in the estuarine portions of the study.

tributaries in the area. EWR Site 6 on the Groot River will also play a key role in determining the contributions from the Kouebokkeveld to the Doring River.

The Olifants and Doring River, and their tributaries, have been the focus of several water development studies. Clearly, there is a perceived need for additional development in the area, for which water will be required. The EWR assessments reported on here can assist in providing direction for such developments, providing decision-makers with a clear indication of the likely consequence for the river resource of selecting one option versus another. They highlight where additional water is available, but equally importantly, they highlight the time of year when additional water is available, and the dangers of over-abstraction at key times in the year, all of which will need to be taken into account if genuine, sustainable development of the Olifants-Doring Rivers is to take place.

11. REFERENCES

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Kleynhans, C.J., Louw, M.D., Thirion, C., Rossouw, N. and Rowntree, K. 2005. River Classification: Manual for ecostatus determination. First Draft for Training Purposes. DWAF, Pretoria.

12. APPENDIX: DRIFT DATABASE (ELECTRONIC COPY)

See appended CD[142].

[142] Please note that the DRIFT Database requires that the User be in possession of a legal copy of MS Excel 2000.