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RESERVE DETERMINATION STUDIES FOR SELECTED SURFACE WATER, GROUNDWATER, ESTUARIES AND WETLANDS IN THE USUTU/MHLATUZE WATER MANAGEMENT AREA
WP 10544

RIVER INTERMEDIATE EWR

VOLUME 2: EWR ASSESSMENT RESULTS

FINAL

VERSION 1.5 (incl. WR2012 results for Mfolozi River)

November 2015

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ACRONYMS

AEC	Alternative Ecological Condition
AS	Assegaai River
BM	Black Mfolozi River
DRIFT	Downstream Response to Imposed Flow Transformations
DSS	Decision Support System
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EF	Environmental Flow
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
EWRS	Ecological Water Requirement Scenarios
MA	Matigulu River
MK	Mkuze River
NS	Nseleni River
PES	Present Ecological State
REC	Recommended Ecological Condition
RQOs	Resource Quality Objectives
TPCs	Thresholds of Potential Concern
UP	Upper Pongola
WM	White Mfolozi River
WMA	Water Management Area
WRCS	Water Resource Classification System.

GLOSSARY OF TERMS

- **Alternate Ecological Condition** (AEC) Target maintenance Ecological Conditions for a water resource reflecting one category up and/or down from the REC.
- **Ecoclassification**. The determination and categorisation of various biophysical attributes of rivers relative to their natural and/or reference condition.
- **Ecological Categories.** A distinction is made between Management Classes, which form part of the National Classification System, and Ecological Categories, which forms part of the Ecological Water Requirement assessment.
- **Ecological Category** (EC) replaces former terms used, namely: Ecological Reserve Category (ERC), Desired Future State (DFS) and Ecological Management Class (EMC).
- **Ecological Water Requirements** (EWR) should be used instead of the term Instream Flow Requirements (IFR) for various reasons, including international acceptance of the former term.
- **Ecological Water Requirement Scenarios** (EWRS) replaces the term Reserve Scenarios. EWRS is the term to use at all stages through the Reserve process until such time a decision has been made about the Reserve (at which time one of the EWRs will be selected as the Preliminary Reserve).
- **Ecospecs.** The quantifiable and enforceable descriptors of the RQOs as they pertain to the ecological objectives for a particular resource (in this case a particular river reach).
- **Ecosystem Integrity**: refers to the integrated composition of physicochemical, habitat and biotic characteristics on a temporal and spatial scale that are comparable to the characteristics of natural ecosystems of the region.
- **Long-term Average Volume**. Calculated for an EWR using the historical flow sequence, and only 'releasing' requirements in response to 'natural' cues.
- **Operational Scenarios** refers to scenarios devised on the basis of issues other than ecological, i.e. availability of water, operational constraints in the system, other demands etc.
- **Preliminary Reserve** refers to Reserve signed off by the Minister or her representative in the absence of the Classification Process having been undertaken in the basin.
- **Present Ecological Status** (PES) The degree to which ecological conditions have been modified from reference conditions, based on water quality, biota and habitat information that is scored on a six point scale from A (natural) to F (critically modified).
- **Recommended Ecological Condition** (REC) The target maintenance Ecological Condition for a water resource based solely on ecological criteria.

- ***Reserve*** refers to the EWR for maintaining a particular ecological condition where operational limitations and stakeholder consultation are taken into account. The Reserve includes both ecological and Basic Human Needs (BHN) requirements.
- **Resource Quality** refers to 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 Quality Objectives** (RQOs) refer to 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.
- **Synthetic EWR scenarios** represent a range of hypothetical flow scenarios in a system designed to assist the specialists in assessing the appropriateness of their indicators' responses, and to select the flow regimes to maintain REC and AEC.

1 INTRODUCTION

1.1 Background to the study

The Chief Directorate: Resource Directed Measures issued an open tender invitation for the "Appointment of a Professional Service Provider to undertake Reserve Determinations for selected Surface water, Groundwater, Estuaries and Wetlands in the Usutu to Mhlatuze Basins". The focus on this area was a result of the high conservation status and importance of various water resources in the basin and the significant development pressures in the area affecting the availability of water.

Preliminary Reserve determinations are required to assist the DWA in making informed decisions regarding the authorisations of future water use and the magnitude of the impacts of the proposed developments on the water resources in the WMA, and to provide the input data for Classification of the area's water resources, and eventual gazetting of the Reserve (DWAF1999a).

DWA appointed Tlou Consulting to undertake the project in July 2013.

1.1.1 Study objectives

The objectives of the study are to:

- determine the Ecological Reserve (DWAF 1999a), at various levels of detail, for the Nyoni, Matigulu, Mlalazi, Mhlatuze, Mfolozi, Nyalazi, Hluhluwe, Mzinene, Mkuze, Assegaai and Pongola Rivers;
- determine the Ecological Reserve, at an Intermediate level for the Pongola floodplain;
- determine the Ecological Reserve, at an Intermediate level for the St Lucia/Mfolozi, Estuary System;
- determine the Ecological Reserve, at an Rapid level for the Mlalazi Estuary;
- determine the Ecological Reserve, at a Rapid level for the Amatikulu Estuary;
- determine the Ecological Reserve, at an Intermediate level for Lake Sibaya;
- determine the Ecological Reserve, at a Rapid level for Kozi Lake and Estuary;
- classify the causal links between water supply and condition of key wetlands
- incorporate existing EWR assessments on the Mhlatuze (river and estuary) and Nhlabane (lake and estuary) into study outputs;
- determine the groundwater contribution to the Ecological Reserve, with particular reference to the wetlands;
- determine the Basic Human Needs Reserve for the Usutu/Mhlatuze WMA;
- outline the socio-economic water use in the Usutu/Mhlatuze WMA;
- build the capacity of team members and stakeholders with respect to EWR determinations and the ecological Reserve.

1.2 Layout of this Report

This report is Volume 2 of four volumes of the River Intermediate EWR Report:
Volume 1: Ecoclassification
Volume 2: EWR Assessment – Results
Volume 3: Specialist reports
Volume 4: Ecospecs and Monitoring Programme.

Companion reports include:

- Delineation Report (Report No. RDM/WMA6/CON/COMP/0213)
- Hydrology Report (Report No. RDM/WMA6/CON/COMP/1013)
- Operational Scenario Design Report (Report No. RDM/WMA6/CON/COMP/0313)
- Socioeconomic Report (Report No. RDM/WMA6/CON/COMP/0413).

2 THE INTERMEDIATE EWR ASSESSMENT PROCESS

2.1 Objectives

The objectives of the EWR assessment were:

- to select sites that represent the study rivers;
- to evaluate the present day condition (i.e. the present structure and functioning) of the river ecosystems at each site, and their ecological importance and sensitivity;
- to populate the DRIFT DSS with the expected response of a range of biophysical indicators to changes in flow;
- to use the DRIFT DSS to evaluate how the condition of the river could change under different flow conditions, including a range of water-resource development scenarios.
- to use this evaluation to recommend Preliminary Reserves for three ecological categories at each site;
- to describe ecological specifications that describe the recommended ecological state at each EWR site, and a programme for monitoring these in the future.

The results from the Intermediate EWR sites will be used to guide Rapid EWR assessments for up to 52 additional river nodes in the study area (see Inception Report and Delineation Report).

2.2 Method

DRIFT (Downstream Response to Imposed Flow Transformations) is a holistic EF assessment approach (Brown *et al.* 2013) that, in this project, was applied at an intermediate level for these EWR assessments. The objective was to describe the present condition of the river ecosystems and then, through scenarios, to predict how these could change with water-resource developments/uses. The social consequences of the predicted river changes can also be predicted using DRIFT, but this was done outside of the DRIFT process in this project.

Changes in the hydrological regime drive the assessment process. Each scenario would change flow conditions along the river in a different way, with possible different repercussions for the river system. Once these hydrological changes have been simulated, then the DRIFT software provides predictions of the consequent changes in the biotic and abiotic aspects of the river.

DRIFT is described in more detail in Appendix A.

2.3 Team

The team members for the Intermediate river EWR assessment are listed

Table 2-1 Team members for the Intermediate river EWR assessment

Person	Organisation	Discipline
Ms A Singh	Tlou Consulting	Team Leader
Mr T Sibande	Tlou Consulting	Coordinator
Prof. C Brown	Southern Waters	DRIFT Mentor
Dr A. Joubert	Southern Waters	DSS Manager
Dr K. Reinecke	Southern Waters	DRIFT assistance
Prof. A. Gorgens Mr A. Sparks Mr G. Howard	Aurecon	Hydrology
Mr M Kleynhans	Aurecon	Hydraulics
Dr H Malan	Independent	Water Quality
Mr M Rountree	Fluvius Environmental Consultants	Geomorphology
Mr J MacKenzie	MacKenzie Ecological and Development Services CC	Riparian vegetation
Ms C Todd	Independent	Macroinvertebrates
Dr B Paxton	Freshwater Research Centre	Fish
Mr T Tlou	Tlou Consulting	Socio-Economics
Mr W Mullins	Mosaka Economists	Socio-Economics

2.4 Programmes

2.4.1 Site visits and data collection

The dates and locations visit for site selection are provided in Table 2-2. The high flow data collection trip dates and personnel are provided in Table 2-3 and the low flow data collection trip in Table 2-4.

Table 2-2 Dates and locations visit for site selection

Date (2013)	River	Locations visited	Latitude	Longitude
16-Sep	Nseleni	Old EWR 6	28°38'4.07"S	31°55'52.73"E
16-Sep	Mhlatuze	Potential 1	28°48'3.14"S	31°57'23.52"E
16-Sep		Old EWR 4	28°48'23.80"S	31°57'6.86"E
16-Sep		Old EWR 3	28°50'40.79"S	31°52'13.00"E
16-Sep	Matigulu	Potential 1	29°1'33.52"S	31°29'31.22"E
16-Sep		Potential 2	29°1'29.33"S	31°28'18.09"E
16-Sep		Potential 3	29°1'13.58"S	31°28'11.75"E
16-Sep		Potential 4	29°2'36.60"S	31°30'39.50"E
16-Sep	Mhlatuze	Old EWR 1	28°44'34.90"S	31°36'20.80"E
16-Sep		Old EWR 2	28°44'49.00"S	31°44'50.80"E
17-Sep	Mfolozi	Rapid site	28°22'10.98"S	32°0'44.34"E
17-Sep	Nylalazi	Potential 1	28°13'10.10"S	32°19'9.90"E
18-Sep	Black Mfolozi	Potential 1	27°56'8.96"S	31°12'18.94"E
18-Sep		Potential 2	28°0'56.29"S	31°20'13.89"E
18-Sep		Potential 3	28°0'50.04"S	31°19'27.48"E
18-Sep		Potential 4	28°27'22.05"S	32°2'04.21"E

Date (2013)	River	Locations visited	Latitude	Longitude
18-Sep		Potential 5	28°02'08.86"S	31°21'20.49"E
18-Sep	Black Mfolozi	Potential 1A	27°55'3.71"S	31°13'7.99"E
18-Sep	White Mfolozii	Potential 1	28°13'59.76"S	31°11'7.36"E
18-Sep		Potential 2	28°20'51.41"S	31°21'2.98"E
18-Sep		Potential 3	28°20'19.35"S	31°22'27.92"E
19-Sep	Mkuze	Potential 1	27°36'29.04"S	32°5'22.00"E
19-Sep		Potential 2	27°36'40.72"S	32°4'59.29"E
19-Sep		Potential 3	27°35'31.37"S	32°13'0.94"E
19-Sep		Potential 4	27°35'55.30"S	32°18'7.00"E
20-Sep	Pongola (floodplain)	General view of study area. Study sites not applicable.		
21-Sep	Lake Sibaya and Kosi			
22-Sep	Phongolo	Potential 1	27°21'50.90"S	30°58'10.60"E
22-Sep		Potential 2	27°18'33.62" S	30°53'51.85"E
22-Sep	Assegaai	Old JMB2	27°3'44.22"S	30°59'19.68"E

Table 2-3 Dates and locations visit for high flow sampling

Team	Martin Kleynhans			
	James Mackenzie			
Date (2013)	River	EWR Site	Latitude	Longitude
25th Nov	Assegaai	AS1	27°3’44.28”S	30°59’19.68”E
26th Nov	Upper Pongola	UP1	27°21’50.88”S	30°58’10.62”E
27th Nov	Black Mfolozi	BM1	27°56’20.04”S	31°12’37.08”E
		BM2	28°0’50.04”S	31°19’27.48”E
28th Nov	White Mfolozi	WM1	28°13’53.24”S	31°11’17.97”E
29th Nov	Mkuze	MK1	27°35’31.56”S	32°13’4.80”E
30th Nov	Nseleni	NS1	27°35’31.56”S	32°13’4.80”E
1st Dec	Matigulu	MA1	29°1’12.36”S	31°28’13.44”E

Table 2-4 Dates and locations visit for low flow sampling

TEAM	Martin Kleynhans			
	Colleen Todd			
	Bruce Paxton			
	Mark Rountree			
Date (2014)	River	Site	Latitude	Longitude
7th July	Matigulu	MA1	29°1’12.36”S	31°28’13.44”E
8th July	Nseleni	NS1	27°35’31.56”S	32°13’4.80”E
9th July	Mkuze	MK1	27°35’31.56”S	32°13’4.80”E
10th July	Assegaai / Pongola	AS1	27°3’44.28”S	30°59’19.68”E
		UP1	27°21’50.88”S	30°58’10.62”E
11th July	Black Mfolozi 1	BM1	27°56’20.04”S	31°12’37.08”E
12th July	Black Mfolozi 2	BM2	28°0’50.04”S	31°19’27.48”E
13th July	White Mfolozi	WM1	28°13’53.24”S	31°11’17.97”E

2.4.2 EWR Workshops

WORKSHOP WEEK 1: 4-8 August 2014

Day	Time	Activities	Focus site	Responsibilities - Specialists	Responsibilities -Process Team
Monday	08:30-09:00	Introduction to week			
	09:00-12:30	Finalise indicators	All	List of indicators and links	Gather all inputs
	13:30-14:30	Ecoclassification	All	Provide input for ecoclassification	Complete and collate summary ecoclassification tables
	14:45-17:00	Ecoclassification	All		
Tuesday	08:30-10:00	DRIFT set up, and instruction	AS1, UP1, NS1	Upload DRIFT DAY 1 and instruction	DRIFT set-up for Day 1, and instruction for use
	10:30-12:30	Population of response curves	AS1	DSS response curves for AS1	Advise and assist with DRIFT DSS
	13:30-15:00		AS1		
	15:00-16:45		AS1		
	16:45-17:00	Hand-over of DSS	AS1		Gather all inputs
	17:00- 19:00	Updating of DRIFT			Update and synthesise DSS inputs from specialists
Wednesday	08:00-09:30	DRIFT set up, and discussion	AS1	Upload DRIFT DAY 2 and discussion	DRIFT set-up for Day 2. ID issues
	10:00-12:30	Population of response curves	AS1	DSS response curves for AS1	Advise and assist with DRIFT DSS
	13:30-15:00		AS1		
	15:30-16:45		AS1		
	16:45-17:00	Hand-over of DSS	All		Gather all inputs
	17:00- 19:30	Updating of DRIFT			Update and synthesise DSS inputs from specialists
Thursday	08:30-09:30	DRIFT set up, and discussion	AS1, UP1, NS1, MK1	Upload DRIFT DAY 3 and discussion	DRIFT set-up for Day 3. ID issues
	10:00-12:30	Population of response curves	UP1	Draft DSS response curves for AS1, UP1	Advise and assist with DRIFT DSS
	13:30-15:00		UP1		
	15:30-16:45		UP1		
	16:45-17:00	Hand-over of DSS	AS1/UP1		Gather all inputs
	17:00-19:30	Updating of DRIFT			Update and synthesise DSS inputs from specialists
Friday	08:30-09:00	DRIFT set up, and discussion	All	Uploading of DRIFT DAY 4 and discussion	DRIFT set-up for Day 4. ID issues
	09:30-11:00	Evaluation of test scenarios and calibration of response curves	MK1	Calibrated DSS curves for AS1 and UP1	
	11:00-12:30		MK1		
	12:30-13:00	Hand-over of DSS	All		Gather all inputs

WORKSHOP WEEK 2: 25-29 August 2014

Day	Time	Activities	Focus site	Responsibilities - Specialists	Responsibilities - Process Team
Monday	09:30-10:30	Presentation on results to date for AS1, and explanation of process going forward			
	10:30-11:00	DRIFT set up, and instruction	All	Upload DRIFT DAY 5	DRIFT set-up for Day 5, and instruction for use
	11:00-17:30	Final calibration of AS1, UP1, MA1, NS1	AS1, UP1, MA1, NS1	Calibrate DSS response curves	Advise and assist with DRIFT DSS
	17:30-19:00	Updating of DRIFT			Update and synthesise DSS inputs from specialists
Tuesday	08:30-10:00	DRIFT set up, and instruction	All	Upload DRIFT DAY 6 and discussion	DRIFT set-up for Day 6, and instruction for use
	10:30-17:30	Population of response curves	BM1 and BM2	Populate DSS response curves for BM1 and BM2	Advise and assist with DRIFT DSS
	17:30-19:00	Updating of DRIFT			Update and synthesise DSS inputs from specialists
Wednesday	08:30-10:00	DRIFT set up, and discussion	All	Upload DRIFT DAY 7 and discussion	DRIFT set-up for Day 7. ID issues
	10:30-17:30	Population of response curves	BM1, BM2, WM1, MA1	Populate DSS response curves for BM1, BM2, WM1, MA1	Advise and assist with DRIFT DSS
	17:30-19:00	Updating of DRIFT			Update and synthesise DSS inputs from specialists
Thursday	08:30-09:30	DRIFT set up, and discussion	All	Upload DRIFT DAY 8 and discussion	DRIFT set-up for Day 8. ID issues
	10:30-17:30	Final calibration ofBM1, BM2, WM1, MA1	BM1, BM2, WM1, MA1	Calibrate DSS response curves	Advise and assist with DRIFT DSS
	17:30-19:00	Updating of DRIFT			Update and synthesise DSS inputs from specialists
Friday	08:30-09:30	DRIFT set up, and discussion	All	Uploading of DRIFT DAY 9 and discussion	DRIFT set-up for Day 9. ID issues
	09:30-11:00	Resolution of outstanding issues	Any	Fine tune response curves for sites - in response to issues raised	
	11:00-12:30	Resolution of outstanding issues	Any		
	12:30-13:00	Hand-over of DSS	All		Gather all inputs
	14:00-15:00	Process team packaging of information			EWR Report
	15:30-17:00				Complete DRIFT DSS

2.4.3 Workshop participants

The workshop participants for workshop 1 are provided in Table 2-5 and workshop 2 in Table 2-6.

Table 2-5 Participants at Workshop 1: 4 - 8 August 2014

	Participants	Dates attended
Project Team	Cate Brown	5-8 August
	Alison Joubert	
	Karl Reynecke	
	Colleen Todd	
	Heather Malan	
	Mark Rountree	
	Bruce Paxton	
	James McKenzie	
	Adhishri Singh	
DWS: RQIS	C Thirion	5-8 August
	CJ Kleynhans	5-6 August
DWS: RDM	Boniwe Nobubele	5-6 August
	Qoko Mathabo	
DWS: KZN Region	Siyabonga Buthelezi	4-5 August

Table 2-6 Participants at Workshop 2: 25 – 29 August 2014

Participants		Dates attended
Project Team	Cate Brown	25-29 August
	Alison Joubert	
	Karl Reynecke	
	Colleen Todd	
	Heather Malan	
	Mark Rountree	
	Bruce Paxton	
	James McKenzie	
	Adhishri Singh	
DWS: RQIS	C Thirion	25-28 August
	CJ Kleynhans	26 August
DWS: RDM	Boniwe Nobubele	25-26 August
	Qoko Mathabo	
	Mazibuko Molefi	

3 STUDY AREA AND EWR SITES

3.1 Study area

The extent of the total study area is shown in (Figure 3-1).

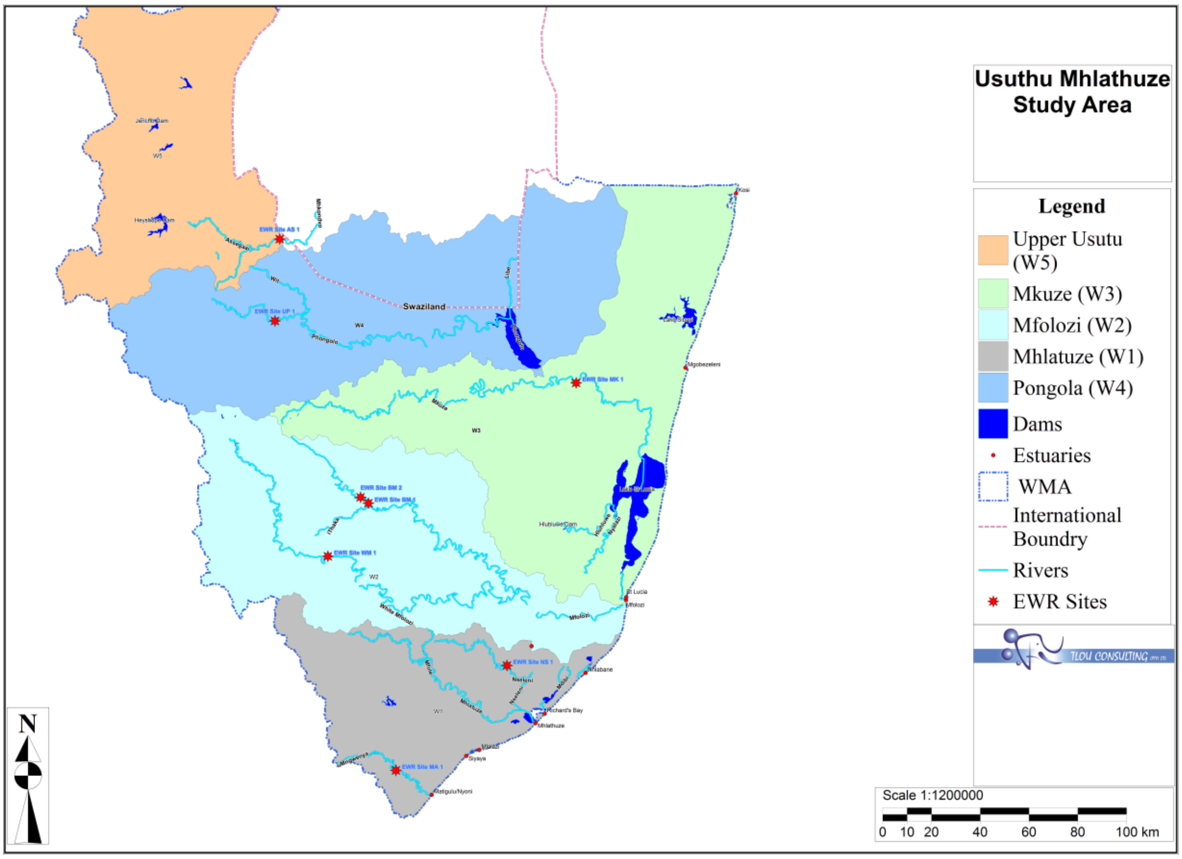


Figure 3-1 Map of the study area

It comprises the following catchment areas, and main rivers:

- Mhlatuze (W1), including:
    - Mhlatuze River
    - Matigulu River
    - Mfule River
    - Nseleni River
    - Mlalazi River
- Mfolozi (W2), including:
    - Mfolozi River
    - White Mfolozi River
    - Black Mfolozi River
    - Mlalazi River
    - Mvunyane River

  - Nondweni River
  - Hlonyane River
  - SikweBezi River
  - Mona River
  - Msunduzi River
- Mkuze (W3), including:
  - Mkuze River
  - Nkongolwana River
  - Msunduzi River
  - Mzinene River
  - Nzimane River
  - Hluhluwe River
  - Nylalazi River
- Pongola (W4), including:
  - Pongola River
  - Bivane River
  - Manzana River
  - Mozana River
  - Ngwavuma River
- Upper Usutu (W5) , including:
  - Assegaai River
  - Ohlelo River
  - Ngwempisi River
  - Usuthu River
  - Bonnie Brook River
- Lake Sibaya / Kosi (W7).

3.2 EWR sites

The NWRCS node delineation process identified 49 river nodes for which EWR data will be required for Classification. In accordance with the Terms of Reference for the study, these data will be informed by intermediate assessments at eight sites that will be used to extrapolate results across the remained of the area.

The locations of the eight EWR sites for which Intermediate assessments will be done are provided in Table 3-1.

Table 3-1 Locations of the eight EWR sites in the Intermediate EWR assessment

Quaternary	River name	Site Name	Location description	Latitude	Longitude
W51D	Assegaai	EWR Site AS1	Downstream of Heyshope Dam, near the Swaziland border	27°3’44.28”S	30°59’19.68”E
W42E	Upper Pongola	EWR Site UP1	Near Frischgewaagd and Bilayoni Townships	27°21’50.88”S	30°58’10.62”E
W31J	Mkuze	EWR Site MK1	Adjacent to Mkuze National Park, almost opposite Mantuma Camp	27°35’31.56”S	32°13’4.80”E
W22C	Black Mfolozi	EWR Site BM1	Downstream of W2H028	27°56’20.04”S	31°12’37.08”E
W22C	Black Mfolozi	EWR Site BM2	Near Basonhoek	28°0’50.04”S	31°19’27.48”E
W21H	White Mfolozi	EWR Site WM1	Just downstream of the R34 at the confluence with the Mvutshini River	28°13’53.24”S	31°11’17.97”E
W12H	Nseleni	EWR Site NS1	near Cwaka. Enter through property at the end of the road	28°38’2.76”S	31°55’51.24”E
W11B	Matigulu	EWR Site MA1	Downstream of old DWA gauging station	29°1’12.36”S	31°28’13.44”E

3.2.1 EWR Site AS1: Assegaai River

EWR Site AS1 (Figure 3-2) is representative of the reach of the Assegaai River from Heyshope Dam to the RSA/Swaziland Border. It was also chosen to provide an extrapolation option for NWRCS nodes on the upper foothills of the Pongola River.

The relevant summary details are as follows:

Location: Assegaai River, downstream of Heyshope Dam, close to the border between South Africa and Swaziland.

Coordinates: 27°3’44.28”S; 30°59’19.68”E.

Figure 3-2 EWR Site AS1: Assegaai River, photograph September 2013

Hydrology: See Section 4.

Comments: EWR AS1 is the site of a previous EWR assessment (EWR site JMB2, Louw and Koekemoer 2008). It comprises a riffle, rapid and run section flanked by indigenous vegetation. There is a camp site and picnic area on the left bank.

3.2.2 EWR Site UP1: Upper Pongola River

EWR Site UP1 (Figure 3-3) is representative of the Pongola River from the R33 to Pongolapoort Dam. It was also chosen to provide an extrapolation option for NWRCS nodes on the Bivane, SikweBezi, upper Mkuze and Manzana Rivers.

The relevant summary details are as follows:

Location: Upper Pongola River, near Frischgewaagd and Bilayoni Townships, upstream of the confluence with the Wit River.

Coordinates: 27°21'50.88"S; 30°58'10.62"E

Hydrology: See Section 4.

Figure 3-3 EWR Site UP1: Upper Pongola River, photograph September 2013

3.2.3 EWR Site MK1: Mkuze River

EWR Site MK1 (Figure 3-4) is representative of the lower reach of the Mkuze River from the N2 to St Lucia. It was also chosen to provide an extrapolation option for NWRCS nodes on the Ngwavuma River (see Rivers Delineation Report).

Figure 3-4 EWR Site MK1: Mkuze River, photograph September 2013

The relevant summary details are as follows:

Location:	Mkuze River, adjacent to Mkuze National Park, almost opposite Mantuma Camp.
Hydrology:	See Section 4.
Coordinates:	27°35'31.56"S; 32°13'4.80"E

3.2.4 EWR Site BM1: Black Mfolozi River

EWR Site BM1 (Figure 3-5) is representative of the upper reaches of the Black Mfolozi River upstream of the confluence with the Kwabizankulu River. It was also chosen to provide an extrapolation option for NWRCS nodes on the Black Mfolozi, Bivane, Nondweni and Mvunyane Rivers (see Rivers Delineation Report).

The relevant summary details are as follows:

Location:	Black Mfolozi River, downstream of DWA Gauge W2H028.
Coordinates:	27°56'20.04"S; 31°12'37.08"E.
Hydrology:	See Section 4.

Figure 3-5 EWR Site BM1: Black Mfolozi River, photograph September 2013

3.2.5 EWR Site BM2: Black Mfolozi River

EWR Site BM2 (Figure 3-6.) is representative of the upper reaches of the Black Mfolozi River from the confluence with the Kwabizankulu River to the confluence with the White Umfolozi River. It was also chosen to provide an extrapolation option for NWRCS nodes on the Black Mfolozi, Bivane, Nondweni and Mvunyane Rivers (see Rivers Delineation Report).

The relevant summary details are as follows:

Location:	Black Mfolozi River, near Basonhoek.
Coordinates:	28^{o}0'50.04"S; 31^{o}19'27.48"E.
Hydrology:	See Section 4.

Figure 3-6 EWR Site BM2: Black Mfolozi River, photograph September 2013

3.2.6 EWR Site WM1: White Mfolozi River

EWR Site WM1 (Figure 3-7) is representative of the upper reaches of the White Mfolozi River from the confluence with the Mvunyane River to the confluence with the Black Mfolozi River. It was also chosen to provide an extrapolation option for NWRCS nodes on the White Mfolozi, Mona, Nzimane, Mozana, Pongola and Mkuze Rivers (see Rivers Delineation Report).

Figure 3-7 EWR Site WM1: White Mfolozi River, photograph September 2013

The relevant summary details are as follows:

Location:	White Mfolozi River, just downstream of the R34 at the confluence with the Mvutshini River.
Coordinates:	28°13'53.24"S; 31°11'17.97"E.
Hydrology:	See Section 4.
Comments:	There is a causeway immediately upstream of the site.

3.2.7 EWR Site NS1: Nseleni River

EWR Site NS1 (Figure 3-8) is representative of the middle reaches of the Nseleni River upstream of its confluence with the Okula River. It was also chosen to provide an extrapolation option for NWRCS nodes on the Nseleni, Msunduzi, Mkuze, Mhlatuze, Mzinene, Nylalazi and Hluhluwe Rivers (see Rivers Delineation Report).

The relevant summary details are as follows:

Location:	Nseleni River, near Cwaka.
Coordinates:	28°38'2.76"S; 31°55'51.24"E.
Hydrology:	See Section 4.
Comments:	EWR Site NS1 is the site of a previous EWR assessment (EWR 6 – Louw and Koekemoer 2008).

Figure 3-8 EWR Site NS1: Nseleni River, photograph September 2013

3.2.8 EWR Site MA1: Matigulu River

EWR Site MA1 (Figure 3-9) is representative of the Matigulu River from the confluence with the Honothi River to the N2.

The relevant summary details are as follows:

Location: Matigulu River, near Izimpohlo.

Coordinates: 29°1’12.36”S; 31°28’13.44”E.

Hydrology: See Section 4.

Figure 3-9 EWR Site MA1: Matigulu River, photograph September 2013

4 BASELINE AND NATURALISED HYDROLOGY

4.1 Introduction

The development of the naturalised and baseline hydrological sequences is presented in the Hydrology Report (Report No. RDM/WMA6/CON/COMP/1013). This section presents the DRIFT flow and hydraulic indicators made available to the specialists. It also provides an overview of the main features of the hydrology at each of the EWR sites.

The baseline hydrology is a "present day" scenario reflecting development and use conditions as in 2013 / 2014.

Due to various modelling considerations the hydrological modelling team produced hydrology for two slightly different time-periods for two groups of sites. For the DRIFT EWR assessment this difference was retained such that two DSSs were created, as follows:

- The baseline and naturalised hydrology used in the DRIFT DSS for EWR sites AS1, UP1, NS1, and MA1 was for the time-period 01 August 1951 to 30 September 2004.
- The baseline and naturalised hydrology used in the DRIFT DSS for EWR sites BM1, BM2, WM1, and MK1 was for the time-period 01 August 1960 to 31 December 2010.

The naming convention is as follows:

- the baseline scenario is referred to as Baseline2014 or abbreviated to Base2014, and
- the naturalised scenatrio is referred to as Naturalised or abbreviated to Nat.

4.1.1 Use of the ACRU model for the influent rivers to St Lucia (Mfolozi, Mkuze and Dusi)

The hydrological simulations for influent catchments for the St Lucia estuarine system were prepared using the ACRU model (Smithers and Schulze 2004; as per the Inception Report No.). This was done to ensure compatability between the river hydrology and that required for the St Lucia Estuarine EWR, and was mainly related to need to deliver daily sediment load sequences for the various catchment scenarios required for the the hydrodynamic modelling of the Lake St Lucia System (Hydrology Report_Report No. RDM/WMA6/CON/COMP/1013).

Thus the EWRs for Mfolozi (BM1, BM2, WM1) and Mkuzi (MK1) were determind using ACRU-generated hydrological sequences.

Queries related to the use of ACRU, and its relationship to WR2012 hydrological data for those catchments were raised at the PSC meeting in August 2015, and resulted in discussion between the study team and the Client on the best ay to address these. The main two outcomes of this process were:

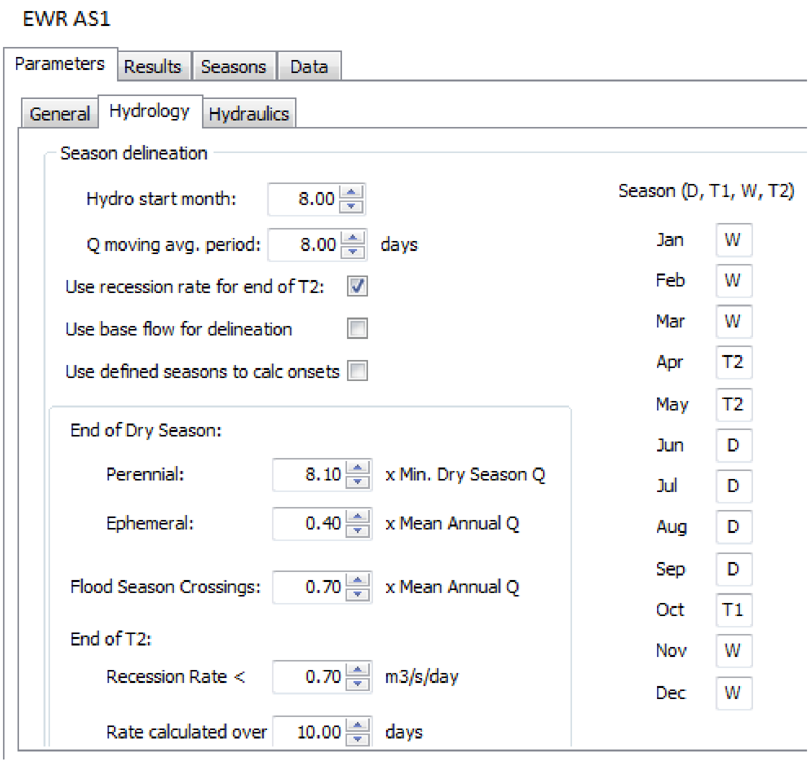
1. A letter from Tlou Consulting and the relevant sub-consultants explaining the reasoning behind the use of ACRU.
2. A comparison between the EWRs for ACRU generated data and WR2012 data, which had two motives:
    a. to document the actual differences between the EWRs generated using these two sets of data, and;
    b. to provide WR2012-corrected EWRs in the event that these were required in later studies.

Both of these outcomes are presented in Appendix B.

4.2 EWR Site AS1: Assegaai River

The rules and thresholds used to define the seasons are provided in Table 4-1.

Table 4-1 Rules and thresholds used to define the seasons for EWR Site AS1



Key summary statistics for the naturalised and baseline hydrology at EWR Site AS1: Assegaai River, are provided in Table 4-2, Figure 4-1 and Table 4-3. Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-2 Key summary statistics for EWR Site AS1

Comparison	Unit	BASE2014	NAT
MAR	MCM	134	278
Dry onset	weeks	12	22
Dry duration	days	191	104
Dry season min 5-day	m^3/s	1.025	1.324
Dry season volume	MCM	0.199	0.185
1:2	m^3/s	39.0	88.1
1:5	m^3/s	74.0	153.5
1:10	m^3/s	105.8	198.1

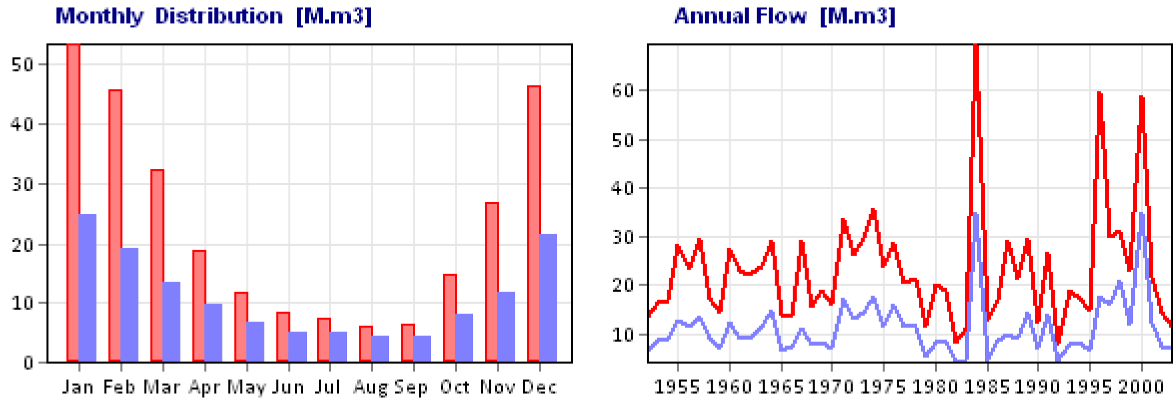


Figure 4-1 Monthly and annual flow volumes for EWR Site AS1: baseline (blue) and naturalised (red)

Table 4-3 Monthly distributions of Class 1-4 flood events at EWR Site AS1: baseline and naturalised

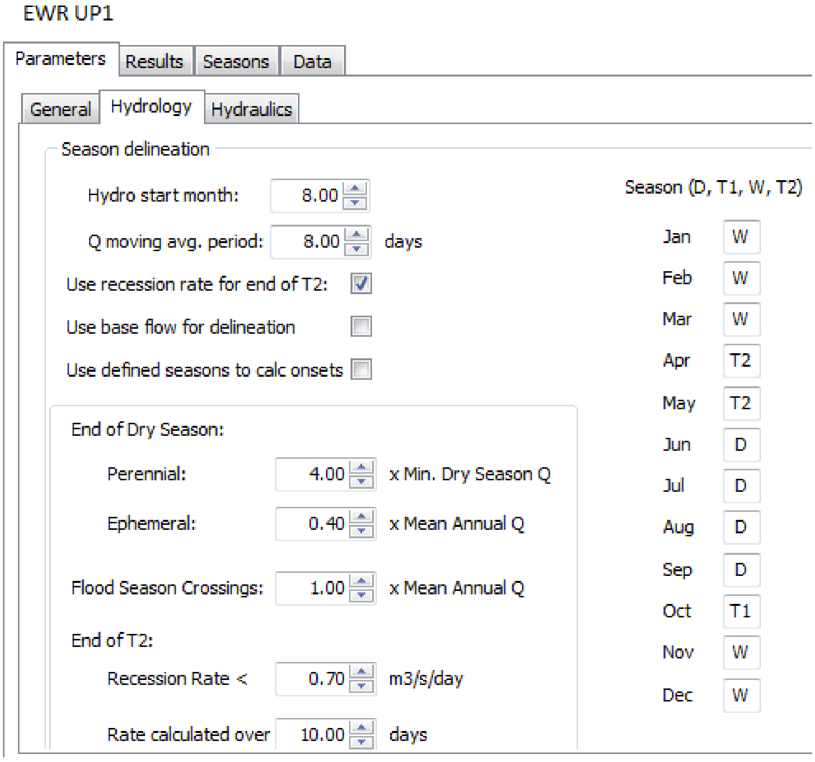
Base2014 Monthly Distribution [#/annum]					**Nat** Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4		Class 1	Class 2	Class 3	Class 4
January	0.70	0.87	0.79	0.51	January	0.04	0.45	1.15	0.91
February	0.38	0.66	0.83	0.32	February	0.04	0.45	0.72	0.91
March	0.53	0.66	0.74	0.19	March	0.06	0.49	0.79	0.72
April	0.57	0.40	0.42	0.19	April	0.13	0.66	0.51	0.45
May	0.42	0.23	0.11	0.02	May	0.15	0.30	0.30	0.08
June	0.15	0.13	0.02	0.02	June	0.08	0.19	0.06	0.04
July	0.17	0.09	0.04	0.02	July	0.15	0.11	0.08	0.00
August	0.13	0.07	0.00	0.02	August	0.19	0.06	0.04	0.00
September	0.33	0.24	0.06	0.02	September	0.30	0.28	0.09	0.06
October	0.55	0.53	0.30	0.11	October	0.42	0.43	0.45	0.28
November	0.66	0.83	0.60	0.34	November	0.21	0.62	0.89	0.55
December	0.49	0.92	1.06	0.51	December	0.09	0.34	0.96	1.02
Annual Total	5.07	5.64	4.96	2.26	Annual Total	1.84	4.39	6.04	5.00

Flood classes	Lower limit	Upper limit
CLASS 1	2 m^3/s	4 m^3/s
CLASS 2	4 m^3/s	9 m^3/s
CLASS 3	9 m^3/s	18 m^3/s
CLASS 4	18 m^3/s	35 m^3/s

4.3 EWR Site UP1: Upper Pongola River

The rules and thresholds used to define the seasons are provided in Table 4-4.

Table 4-4 Rules and thresholds used to define the seasons for EWR Site UP1



Key summary statistics for the naturalised and baseline hydrology at EWR Site UP1: Upper Pongola River, are provided in Table 4-5, Figure 4-2 and Table 4-6. Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-5 Key summary statistics for EWR Site UP1

Comparison	Unit	BASE2014	NAT
MAR	MCM	238.5	288.5
Dry onset	weeks	12	135
Dry duration	days	234	209
Dry season min 5-day	m^3/s	0.519	0.739
Dry season volume	MCM	0.270	0.318
1:2	m^3/s	82.4	97.6
1:5	m^3/s	187.0	220.5
1:10	m^3/s	259.0	301.6

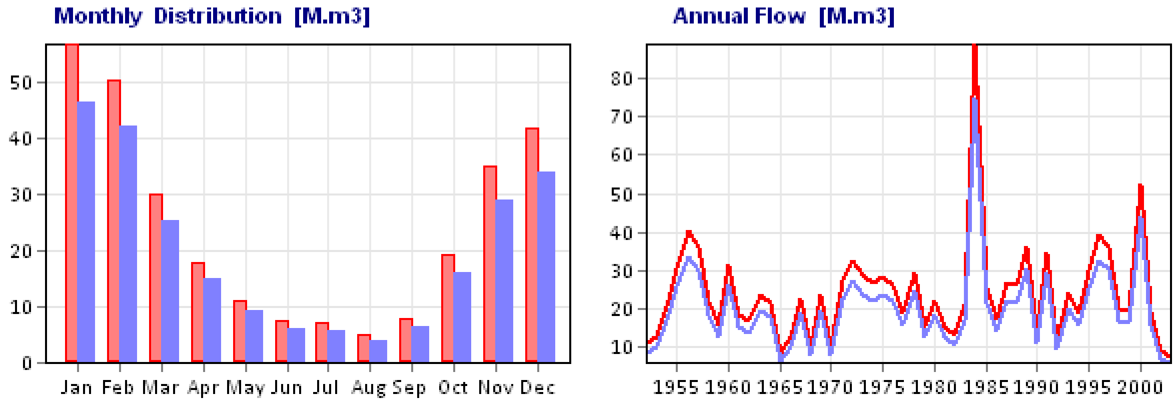


Figure 4-2 Monthly and annual flow volumes for EWR Site UP1: baseline (blue) and naturalised (red)

Table 4-6 Monthly distributions of Class 1-4 flood events at EWR Site UP1: baseline and naturalised

Base2014 Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4
January	0.45	1.26	0.72	0.49
February	0.21	0.75	0.87	0.26
March	0.23	0.83	0.74	0.26
April	0.26	0.60	0.30	0.02
May	0.09	0.23	0.06	0.00
June	0.02	0.08	0.02	0.00
July	0.08	0.04	0.02	0.00
August	0.02	0.04	0.04	0.00
September	0.15	0.04	0.06	0.02
October	0.21	0.55	0.30	0.17
November	0.32	0.66	0.74	0.42
December	0.32	1.21	1.17	0.36
Annual Total	2.36	6.28	5.02	2.00

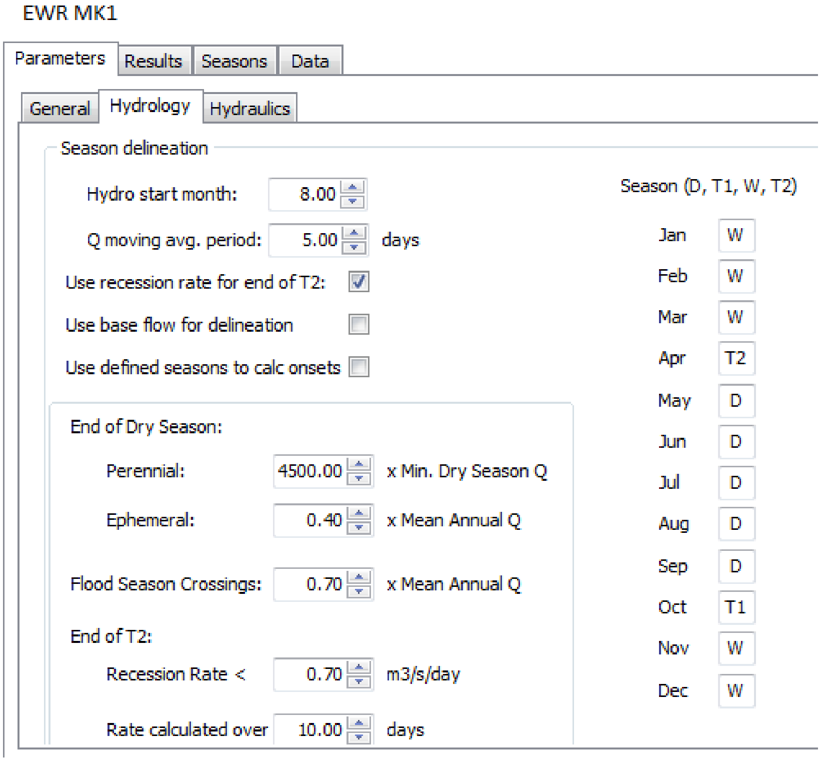
Nat Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4
January	0.26	1.11	1.04	0.68
February	0.26	0.77	0.79	0.55
March	0.21	0.91	0.81	0.34
April	0.30	0.79	0.36	0.08
May	0.11	0.21	0.13	0.00
June	0.06	0.08	0.04	0.00
July	0.08	0.08	0.02	0.00
August	0.07	0.02	0.06	0.00
September	0.13	0.13	0.04	0.04
October	0.25	0.62	0.36	0.25
November	0.64	0.75	0.66	0.51
December	0.26	1.21	1.36	0.51
Annual Total	2.64	6.68	5.66	2.94

Flood classes	Lower	Upper
CLASS 1	5 m3/s	9 m3/s
CLASS 2	9 m3/s	19 m3/s
CLASS 3	19 m3/s	37 m3/s
CLASS 4	37 m3/s	74 m3/s

4.4 EWR Site MK1: Mkuze River

The rules and thresholds used to define the seasons are provided in Table 4-7.

Table 4-7 Rules and thresholds used to define the seasons for EWR Site MK1



Key summary statistics for the naturalised and baseline hydrology at EWR Site MK1: Mkuze River, are provided in Table 4-8, Figure 4-3 and Table 4-9. Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-8 Key summary statistics for EWR Site MK1

Comparison	Units	BASE2014	NAT
MAR	MCM	271.3	275.4
Dry onset	weeks	15	12
Dry duration	days	255	249
Dry season min 5-day	m^3/s	0.353	0.353
Dry season volume	MCM	0.193	0.229
1:2	m^3/s	143.9	134.7
1:5	m^3/s	371.5	368.0
1:10	m^3/s	515.4	523.9

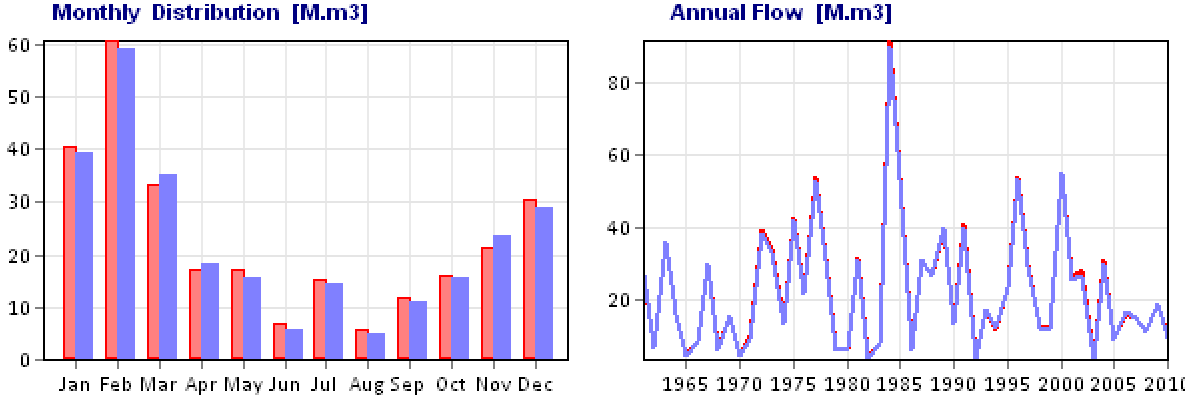


Figure 4-3 Monthly and annual flow volumes for EWR Site MK1: baseline (blue) and naturalised (red)

Table 4-9 Monthly distributions of Class 1-4 flood events at EWR Site MK1: baseline and naturalised

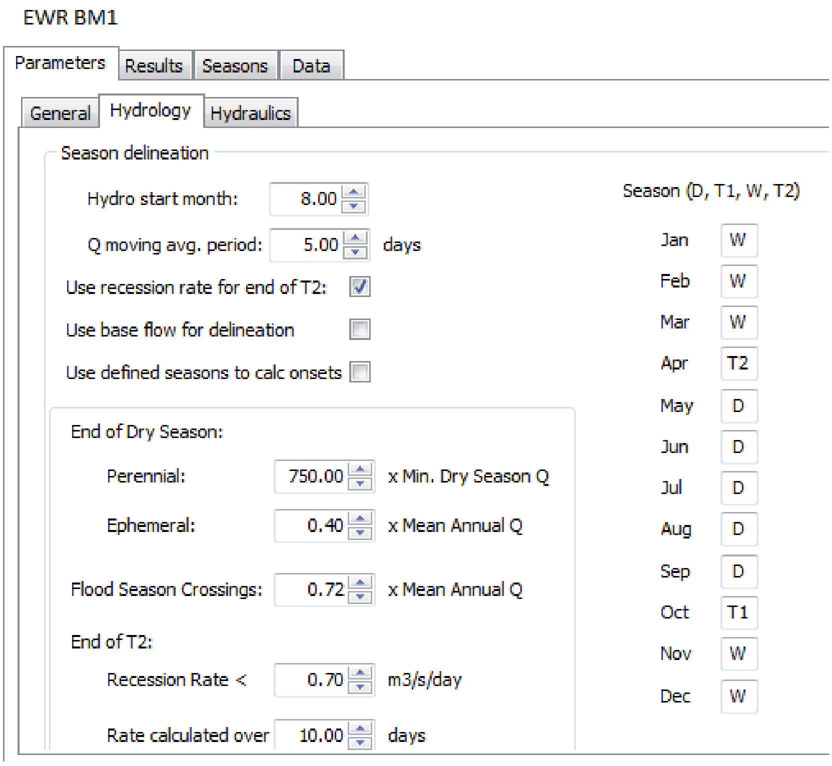
Bas2014 Monthly Distribution [#/annum]						**Nat** Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4			Class 1	Class 2	Class 3	Class 4
January	0.42	0.48	0.44	0.22		January	0.34	0.62	0.44	0.26
February	0.24	0.38	0.40	0.28		February	0.20	0.36	0.42	0.30
March	0.12	0.32	0.50	0.22		March	0.26	0.26	0.46	0.22
April	0.12	0.42	0.08	0.04		April	0.42	0.14	0.08	0.04
May	0.06	0.10	0.04	0.02		May	0.04	0.12	0.04	0.02
June	0.04	0.02	0.00	0.00		June	0.04	0.04	0.00	0.00
July	0.02	0.02	0.04	0.04		July	0.02	0.02	0.04	0.04
August	0.06	0.02	0.02	0.02		August	0.06	0.02	0.02	0.02
September	0.08	0.06	0.00	0.00		September	0.08	0.06	0.02	0.00
October	0.12	0.31	0.08	0.02		October	0.20	0.29	0.06	0.00
November	0.25	0.53	0.27	0.12		November	0.37	0.53	0.20	0.08
December	0.29	0.41	0.35	0.22		December	0.27	0.49	0.39	0.22
Total	1.82	3.07	2.23	1.19		Total	2.3	2.95	2.17	1.19

Flood classes	Lower	Upper
CLASS 1	8 m3/s	16 m3/s
CLASS 2	16 m3/s	32 m3/s
CLASS 3	32 m3/s	65 m3/s
CLASS 4	65 m3/s	129 m3/s

4.5 EWR Site BM1: Black Mfolozi River

The rules and thresholds used to define the seasons are provided in Table 4-10.

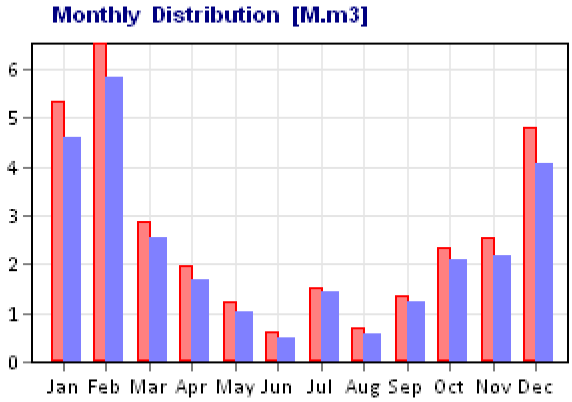
Table 4-10 Rules and thresholds used to define the seasons for EWR Site BM1



Key summary statistics for the naturalised and baseline hydrology at EWR Site BM1: Black Mfolozi River, are provided in Table 4-11, Figure 4-4 and Table 4-12. Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-11 Key summary statistics for EWR Site BM1

Comparison	Units	BASE2014	NAT
MAR	MCM	27.8	31.8
Dry onset	weeks	12	10
Dry duration	days	260	253
Dry season min 5-day	m^3/s	0.012	0.012
Dry season volume	MCM	0.016	0.017
1:2	m^3/s	19.6	21.7
1:5	m^3/s	40.2	42.6
1:10	m^3/s	54.7	58.2



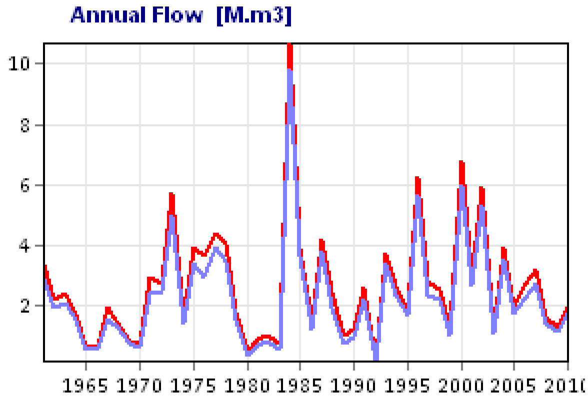


Figure 4-4 Key summary statistics for EWR Site BM1: baseline (blue) and naturalised (red)

Table 4-12 Monthly distributions of Class 1-4 flood events at EWR Site BM1: baseline and naturalised

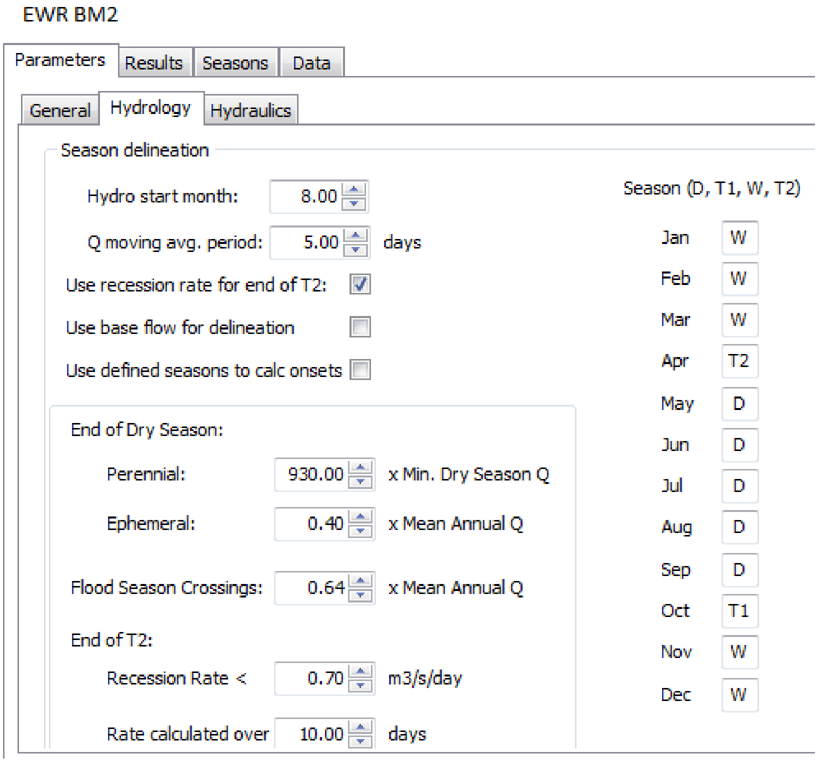
Base2014 Monthly Distribution [#/annum]						**Nat** Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4			Class 1	Class 2	Class 3	Class 4
January	0.26	0.30	0.32	0.18		January	0.34	0.38	0.30	0.24
February	0.24	0.30	0.16	0.20		February	0.18	0.34	0.18	0.24
March	0.18	0.14	0.08	0.08		March	0.12	0.14	0.10	0.10
April	0.08	0.14	0.12	0.02		April	0.04	0.12	0.12	0.04
May	0.00	0.02	0.02	0.02		May	0.00	0.00	0.04	0.02
June	0.02	0.02	0.00	0.00		June	0.00	0.04	0.00	0.00
July	0.04	0.02	0.04	0.02		July	0.06	0.02	0.04	0.02
August	0.02	0.02	0.02	0.00		August	0.06	0.02	0.02	0.00
September	0.02	0.06	0.06	0.08		September	0.00	0.06	0.06	0.10
October	0.08	0.14	0.10	0.06		October	0.04	0.16	0.12	0.06
November	0.33	0.22	0.16	0.08		November	0.25	0.24	0.18	0.12
December	0.24	0.51	0.24	0.18		December	0.10	0.43	0.41	0.20
Total	1.51	1.88	1.31	0.91		Total	1.19	1.94	1.56	1.13

Flood classes	Lower	Upper
CLASS 1	1 m3/s	2 m3/s
CLASS 2	2 m3/s	4 m3/s
CLASS 3	4 m3/s	9 m3/s
CLASS 4	9 m3/s	18 m3/s

4.6 EWR Site BM2: Black Mfolozi River

The rules and thresholds used to define the seasons are provided in Table 4-13.

Table 4-13 Rules and thresholds used to define the seasons for EWR Site BM2



Key summary statistics for the naturalised and baseline hydrology at EWR Site BM2: Black Mfolozi River, are provided in Table 4-14, Figure 4-5 and Table 4-15. Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-14 Key summary statistics for EWR Site BM2

Comparison	Units	BASE2014	NAT
MAR	MCM	78.0	96.2
Dry onset	weeks	12	14
Dry duration	days	245	223
Dry season min 5-day	m^3/s	0.039	0.078
Dry season volume	MCM	0.035	0.047
1:2	m^3/s	39.0	51.9
1:5	m^3/s	85.6	90.9
1:10	m^3/s	167.2	229.0

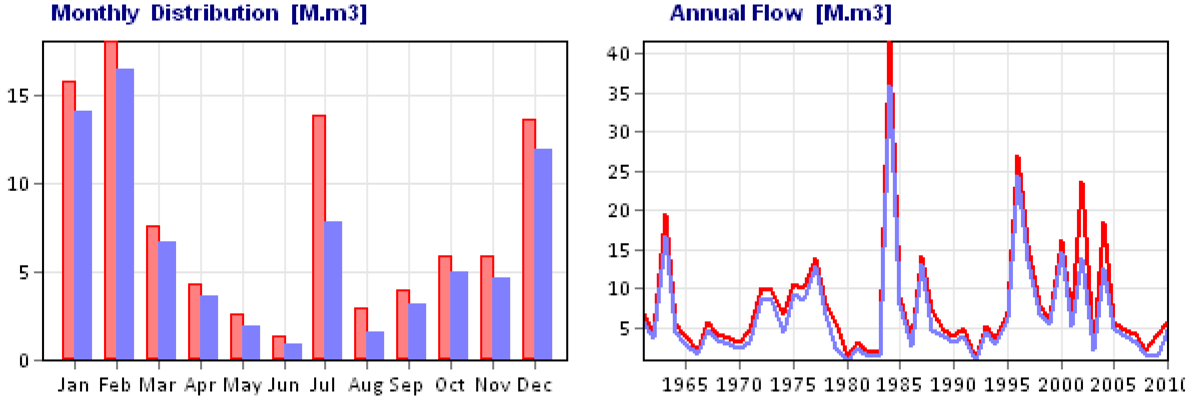


Figure 4-5 Monthly and annual flow volumes for EWR Site BM2: baseline (blue) and naturalised (red)

Table 4-15 Monthly distributions of Class 1-4 flood events at EWR Site BM2: baseline and naturalised

Base2014 Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4
January	0.26	0.50	0.46	0.12
February	0.26	0.26	0.40	0.16
March	0.22	0.26	0.22	0.12
April	0.20	0.16	0.08	0.02
May	0.06	0.02	0.04	0.00
June	0.02	0.02	0.00	0.00
July	0.04	0.06	0.02	0.00
August	0.02	0.02	0.02	0.00
September	0.04	0.10	0.04	0.02
October	0.06	0.22	0.16	0.04
November	0.47	0.24	0.12	0.08
December	0.43	0.33	0.41	0.27
Total	2.08	2.18	1.97	0.83

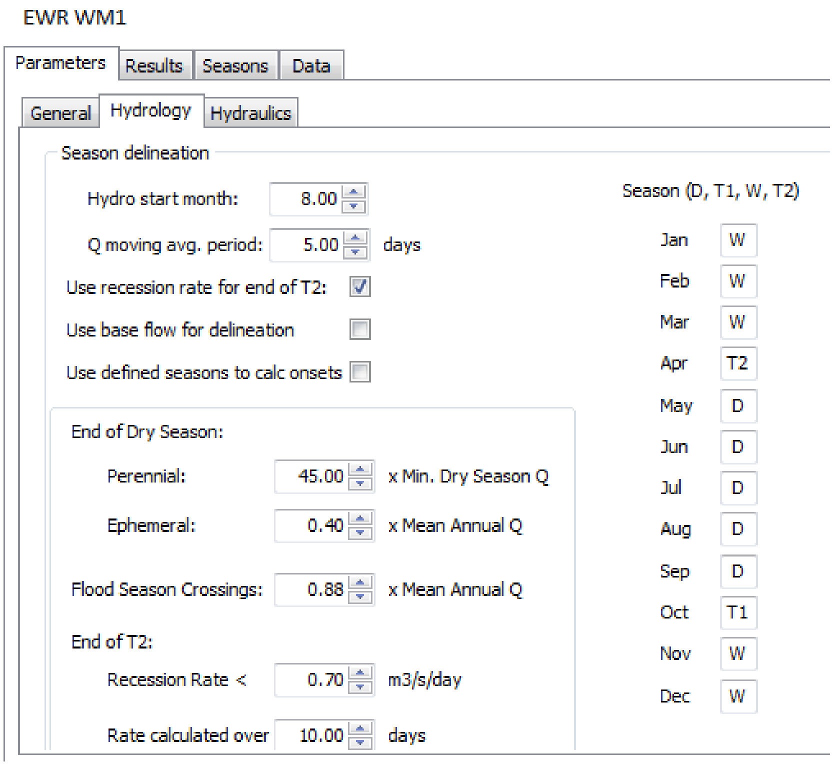
Nat Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4
January	0.26	0.50	0.48	0.14
February	0.24	0.30	0.30	0.20
March	0.24	0.26	0.20	0.12
April	0.20	0.16	0.10	0.02
May	0.06	0.02	0.04	0.00
June	0.04	0.02	0.00	0.00
July	0.06	0.10	0.04	0.02
August	0.04	0.02	0.02	0.00
September	0.10	0.06	0.10	0.04
October	0.12	0.16	0.18	0.06
November	0.41	0.35	0.18	0.10
December	0.37	0.37	0.37	0.29
Total	2.14	2.32	2.00	0.99

Flood classes	Lower	Upper
CLASS 1	2 m3/s	4 m3/s
CLASS 2	4 m3/s	9 m3/s
CLASS 3	9 m3/s	18 m3/s
CLASS 4	18 m3/s	35 m3/s

4.7 EWR Site WM1: White Mfolozi River

The rules and thresholds used to define the seasons are provided in Table 4-16.

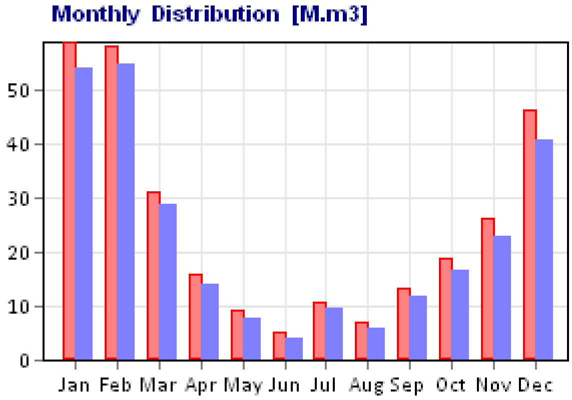
Table 4-16 Rules and thresholds used to define the seasons for EWR Site WM1



Key summary statistics for the naturalised and baseline hydrology at EWR Site WM1: White Mfolozi River, are provided in Table 4-17, Figure 4-6 and Table 4-18. Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-17 Key summary statistics for EWR Site WM1

Comparison	Units	BASE2014	NAT
MAR	MCM	271.3	300.4
Dry onset	weeks	9	10
Dry duration	days	266	244
Dry season min 5-day	m^3/s	0.339	0.362
Dry season volume	MCM	0.189	0.213
1:2	m^3/s	131.0	133.2
1:5	m^3/s	245.0	258.4
1:10	m^3/s	413.3	413.0



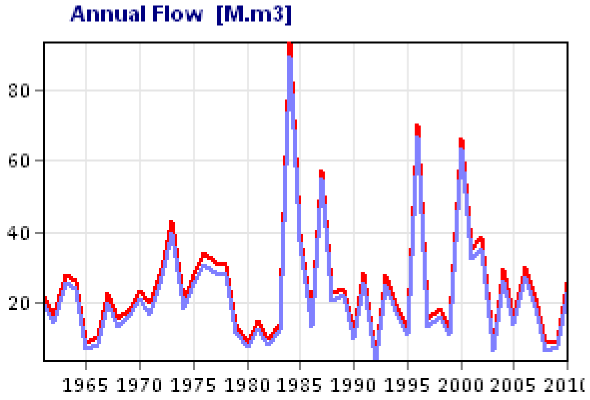


Figure 4-6 Monthly and annual flow volumes for EWR Site WM1: baseline (blue) and naturalised (red)

Table 4-18 Monthly distributions of Class 1-4 flood events at EWR Site WM1: baseline and naturalised

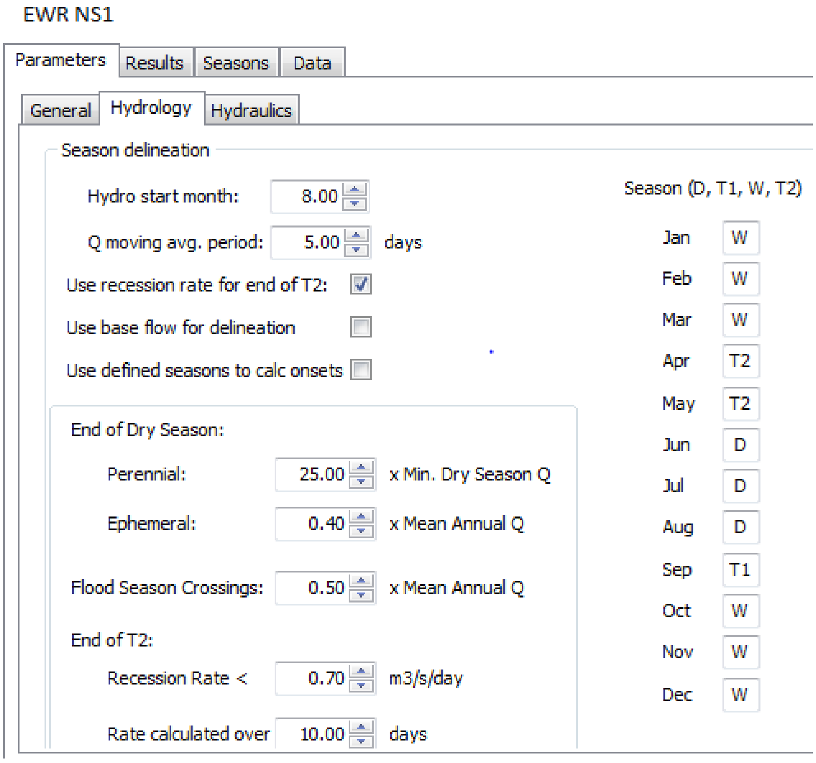
Base2014 Monthly Distribution [#/annum]						**Nat** Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4			Class 1	Class 2	Class 3	Class 4
January	0.36	0.74	0.50	0.38		January	0.46	0.64	0.66	0.36
February	0.34	0.48	0.28	0.30		February	0.34	0.50	0.28	0.32
March	0.30	0.32	0.34	0.04		March	0.30	0.34	0.34	0.04
April	0.16	0.10	0.10	0.02		April	0.22	0.10	0.10	0.02
May	0.02	0.04	0.02	0.00		May	0.02	0.02	0.04	0.00
June	0.02	0.02	0.00	0.00		June	0.02	0.02	0.00	0.00
July	0.04	0.04	0.02	0.00		July	0.00	0.06	0.04	0.00
August	0.04	0.04	0.04	0.02		August	0.04	0.04	0.02	0.04
September	0.06	0.10	0.06	0.02		September	0.10	0.08	0.08	0.04
October	0.18	0.10	0.16	0.06		October	0.16	0.16	0.20	0.06
November	0.37	0.33	0.16	0.14		November	0.43	0.33	0.22	0.22
December	0.35	0.61	0.71	0.18		December	0.33	0.55	0.84	0.22
Total	2.24	2.92	2.38	1.15		Total	2.42	2.84	2.81	1.31

Flood classes	Lower	Upper
CLASS 1	7 m3/s	15 m3/s
CLASS 2	15 m3/s	29 m3/s
CLASS 3	29 m3/s	59 m3/s
CLASS 4	59 m3/s	118 m3/s

4.8 EWR Site NS1: Nseleni River

The rules and thresholds used to define the seasons are provided in Table 4-19.

Table 4-19 Rules and thresholds used to define the seasons for EWR Site NS1



Key summary statistics for the naturalised and baseline hydrology at EWR Site NS1: Nseleni River, are provided in Table 4-20, Figure 4-7 and Table 4-21. Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-20 Key summary statistics for EWR Site NS1

Comparison	Unit	BASE2014	NAT
MAR	MCM	31.3	32.1
Dry onset	weeks	14	14
Dry duration	days	214	213
Dry season min 5-day	m^3/s	0.028	0.029
Dry season volume	MCM	0.022	0.023
1:2	m^3/s	16.3	17.6
1:5	m^3/s	57.4	59.6
1:10	m^3/s	130.8	131.6

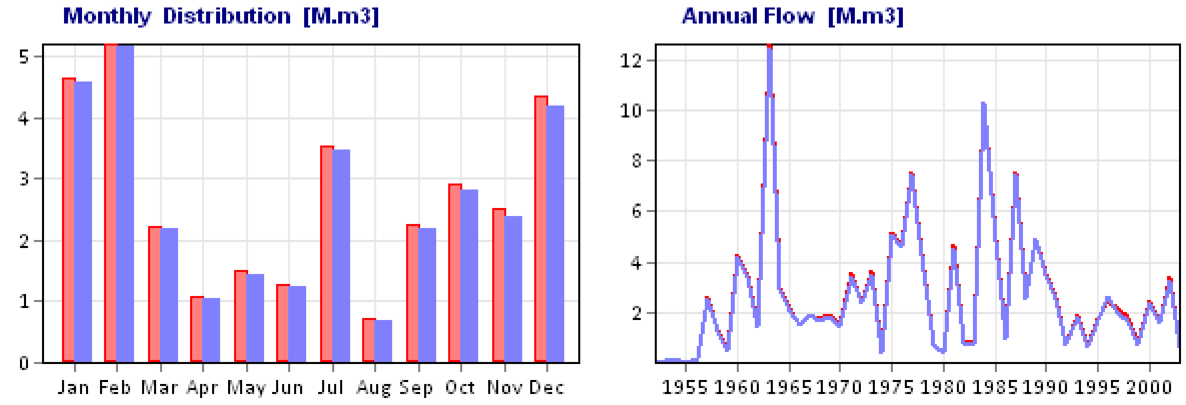


Figure 4-7 Monthly and annual flow volumes for EWR Site NS1: baseline (blue) and naturalised (red)

Table 4-21 Monthly distributions of Class 1-4 flood events at EWR Site NS1: baseline and naturalised

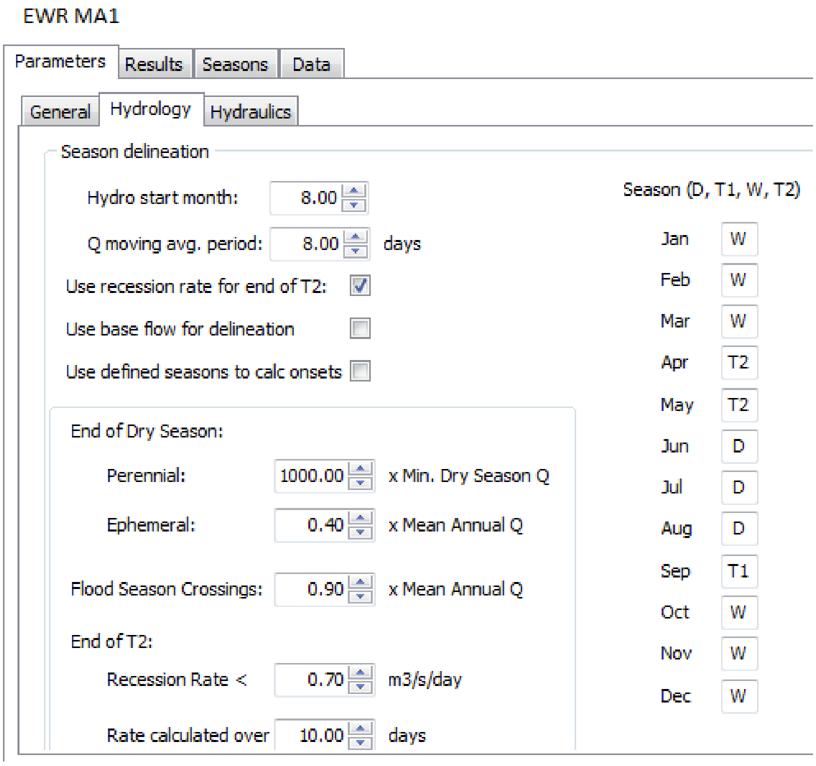
Base2014 Monthly Distribution [#/annum]						**Nat** Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4			Class 1	Class 2	Class 3	Class 4
January	0.28	0.42	0.11	0.17		January	0.28	0.42	0.13	0.15
February	0.26	0.25	0.23	0.21		February	0.23	0.26	0.25	0.21
March	0.25	0.32	0.26	0.08		March	0.21	0.36	0.26	0.08
April	0.19	0.34	0.02	0.04		April	0.19	0.32	0.04	0.04
May	0.08	0.09	0.02	0.04		May	0.08	0.09	0.02	0.04
June	0.02	0.08	0.06	0.04		June	0.02	0.06	0.06	0.04
July	0.15	0.11	0.02	0.00		July	0.15	0.11	0.02	0.00
August	0.06	0.09	0.07	0.02		August	0.04	0.11	0.06	0.04
September	0.11	0.09	0.06	0.09		September	0.11	0.09	0.06	0.09
October	0.26	0.19	0.19	0.09		October	0.26	0.19	0.15	0.13
November	0.34	0.43	0.13	0.04		November	0.30	0.45	0.13	0.06
December	0.36	0.38	0.43	0.09		December	0.38	0.34	0.42	0.13
Annual Total	2.36	2.79	1.60	0.90		Annual Total	2.24	2.81	1.58	1.00

Flood classes	Lower	Upper
CLASS 1	1 m3/s	2 m3/s
CLASS 2	2 m3/s	4 m3/s
CLASS 3	4 m3/s	7 m3/s
CLASS 4	7 m3/s	15 m3/s

4.9 EWR Site MA1: Matigulu River

The rules and thresholds used to define the seasons are provided in Table 4-22Table 4-4.

Table 4-22 Rules and thresholds used to define the seasons for EWR Site MA1



Key summary statistics for the naturalised and baseline hydrology at EWR Site MA1: Matigulu River, are provided in Figure 4-8 and Table 4-24 Additional hydrological information, and details of the data synthesis, is given in the Hydrology Report.

Table 4-23 Key summary statistics for EWR Site MA1

Comparison	Units	BASE2014	NAT
MAR	MCM	81.4	85.3
Dry onset	weeks	20	21
Dry duration	days	237	235
Dry season min 5-day	m^3/s	0.211	0.260
Dry season volume	MCM	0.070	0.076
1:2	m^3/s	38.3	39.3
1:5	m^3/s	120.7	121.6
1:10	m^3/s	322.6	327.5

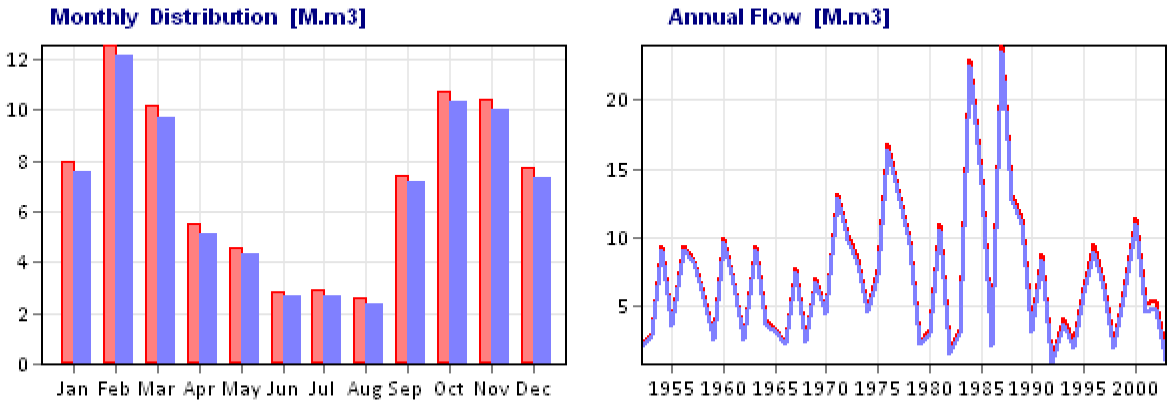


Figure 4-8 Monthly and annual flow volumes for EWR Site MA1: baseline (blue) and naturalised (red)

Table 4-24 Monthly distributions of Class 1-4 flood events at EWR Site MA1: baseline and naturalised

Base2014 Monthly Distribution [#/annum]						**Nat** Monthly Distribution [#/annum]				
	Class 1	Class 2	Class 3	Class 4			Class 1	Class 2	Class 3	Class 4
January	0.28	0.34	0.21	0.11		January	0.21	0.4	0.19	0.13
February	0.25	0.32	0.34	0.13		February	0.32	0.3	0.4	0.13
March	0.32	0.34	0.3	0.25		March	0.34	0.38	0.3	0.26
April	0.21	0.28	0.17	0.08		April	0.25	0.32	0.19	0.08
May	0.15	0.11	0.02	0.06		May	0.15	0.09	0.04	0.06
June	0.06	0.04	0.02	0.04		June	0.04	0.06	0.02	0.04
July	0.08	0	0.04	0.02		July	0.08	0.02	0.04	0.02
August	0.19	0.19	0.02	0.04		August	0.15	0.19	0.06	0.04
September	0.31	0.15	0.04	0.06		September	0.35	0.15	0.04	0.06
October	0.25	0.43	0.23	0.26		October	0.26	0.47	0.21	0.28
November	0.43	0.72	0.45	0.13		November	0.45	0.72	0.47	0.13
December	0.45	0.32	0.19	0.09		December	0.4	0.4	0.19	0.09
Total	2.97	3.24	2.02	1.26		Total	2.99	3.48	2.13	1.32

Flood classes	Lower	Upper
CLASS 1	2 m3/s	4 m3/s
CLASS 2	4 m3/s	9 m3/s
CLASS 3	9 m3/s	17 m3/s
CLASS 4	17 m3/s	34 m3/s

5 ECOCLASSIFICATION, ECOLOGICAL SENSITIVITY AND IMPORTANCE, AND THE RECOMMENDED AND ALTERNATIVE ECOLOGICAL CATEGORIES

This section summarises the outcome of the discipline-specific Ecoclassification (Present Ecological Status; PES) and Ecological Importance and Sensitivity assessments (EIS), which are provided in Volume 2.

5.1 Present Ecological Status and Ecological Importance and Sensitivity

The PES and EIS of each of the EWR sites is provided in Table 5-1.

Table 5-1 PES of each of the EWR sites

River	Site	PES	EIS
Assegaai	AS1	C	Moderate
Upper Pongola	UP1	C	Moderate
Mkuse	MK1	C	Moderate
Black Mfolozi	BM1	C	Moderate
Black Mfolozi	BM2	C	Moderate
White Mfolozi	WM1	B/C	High
Nseleni	NS1	C	Moderate
Matigulu	MA1	B/C	Moderate

With the exception of EWR Site AS1, the bulk of the reasons provided for the decline in condition from natural were non-flow related.

5.2 Recommended and alternative ecological categories

The recommended and alternative ecological categories for each of the EWR sites are provided in Table 5-2. These are based solely on ecological considerations.

In accordance with the requirements of the NWRCS, EWRs were determined for (at minimum) a B; C and D EC to facilitate extrapolation of the results from the Intermediate EWR site to the NWRCS nodes in the catchment.

Table 5-2 The recommended and alternative ecological categories (EC) for each of the EWR sites

River	Site	REC	AEC1	AEC2	AEC3
Assegaai	AS1	C	B	D	-
Upper Pongola	UP1	C	B	D	-
Mkuse	MK1	C	B	D	-
Black Mfolozi	BM1	C	B	D	-
Black Mfolozi	BM2	C	B	D	-
White Mfolozi	WM1	B/C	B	C	-
Nseleni	NS1	C	B	D	-
Matigulu	MA1	B/C	B	C	D

6 DRIFT INDICATORS

6.1 Hydrological and hydraulic indicators

The flow and hydraulic indicators calculated are provided in Table 6-1. The relevant site specific hydrological summaries: naturalised and baseline are provided in Section 4.

Table 6-1 Flow and hydraulic indicators calculated for the baseline and scenario hydrology

Discipline	Indicators
Hydrology	Mean annual runoff
	Dry season onset
	Dry season minimum 5-day discharge
	Dry season duration
	Dry season average daily volume
	Wet season onset
	Wet season maximum 5-day discharge
	Wet season duration
	Wet season flood volume
	Wet season within day range in discharge
	Wet season maximum instantaneous discharge
	Wet season minimum instantaneous discharge
	Transition 2 average daily volume
	Transition 2 recession shape (slope of decrease in flow)
Hydraulics	Minimum 5-day dry season fish breeding habitat[1]
	Depth
	Minimum 5-day average velocity (across the cross-section)
	Seven fish habitat classes (combinations of velocity and depth; see Volume 3)
	Six macroinvertebrate classes (combinations of velocity and substrate; see Volume 3)

6.2 Biophysical indicators

In addition to the flow indicators provided in Section 6.1, DRIFT makes use of a series of biophysical indicators to capture the response to the river ecosystem to flow change. The indicators used in this assessment are listed in (Table 6-2).

[1] Fish breeding habitat was the number of meters of the cross-section where depth is between X and X m, and velocity is between 0 and 0.5 m^3s^{-1}.

Table 6-2 Biophysical indicators used in the DRIFT DSS

Discipline	Indicators	EWR sites							
		AS1	UP1	NS1	MK1	BM1	BM2	WM1	MA1
Geo-morphology	Channel width	All							
	Extent of cut banks								
	Secondary channels								
	Pool depth								
	Bed sediment conditions								
	Inundated floodplain				X				
Water quality	Summer water Temperature	All							
	Dissolved oxygen								
	Nutrients - phosphates								
	Nutrients - nitrogen								
	Electrical conductivity (salinity)								
	Sulphates								
Riparian vegetation	Algae	All							
	Marginal zone graminoids								
	Marginal zone trees								
	Lower zone graminoids								
	Lower zone trees								
	Upper zone / bank trees (riparian)								
	Upper zone / bank trees (terrestrial)								
Macro-invertebrates	Atyidae (Freshwater Shrimps)	X				X			
	Palaemonidae (Freshwater Prawns)					X	X	X	X
	Perlidae (Stoneflies)	X	X			X	X		X
	Hydropsychidae (Caddisflies)	X	X	X		X	X	X	X
	Heptagenaidae (Flatheaded mayflies)	X	X			X	X	X	
	Elmidae (Riffle beetles)			X					X
	Gomphidae (Clubtails)	X	X		X	X	X	X	X
	Leptophlebidae (Pronggills)	X	X	X		X	X	X	X
	Baetidae (Minnow mayflies)	X	X	X	X	X	X	X	X
	Chironomidae (Midges)	X	X	X	X	X	X	X	X
	Simulidae (Blackflies)	X	X	X	X	X	X	X	X
	Coenagrionidae (Sprites and Blues)		X	X	X		X	X	X
Fish	*Amphilius uranoscopus*	X	X			X	X	X	
	Oreochromis mossambicus		X	X	X	X	X	X	X
	Labeo molybdinus					X	X	X	
	Labeobarbus marequensis	X	X						
	Labeobarbus natalensis			X	X	X	X	X	X
	Barbus trimaculatus	X	X				X		
	Barbus paludinosus			X	X				X
	Barbus eutenia					X			
	Glossobius callidus			X					X
	Anguilla mossambica			X					X
	Varicorhinus nelspruitensis	X	X						
	Brycinus lateralis				X				

Response curves were then compiled that described the relationships between the driving (flow/hydraulics) and responding (biophysical) indicators. In some cases, indicators responded indirectly to flow changes through an intermediary influence. Fish, for instance, might be responding directly to pool depth or nutrient levels, which in turn might be driven by changes in a flow indicator(s). These intermediaries reflect that flow may not be the only driver used in a response curve. The full system of links between driver and responding indicators is a complex web of response curves within the DRIFT DSS.

Each response curve describes the expected impact of a change in a single flow or other driving indicator on the abundance of a single responding biophysical indicator, using a response scale of 0 (no response) to 5 (critically high response). A change in flow could thus be followed through various linked indicators to a change in river condition. The ratings of change were also converted to percentages for use in some meetings and reports. In total, >200 response curves were created per site for the project and housed in the Usuthu-Mthlatuze DRIFT DSS.

In the DSS, for each site and scenario, each year's value for a driving indicator is linked with each response curve that employs that driver and the corresponding value of the responding indicator is recorded. An indicator such as Dry Season Onset, for instance, would have 52 values from a 52-year simulated flow regime of the calendar week in which the onset occurred. Through a response curve, this would produce 52 annual values for the predicted abundance of, for instance, the indicator '*Labeobarbus natalensis'*.

The scores from all the response curves for any one indicator were combined in various ways, so that measures of change could be expressed as time-series per indicator, per discipline, or as overall ecosystem integrity. For the latter, results were provided on a scale of A to E, where A represented a pristine ecosystem and E a critically modified one with few, if any, intact ecosystem functions and thus of little value to people (King and Brown 2010).

The DRIFT DSS and process are described in more detail in Appendix A.

6.3 Uncertainty

With contemporary understanding of how river ecosystems function, it has become easier to predict WHAT will change and the DIRECTION of change. It is less easy to predict by HOW MUCH ecosystem components will change and HOW LONG it will take. Recognising this, the indicators are chosen as the WHAT, and the response curves show in which DIRECTION they are expected to change. Predictions of by HOW MUCH each indicator might change are less certain and so are captured using severity ratings; these are broad ranges of change from baseline, which is the 2013/2014 condition (Table 6-3).[2]

2 The HOW MUCH predictions will however be used to inform Resource Quality Objectives (RQOs).

Table 6-3 DRIFT severity ratings and their associated abundances and losses (King and Brown 2010)

Severity rating[3]	Severity of change	% abundance change
5	Critically severe	501% gain to ∞ up to pest proportions
4	Severe	251-500% gain
3	Moderate	68-250% gain
2	Low	26-67% gain
1	Negligible	1-25% gain
0	None	no change (represents Baseline)
-1	Negligible	80-100% retained
-2	Low	60-79% retained
-3	Moderate	40-59% retained
-4	Severe	20-39% retained
-5	Critically severe	0-19% retained includes local extinction

The incoming flow regime for any chosen scenario/site accesses the response curves and produces a prediction of change for each indicator and for the ecosystem as a whole. Although these are given by the DSS as precise numbers, they are best interpreted through a search for broad trends of change. In Table 3.7, for instance, one would expect: all but indicator 2 to decrease in abundance from the 2013 condition; indicators 1, 6, 7 and 8 to show more change than the others; and Scenarios 1 and 2 to have the most impact on the river while Scenario 3 has the least impact.

HOW LONG BEFORE CHANGE STARTS is addressed through the DRIFT time-series, which depict baseline conditions and future change over the span of years used in the hydrological simulations (in the case of the rivers in this study, the 52 years from 1960 to 2012). These prediction of onset of change are based on past climate conditions, and so may differ in reality, depending on future climatic conditions.

Table 3.7 Example of depicting trends: the mean percentage changes, relative to 2013, of eight ecosystem indicators under four development scenarios

Indicator	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Percentage change				
1	0	-50	-50	-33	-33
2	0	19.0	19.0	6.1	14.2
3	0	-21.2	-20.0	-2.3	-6.4
4	0	-15.1	-15.0	1.0	0
5	0	-2.3	-3.3	0	-1.6
6	0	-49.7	-48.2	-7.2	-17.8
7	0	-79.5	-78.2	-13.6	-35.9
8	0	-65.5	-62.8	-9.4	-28.4

[3] A negative score is a loss in abundance relative to Baseline, a positive is a gain. Zero severity is the Baseline situation.

6.4 Weightings

For the discipline-specific Integrity values, most indicators were equally weighted. The exceptions were in situations where an indicator was excluded from the calculations. Details are available in the DRIFT DSS.

In calculating the Overall Integrity values for each scenario, all disciplines were weighted equally, except for water quality, which was down-weighted because of the difficulties in predicting flow-related water quality changes in a context where other aspects have a far greater influence over the water quality than does flow, e.g., mining.

7 SCENARIOS EVALUATED

The Baseline2014 and Naturalised scenarios were described in Section 4.

In terms of other scenarios evaluated, there were essentially two kinds:

1. Synthetic EWR scenarios constructed to represent hypothetical flow regimes between baseline and naturalised flow regimes, and between baseline and zero flow at each relevant EWR site.
2. Operational scenarios that represent a realistic reflection of potential future water demand in the relevant river.

The Synthetic EWR scenarios were used to set an initial recommended EWR for different ecological conditions at the relevant EWR site.

The second set was used to evaluate whether or not the initial EWRs could be met taking into account the future water-resource developments and the ecological implications of future water-resource developments, if any.

The initial EWRs for each EWR site were reviewed in the light of the results from the operational scenarios and adjustments were made where appropriate.

Note: The volumetric summaries for all the scenarios INCLUDE the volume of water associated with floods with a return period of 1:2 years and greater. As per RDM convention, the EWRs suggested for the Preliminary RESERVE (Section 16) are provided EXCLUDING the volume of water associated with these floods. However, the assumption is that they will occur.

7.1 Synthetic EWR scenarios

Synthetic EWR scenarios represent a range of hypothetical flow changes in a system designed to assist the specialists in assessing the appropriateness of their indicators' responses. For instance, some scenarios may reflect a situation of continuous drought and others of excessively high baseflow. Some may have higher flows than baseline (but less than naturalised), etc. Synthetic scenarios are used in one of two ways:

1. a wide range of (possibly unrealistic) scenarios are provided to the specialists to facilitate calibration, and thereafter;
2. a range of (realistic) flow regimes, that could represent EWRs for maintaining the river ecosystem at different levels of integrity, are evaluated using the DSS. The EWRs for different categories in the Operational scenarios were selected from these.

In general, the first set of synthetic scenarios was compiled as follows:

SSmin: Lowflows restricted to the 99th percentile of Base2014.
SS1: Lowflows restricted to the 95th percentile of Base2014.
SS2: Lowflows restricted to the 90th percentile of Base2014.
SS3: Lowflows restricted to the 80th percentile of Base2014.
SS3a: Lowflows restricted to the 70th percentile of Base2014.
SS4: Lowflows restricted to the 50th percentile of Base2014.
SS4a[4]: Lowflows restricted to 30th percentile of Base2014.
SS4b[5]: Lowflows restricted to 20th percentile of Base2014.
SS5: Lowflows greater than Base2014.

Floods were 'added' to the lowflows for each scenario by applying the following rules:

- Class 5 to 8 floods: If the baseline flow was greater than a 1:2 year flow, the flood was added to the lowflow.
- Class 1 to 4 floods: Within year flood frequencies (classes 1 to 4) were generated by interpolating between zero floods (SSMin) and the average number of floods in the baseline scenario at each site. There were three interpolation levels: level 1 correspon-ded with SS1, level 2 with SS2, and level 3 with SS3 (and SS3a). For SS4 (SS4a, and SS4b), the same frequency of floods as the average frequency of Base2014 was applied. In addition, there was one interpolation level between Base2014 and Naturalised, and this frequency of floods was applied to SS5 (see Table 7-1).
- For all scenarios, floods were only added if a flood of a suitable size occurred in the baseline hydrological record for each year. If so, floods were capped at the magnitude of the particular flood class. If not, the baseline flood was added instead (i.e. less than the cap).

Table 7-1 Flood allocations for Class 1 to 4 floods for the synthetic scenarios

0 floods		Level1	Level2	Level3		# floods = average frequency of Baseline		Level1		# floods = average frequency of Naturalised
SSMin		SS1	SS2	SS3, SS3a		SS4, SS4a, SS4b		SS5		-

The resulting frequency of all within year floods (i.e. the sum) of the synthetic flow regimes will tend to be less than the target frequency. The effect of applying the criterion (sufficient size of baseline flow) each year and of capping floods at either the flood class size or the baseline flow will tend to reduce the number of the larger floods and increase the frequency of the smaller floods. The resulting overall flood frequencies are given in Table 7-2. Note also that difference might arise between scenarios which had the same flood allocation (e.g. SS4, 4a and 4b), due to differences in "clicking" off the floods in the DRIFT-DSS.

[4] Where applicable.
[5] Where applicable.

Table 7-2 Average flood frequencies for the synthetic scenarios

Site	Flood Class	Base-2014	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	SS4a	SS4b	SS5
AS1	C1	4.98	1.81	0.00	0.72	1.63	2.89	2.89	1.91	3.80	3.70	5.85
	C2	5.54	4.31	0.00	0.87	1.83	2.87	2.87	2.93	6.11	6.07	8.11
	C3	4.87	5.93	0.02	0.81	1.81	2.69	2.69	2.54	4.31	4.31	4.09
	C4	2.22	4.91	0.13	0.15	1.02	1.02	1.02	1.65	1.48	1.48	1.46
UP1	C1	2.31	2.59	0.00	0.00	1.02	1.09	1.09	2.48			
	C2	6.17	6.56	0.00	0.98	2.93	3.87	3.87	5.93			
	C3	4.93	5.56	0.00	0.98	2.17	3.11	3.11	4.91			
	C4	1.96	2.89	0.09	0.06	0.81	0.81	0.81	1.48			
MK1	C1	1.67	2.20	0.00	1.23	1.82	1.16	1.16	2.25	4.47		
	C2	2.98	2.94	0.00	21.20	1.88	1.94	1.94	2.84	2.76		
	C3	2.20	2.14	0.00	0.92	0.92	1.16	1.16	1.76	1.76		
	C4	1.18	1.18	0.00	0.00	0.00	0.55	0.55	0.55	0.55		
BM1	C1	1.10	0.88	0.00	0.04	0.04	1.04	1.04	1.33			
	C2	1.76	1.71	0.00	1.04	1.06	1.29	1.29	2.18			
	C3	1.49	1.86	0.00	0.92	0.90	0.94	0.94	1.43			
	C4	1.02	1.16	0.00	0.00	0.00	0.63	0.63	0.63			
BM2	C1	1.25	1.06	0.00	0.04	1.04	1.04	1.06	1.31	5.53		
	C2	2.06	2.39	0.00	1.00	1.08	1.08	1.08	2.10	2.10		
	C3	2.18	2.31	0.00	0.94	1.14	1.14	1.12	1.73	1.73		
	C4	1.31	1.37	0.00	0.00	0.65	0.65	0.65	0.65	0.65		
WM1	C1	2.22	2.39	0.00	0.00	1.04	1.04	1.04	2.18	3.43		
	C2	2.88	2.80	0.00	1.00	1.02	2.02	2.04	2.94	2.86		
	C3	2.35	2.78	0.00	0.00	0.96	1.14	1.12	1.88	1.80		
	C4	1.14	1.29	0.00	0.00	0.00	0.71	0.71	0.71	0.75		
NS1	C1	2.31	2.20	0.00	0.09	0.87	1.30	1.30	2.20	2.13		
	C2	2.74	2.76	0.00	0.81	0.94	1.80	1.80	2.48	2.52		
	C3	1.57	1.56	0.00	0.00	0.65	0.78	0.78	1.22	1.20		
	C4	0.89	0.98	0.06	0.06	0.00	0.50	0.50	0.06	0.06		
MA1	C1	2.93	2.94	0.00	0.98	1.17	2.17	2.17	3.07			
	C2	3.19	3.43	0.00	0.89	1.09	1.83	1.83	2.67			
	C3	1.98	2.09	0.07	0.00	0.93	0.93	0.93	1.54			
	C4	1.24	1.30	0.41	0.13	0.65	0.65	0.65	0.54			

The results for selected Synthetic Scenarios are provided in Sections 8 to 15.

The preliminary Reserves (Section 16) were only set AFTER consideration of their implications for future water-resource developments and any adjustments that could be made to reduce potential conflicts.

7.2 Operational scenarios

The operational scenarios evaluated are described in full in the Scenario Report (RDM/WMA6/CON/COMP/0313). The demands considered in the operational scenarios for each EWR site are summarised in Table 7-3 to Table 7-18.

One important consideration was that flow sequences for the baseline scenarios changed when the operational scenarios were run, i.e., they differed from the Base2014 hydrology presented in Section 4 (see Table 7-3, Table 7-5, Table 7-7, Table 7-9, Table 7-11, Table

7-13, Table 7-15 and Table 7-17). These hydrological modelling changes were done post calibration of the DRIFT DSS, and so it was not possible to re-calibrate using the new baselines. Instead, they were run as scenarios, and their relative positions in the DRIFT category diagrams were used to inform the final selection of the EWRs recommended for maintaining REC and AEC. This is discussed individual, and where relevant, in the results sections for each EWR sites (see Sections 8 to 15).

Table 7-3 Baseline land-use and water demands for operational scenarios at AS1

Quat	Afforestation (km^2)	IAPs (km^2)	Irrigation Area (km^2)	Domestic Demands ($10^6\ m^3$)	Inter-Basin Transfer for Eskom ($10^6\ m^3$)	Dam Capacity ($10^6\ m^3$)
W51A	52	8.8	16.8	0	0	3.8
W51B				1.42	64.2	454
W51C	430	0	3.9	0	0	0
W51D				3.1	0	1.16
Total	482	8.8	20.7	4.52	0	458.96

#: The latest existing configuration of the WRYM model for the Usutu-Pongola System, inherited from the PRIMA IAAP 10 Study (TPTC, 2011), is based on these land-use and water demand values.

Table 7-4 Main land-use, water demands and operational features of AS1 operational scenarios

Item	Baseline variations		Scenarios						
Hydrology report name	AS1-1A	AS1-1B	AS1-2	AS1-3	AS1-4	AS1-5	AS1-6	AS1-7	AS1-8
DRIFT name	ModVar1	ModVar2	ModVar3	ModVar4	ModVar5	Sc2	Sc3	Sc4	Sc5
With EWRs	No	No	Baseflow only	Heyshope Dam release capped to $10^4\ m^3/s$	Full	Baseflow only	Baseflow only	Baseflow only	Baseflow only
Domestic demands ($10^6\ m^3/a$)	4.5	4.5	4.5	4.5	4.5	7.8 (2040)	6.1 (2040 with 21% WDM)	6.1	6.1
Domestic return flows (%)	40	40	40	40	40	40	40	40	40
Irrigation efficiency	85	85	85	85	85	85	100	100	100
Invasive Alien Plants (km^2)	9	9	9	9	9	9	9	0	0
Afforestation (km^2)	482	482	482	482	482	482	482	482	300
Non-Failure inter-basin transfer for Eskom ($10^6 m^3/a$)	64.2	75.6	64	64	64	62.9	64.9	67.1	68.7
Releases from Heyshope (m^3/s)	0.64 (PRIMA)	0.28 (Actual)	0.64	0.64	0.64	0.64	0.64	0.64	0.64

Table 7-5 Baseline land-use and water demands for operational scenarios at UP1

Quat	Afforestation (km^2)	IAPs (km^2)	Irrigation Area (km^2)	Domestic Demands (10^6 m^3)	Dam Capacity (10^6 m^3)
W42A	15.5	0.8	3.0	0	0
W42B	90.9	0.0	3.6	0	0
W42C	22.0	2.7	1.7	0	0
W42D	209.6	0.0	1.4	1.32	0
W42E u/s UP1	29.1	0.0	1.2	1.93	1.5
W42E d/s UP1	11.2	0.0	0.0	0	0

#: #: The latest existing configuration of the WRYM model for the Usutu-Pongola System, inherited from the PRIMA IAAP 10 Study (TPTC, 2011), is based on these land-use and water demand values.

Table 7-6 Main land-use, water demands and operational features of UP1 operational scenarios

Item	Baseline variation	Scenarios			
Hydrology report name	UP1-1	UP1-2	UP1-3	UP1-4	UP1-5
DRIFT DSS name	ModVar1	Sc2	Sc3	Sc4	Sc5
With EWRs	No	No	No	No	No
Domestic demand (10^6 m^3)	3.3	8.4 (2040)	6.7 (2040 with 20% WDM)	6.7	6.7
Domestic return flows (%)	0	0	0	0	0
Irrigation efficiency (%)	85	85	100	100	100
Alien vegetation (km^2)	3.5	3.5	3.5	0	0
Afforestation (km^2)	367	367	367	367	220
Dam Capacity to meet domestic demand (10^6 m^3)	1.5	4.0	3.5	3.5	3.5

Table 7-7 Baseline land-use and water demands for operational scenarios at MK1

Quaternary Catchment	Afforestation and IAPs (km^2)	Irrigation Area (km^2)	Domestic/Industrial Demands (10^6 m^3)	Dam Capacity (10^6 m^3)
W31A	51.1	3.22	2.33 (Industrial)	6.79
W31B	43.2	1.60	0	1.03
W31C	44.6	1.62	0	0
W31D	51.4	1.56	0	0.79
W31E	0	0.68	0	0
W31F	11.8	18.0	0	2.19
W31G	0	4.0	0	0.47
W31H	0	25.0	3.02 (Domestic)	3.75
W31J	0	1.0	0	0
Total	202.1	56.68	5.35	15.02

Table 7-8 Main land-use, water demands and operational features of MK1 operational scenarios

Item	Baseline variation	Scenarios			
Hydrology report name	MK1-1	MK1-2	MK1-3	MK1-4	MK1-5
DRIFT DSS name	ModVar1	Sc2	Sc3	Sc4	Sc5
With EWRs	No	Yes	No	No	Yes
Domestic demand (10^6 m^3)	3.02	3.02	5.74 (2040)	5.74	5.74
Industrial demand (10^6 m^3)	2.33	2.33	5.16 (2040)	4.02 (2040 with 22% WDM savings)	4.02
Afforestation (km^2)	202.1	202.1	202.1	202.1	202.1
Domestic return flows (%)	35	35	35	35	35
Irrigation (km^2)	56.8	48.76	56.8	56.8	56.8
Irrigation effic.. (incl. distrib. losses) (%)	75	90	75	90	90

Table 7-9 Baseline land-use and water demands for operational scenarios at BM1

Quat	Afforestation and IAPs (km^2)	Irrigation Area (km^2)	Domestic Demands (10^6 m^3)	Dam Capacity (10^6 m^3)
W22A	84.0	2.16	0.13	0.62

Table 7-10 Main land-use, water demands and operational features of BM1 operational scenarios

Item	Baseline variation	Scenarios		
Hydrology report name	BM1-1	BM1-2	BM1-3	BM1-4
DRIFT DSS names	ModVar1	Sc2	Sc3	Sc4
With EWRs	No	Yes	No	Yes
Domestic demand (10^6 m^3)	0.13	0.091 (Curtailed to 70% as basic human needs)	0.31 (2040)	0.217 (2040 - Curtailed to 70% as basic human needs)
Afforestation (km^2)	84.0	84.0	84.0	84.0
Domestic return flows (%)	25	25	25	25
Irrigation efficiency and distribution losses (%)	75	90	75	90

Table 7-11 Baseline land-use and water demands for operational scenarios at BM2

Quat	Afforestation and IAPs (km^2)	Irrigation Area (km^2)	Domestic Demands (10^6 m^3)	Dam Capacity (10^6 m^3)
W22A	84.0	2.16	0.13	0.62
W22B	19.4	0.41	0	0
W22C	12.7	4.77	0	1.3
W22D	0	0	0	0
W22E	187.5	0	0	0
W22F	2.8	0	2.26 (Ceza)	0
W22G	0	0	3.23 (Nongoma)	6.0
Total	306.4	5.34	5.62	7.92

Table 7-12 Main land-use, water demands and operational features of BM2 operational scenarios

Item	Baseline variation	Scenarios			
Hydrology report name	B2M-1	B2M-2	B2M-3	B2M-4	B2M-5
DRIFT DSS names	ModVar1	Sc2	Sc3	Sc4	Sc5
With EWRs	No	Yes	No	No	No
Domestic demand (10^6 m^3)	5.49 (Includes 22% excess losses)	3.85 (Basic human needs)	17.63 (2025 + 22% Excess losses)	21.37 (2040 + 22% Excess losses)	17.52 (2040 with 22% WDM savings)
Afforestation (km^2)	306.4	153.2	306.4	306.4	306.4
Domestic return flows (%)	25	25	25	25	25
Irrigation effic. and distrib. losses (%)	75	90	75	90	90
Vukwana Dam capacity (10^6 m^3)	6	6	20	0	0
New OCS capacity (10^6 m^3)	0	0	0	25	25

Table 7-13 Baseline land-use and water demands for operational scenarios at WM1

Quat	Afforestation and IAPs (km^2)	Irrigation Area (km^2)	Domestic Demands (10^6 m^3)	Dam Capacity (10^6 m^3)
W21A	87.0	1.17	7.51	22.46
W21B	79.0	3.5	0	1.2
W21C	2.9	4.67	0	0.82
W21D	0.6	0	5.17	2.87
W21E	0.4	0	0	0
W21F	3.1	0.32	0	0
W21G	4.8	0	0	0
W21H	2.4	0	0.79	0
W21J	0	0	0	0
W21K	0	0	8.57	0
Total	180.2	8.66	22.04	27.35

Table 7-14 Main land-use, water demands and operational features of WM1 operational scenarios

Item	Baseline variation	Scenarios				
Hydrology report name	WM1-1	WM1-2	WM1-3	WM1-4	WM1-5	WM1-6
DRIFT DSS name	ModVar1	Sc2	Sc3	Sc4	Sc5	Sc6
With EWRs	No	Yes	Yes	No	No	No
Domestic demand (10^6 m^3)	22.04	17.75 (Ulundi demand = 50%)	22.04 (Pipeline from Klipfontein Dam)	62.64 (2040) (No pipeline)	62.64 (2040) (No pipeline)	43.85 (2040 + Curtailed to BHN)
Dam storage (10^6.m^3)	24.83	23.40 (Mvunyana 50% silted)	21.96 (Mvunyana not used)	24.83	39.83 (Klipfontein raised 4m)	39.83 (Klipfontein raised 4m)
Domestic return flows (%)	25	25	25	25	25	25
Irrigation effic. and distrib. losses (%)	75	75	75	75	75	90
Gluckstadt I.S. (km^2)	2.5	1.25	0	2.5	2.5	0
New OCS capacity (10^6 m^3)	0	0	0	0	0	40

Table 7-15 Baseline land-use and water demands for operational scenarios at NS1

Quat	Afforestation (km^2)	IAPs (km^2)	Irrigation Area (km^2)	Domestic Demands (10^6 m^3)	Dam Capacity (10^6 m^3)
W12G	0	21.2	7	0	1.2
W12H	134.4	35.7	21.92	0	6.08

Table 7-16 Main land-use, water demands and operational features of NS1 operational scenarios

Item	Baseline variation	Scenario
Hydrology report name	NS1-1	NS1-2
DRIFT DSS name	ModVar1	Sc4 (This included domestic, irrigation and alien changes
With EWRs	No	No
Domestic demand (10^6 m^3)	0	0
Domestic return flows (%)	0	0
Irrigation efficiency (%)	75	85
Alien vegetation (km^2)	56.9	0
Afforestation (km^2)	134.4	134.4

Table 7-17 Baseline land-use and water demands for operational scenarios at MA1

Quat	Afforestation (km^2)	IAPs (km^2)	Irrigation Area (km^2)	Domestic Demands (10^6 m^3)	Dam Capacity (10^6 m^3)
W11A	8.9	45.4	12	0.06	0.428
W11B	0	6.4	6.4	0	0.142
W11C	13.2	25.8	0	0.39	2.066

Table 7-18 Main land-use, water demands and operational features of MA1 operational scenarios

Item	Baseline variation	Scenarios	
Hydrology report name	MA1-1	MA1-2	MA1-3
DRIFT DSS name	ModVar1	Sc2	Sc3
With EWRs	No	No	No
Domestic demand (10^6 m^3)	0.45	1.59 (2040)	1.26 (2040 with 21% WDM)
Domestic return flows (%)	0	0	0
Irrigation efficiency (%)	85	85	100
Alien vegetation (km^2)	78	78	78
Afforestation (km^2)	22	22	22
Dam capacity to meet demands (10^6 m^3)	2.64	3.0	2.7

8 SCENARIO EVALUATION: EWR SITE AS1 (ASSEGAI RIVER)

River	Site	REC	AEC1	AEC2	AEC3
Assegaai	AS1	C	B	D	-

8.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site AS1 associated with each of the scenarios are summarised in Table 8-1.

8.2 Overall ecosystem integrity

Figure 8-1 (Overall Ecological Integrity for each scenario at EWR Site AS1) shows that the Base2014 ecostatus for EWR Site AS1 is a C category (for details see EWR Ecoclassification Report). The reasons for this are partly flow related and include:

- elevated phosphate levels and possibly also nitrogen;
- reduced flood incidence and flow volumes (MAR);
- trapping of sediments in upstream dam;
- less variability in flow regime and a resultant increased cover and abundance of woody species, and a change in species composition of plant community;
- reduced passage for migratory species of fish.

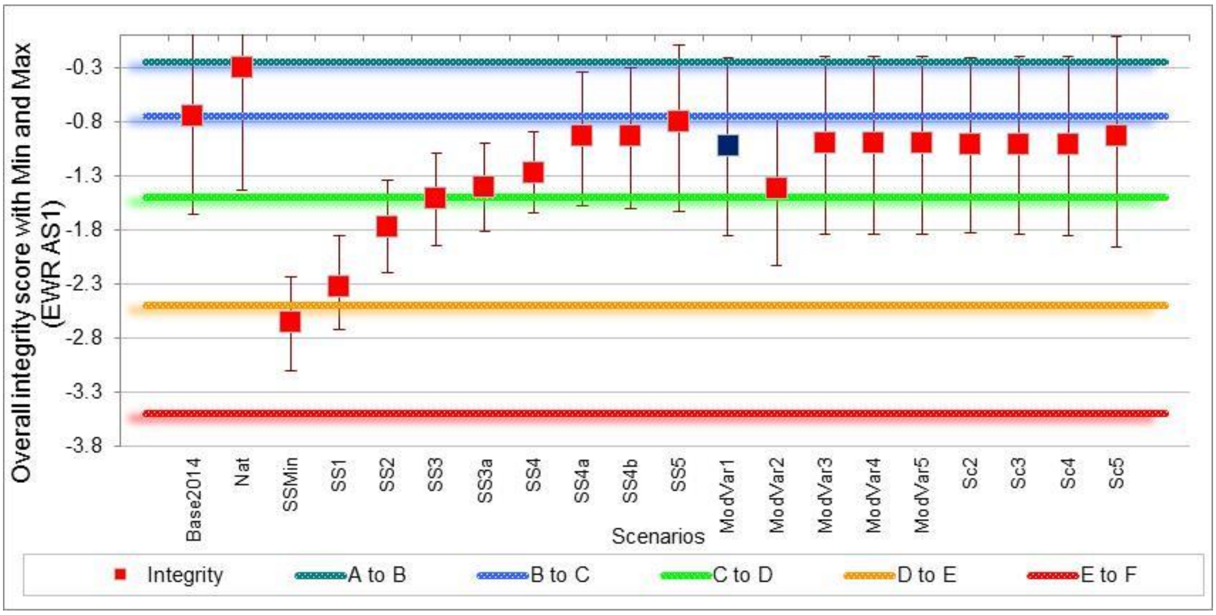


Figure 8-1 Overall ecosystem integrity scores for the scenarios at EWR Site AS1 (Assegaai River).

With this in mind, the results in Figure 8-1 suggest the following:

- SS5, currently a B/C condition, will maintain the river in a B, provided non-flow related impacts on Ecostatus, such as elevated nutrient levels, are addressed.
- SS4, SS4a or SS4b will maintain the river in a C category.
- SS1 or SS2 will maintain the river in a D-category.

In accordance with the precautionary principle, SS4a was selected as the EWR for maintenance of the REC – category C for use in the operational scenarios.

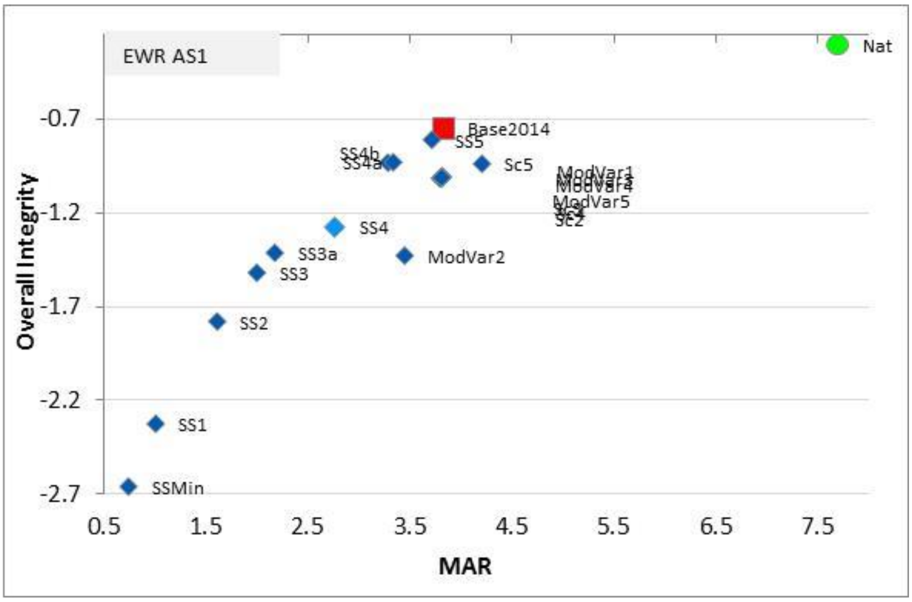


Figure 8-2 Overall ecosystem integrity scores for the synthetic and operational scenarios at EWR Site AS1 (Assegaai River) shown against MAR.

8.3 Identification of EWRs for Reserves

On the basis of the results in Figure 8-1 and Figure 8-2 (Integrity vs. MAR) the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Assegaai	AS1	C	B	D	-
		SS4a	SS5	SS2	-

The details of these are provided in Section 16. A B-category (AEC1) will not be maintained through application of the AEC1 flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 8-1 Characteristics of the flow regimes of the scenarios at EWR Site AS1: Assegaai River. Median values are given for all indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

	Base2014	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	SS4a	SS4b	SS5	ModVar1	ModVar2	ModVar3	ModVar4	ModVar5	Sc2	Sc3	Sc4	Sc5
Mean annual runoff (m^3/s)	3.83	7.69	0.74	1.01	1.61	2.00	2.18	2.76	3.28	3.34	3.72	3.81	3.45	3.82	3.82	3.82	3.79	3.81	3.81	4.21
Dry season Min 5d Q	1.025	1.324	0.30	0.45	0.69	0.73	0.73	0.74	1.01	1.01	1.04	1.01	0.57	1.02	1.02	1.02	1.02	1.02	1.02	1.09
Dry season onset	12.00	22.00	22.00	10.00	9.00	8.50	8.50	10.50	12.50	12.50	12.00	12.50	12.00	12.50	12.50	12.50	12.00	12.50	12.50	13.50
Dry season duration	191.00	104.00	224.0	311.50	304.50	291.50	286.50	267.50	201.00	207.00	205.50	191.50	217.00	191.50	191.50	191.50	191.50	191.50	191.50	179.50
Dry season ave daily vol	0.199	0.185	0.04	0.06	0.10	0.13	0.14	0.16	0.19	0.18	0.20	0.20	0.16	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Wet season Max 5d Q	19.20	48.59	9.30	9.46	12.70	13.18	13.26	16.34	16.92	16.97	16.12	19.15	18.43	19.15	19.15	19.15	19.06	19.12	19.12	21.32
Wet season onset	42.50	40.00	44.00	44.00	46.00	46.00	46.00	45.50	45.00	44.00	44.00	42.50	43.00	42.50	42.50	42.50	42.50	42.50	42.50	42.00
Wet season duration	136.50	231.50	68.50	11.00	35.50	47.50	47.50	77.50	114.00	110.50	122.00	136.00	119.50	136.00	136.00	136.00	135.50	136.00	136.00	144.00
Wet season ave daily vol	0.50	0.91	0.45	0.33	0.55	0.57	0.56	0.48	0.48	0.50	0.51	0.50	0.58	0.50	0.50	0.50	0.50	0.50	0.50	0.54
Flood volume	73.76	213.73	9.03	10.03	18.75	22.57	24.40	40.90	58.43	58.64	67.67	73.46	66.59	73.46	73.46	73.46	73.08	73.35	73.35	83.92
T1 ave daily vol	0.16	0.26	0.00	0.16	0.17	0.22	0.21	0.21	0.16	0.16	0.16	0.16	0.21	0.16	0.16	0.16	0.16	0.16	0.16	0.18
T2 ave daily vol	0.00	0.00	0.04	0.08	0.11	0.16	0.19	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry season Min 5d Depth	0.22	0.25	0.14	0.15	0.19	0.19	0.19	0.19	0.22	0.22	0.22	0.22	0.17	0.22	0.22	0.22	0.22	0.22	0.22	0.23
Dry season Min 5d Velocity	0.34	0.39	0.21	0.23	0.28	0.29	0.29	0.29	0.34	0.34	0.34	0.34	0.26	0.34	0.34	0.34	0.34	0.34	0.34	0.35
Wet season Max 5d Depth	0.75	1.13	0.52	0.58	0.61	0.60	0.61	0.67	0.68	0.68	0.66	0.75	0.73	0.75	0.75	0.75	0.75	0.75	0.75	0.81
Wet season Max 5d Velocity	0.80	0.94	0.74	0.74	0.76	0.77	0.77	0.78	0.78	0.78	0.78	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.82
Wet season Min 5d Velocity	0.39	0.47	0.22	0.53	0.42	0.46	0.48	0.44	0.45	0.45	0.46	0.40	0.45	0.40	0.40	0.40	0.39	0.40	0.40	0.39
MAR-baseflow	2.52	4.81	0.49	0.69	1.07	1.39	1.61	1.96	2.28	2.36	2.72	2.50	2.21	2.51	2.51	2.51	2.49	2.50	2.51	2.76
Dry-Min 5d Q-baseflow	1.03	1.31	0.30	0.45	0.69	0.73	0.73	0.74	1.01	1.01	1.04	1.01	0.57	1.02	1.02	1.02	1.00	1.02	1.02	1.09
Dry-daily ave vol-baseflow	0.18	0.18	0.04	0.06	0.09	0.11	0.13	0.15	0.18	0.18	0.19	0.18	0.14	0.18	0.18	0.18	0.18	0.18	0.18	0.19
Wet-Max 5d Q-baseflow	7.32	16.39	0.69	0.99	1.31	1.88	2.23	3.25	4.60	5.62	7.46	7.30	6.60	7.30	7.30	7.30	7.26	7.28	7.28	8.12
Wet-daily ave vol-baseflow	0.28	0.54	0.05	0.09	0.11	0.15	0.18	0.21	0.26	0.28	0.33	0.28	0.26	0.28	0.28	0.28	0.28	0.28	0.28	0.31
T1-daily ave vol-baseflow	0.12	0.18	0.00	0.04	0.07	0.09	0.11	0.13	0.12	0.12	0.13	0.12	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.12
T2-daily ave vol-baseflow	0.00	0.00	0.04	0.08	0.11	0.16	0.19	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet season max instantaneous Q	37.56	82.32	37.56	37.56	37.56	37.56	37.56	37.56	37.56	37.56	37.56	37.48	36.11	37.48	37.48	37.48	37.32	37.42	37.42	41.75
Wet season min instantaneous Q	1.03	1.68	0.30	0.98	0.86	1.02	1.21	1.34	1.35	1.35	1.35	1.06	1.17	1.06	1.06	1.06	1.05	1.06	1.06	1.05
1:2 Class5	0.96	2.93	1.00	1.00	0.96	1.02	1.02	1.00	0.78	0.78	0.81	0.96	0.91	0.96	0.96	0.96	0.93	0.94	0.94	1.15
1:5 Class6	0.20	0.67	0.20	0.20	0.20	0.22	0.22	0.20	0.13	0.13	0.13	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.22
1:10 Class7	0.04	0.44	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.07
1:20 Class8	0.04	0.19	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.06
Dry Class1	0.78	0.70	0.00	0.00	0.00	0.00	0.00	0.04	0.15	0.17	0.48	0.67	0.76	0.57	0.59	0.57	0.56	0.63	0.63	0.57
Dry Class2	0.54	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.07	0.54	0.30	0.56	0.56	0.56	0.56	0.56	0.56	0.59
Dry Class3	0.11	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.15	0.15	0.15	0.15	0.15	0.15	0.13
Dry Class4	0.07	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.07
T1 Class1	0.54	0.41	0.00	0.07	0.13	0.15	0.15	0.09	0.43	0.39	1.00	0.44	0.54	0.43	0.43	0.43	0.41	0.43	0.44	0.35
T1 Class2	0.52	0.43	0.00	0.02	0.11	0.17	0.17	0.22	0.33	0.33	0.43	0.52	0.41	0.52	0.52	0.52	0.52	0.52	0.52	0.59
T1 Class3	0.30	0.44	0.00	0.07	0.13	0.19	0.19	0.20	0.30	0.30	0.22	0.30	0.24	0.30	0.30	0.30	0.30	0.30	0.30	0.33
T1 Class4	0.11	0.28	0.00	0.00	0.09	0.09	0.09	0.11	0.11	0.11	0.11	0.11	0.09	0.11	0.11	0.11	0.11	0.11	0.11	0.09
Wet Class1	2.70	0.43	0.00	0.63	1.33	2.52	2.52	1.44	2.61	2.52	2.69	2.43	3.00	2.30	2.30	2.30	2.41	2.35	2.35	1.72
Wet Class2	3.87	2.31	0.00	0.78	1.54	2.35	2.35	2.50	5.09	5.15	6.81	3.93	3.76	3.91	3.91	3.91	3.89	3.91	3.91	3.70
Wet Class3	3.94	4.43	0.02	0.70	1.61	2.33	2.33	2.09	3.61	3.61	3.50	3.89	3.48	3.89	3.89	3.89	3.81	3.87	3.85	4.30
Wet Class4	1.83	4.02	0.13	0.15	0.87	0.87	0.87	1.44	1.28	1.28	1.26	1.83	1.78	1.83	1.83	1.83	1.87	1.85	1.87	2.11
T2 Class1	0.96	0.28	0.00	0.02	0.17	0.22	0.22	0.33	0.61	0.63	1.69	1.00	0.96	0.89	0.89	0.89	0.91	0.94	0.96	0.76
T2 Class2	0.61	0.94	0.00	0.07	0.19	0.35	0.35	0.20	0.59	0.59	0.80	0.59	0.61	0.59	0.59	0.59	0.59	0.61	0.63	0.72
T2 Class3	0.52	0.80	0.00	0.04	0.07	0.17	0.17	0.24	0.41	0.41	0.37	0.52	0.44	0.52	0.52	0.52	0.50	0.50	0.50	0.61
T2 Class4	0.20	0.52	0.00	0.00	0.06	0.06	0.06	0.09	0.09	0.09	0.09	0.20	0.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20

9 SCENARIO EVALUATION: EWR SITE UP1 (UPPER PONGOLA RIVER)

River	Site	REC	AEC1	AEC2	AEC3
Upper Pongola	UP1	C	B	D	-

9.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site UP1 associated with each of the scenarios are summarised in Table 9-1.

9.2 Overall ecosystem integrity

Figure 9-1 (Overall Ecological Integrity for the scenarios) shows that the baseline ecostatus for EWR Site UP1 is a C category (for details see EWR Ecoclassification Report). The reasons provided for this are partly flow related and include:

- possible nutrient contamination from nearby residential areas;
- some sand mining, catchment erosion and invasive plant species;
- reduced cover and abundance of woody species, and increased reeds;
- sedimentation resulting in a minor reduction in quality of interstitial habitat, reduced feeding opportunities.

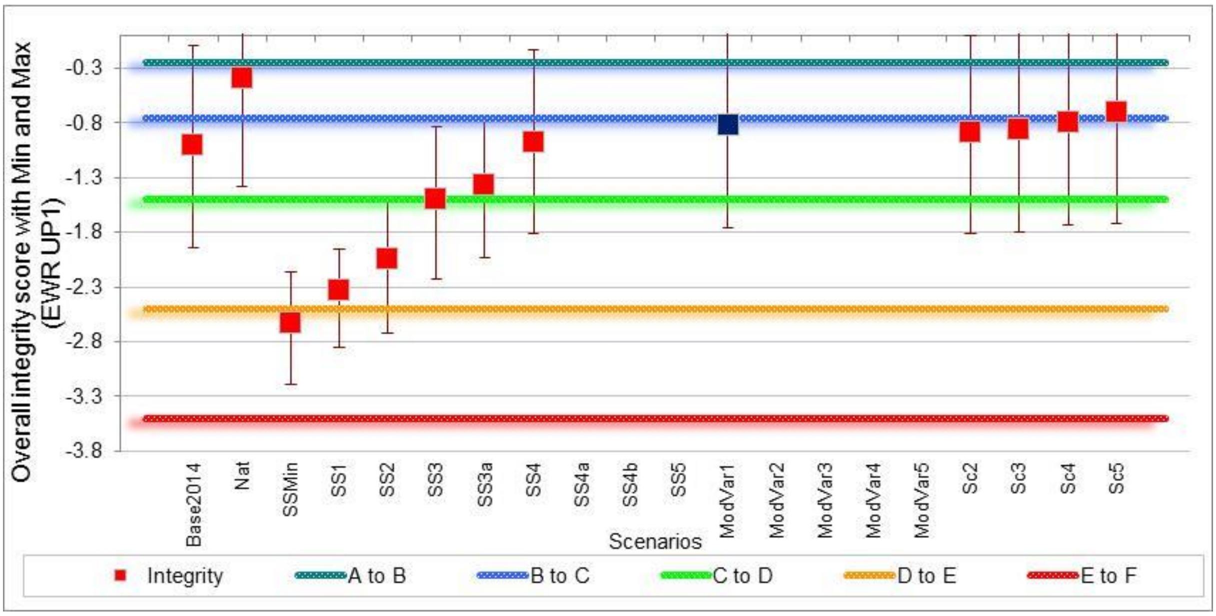


Figure 9-1 Overall ecosystem integrity scores for the scenarios at EWR Site UP1 (Upper Pongola River).

With this in mind, the results in Figure 9-1 suggest the following:

- Sc5 will maintain the river in a B condition, provided some of the non-flow related impacts on Ecostatus, such as elevated nutrient levels, are addressed.
- SS4 will maintain the river in a C category.
- SS1 or SS2 will maintain the river in a D-category.

In accordance with the precautionary principle, SS4 was selected as the EWR for maintenance of the REC – category C for use in the operational scenarios.

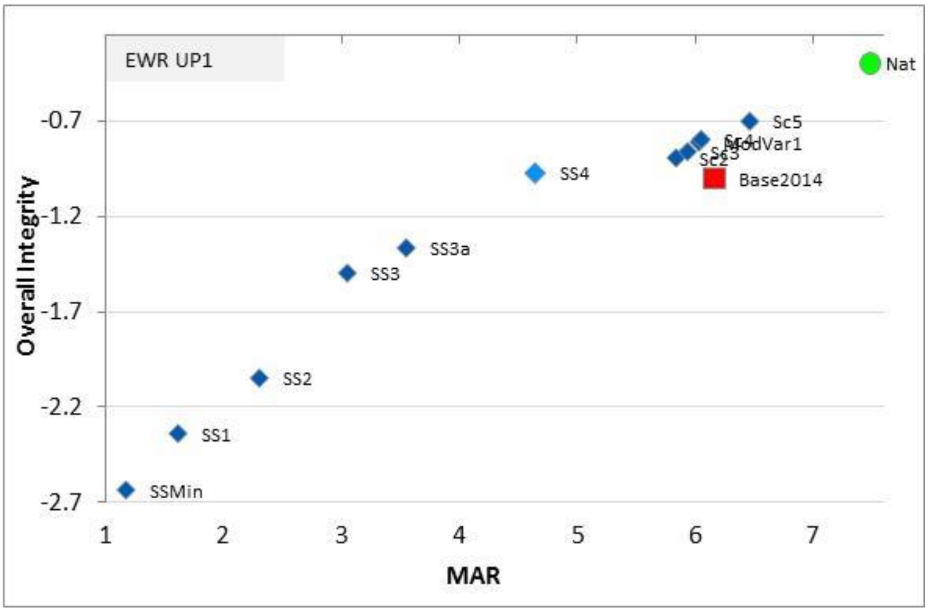


Figure 9-2 Overall ecosystem integrity scores for the synthetic and operational scenarios at EWR Site UP1 (Upper Pongola River) shown against MAR.

9.3 Identification of EWRs for Reserves

On the basis of the results in Figure 9-1 and Figure 9-2 (Integrity vs. MAR), the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Upper Pongola	UP1	C	B	D	-
		SS4	Sc5	SS2	-

The details of these are provided in Section 16. A B-category (AEC1) will not be maintained through application of the AEC1 flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 9-1 Characteristics of the flow regime of each scenario at EWR Site UP1: Upper Pongola River. Median values are given for the flow indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

	Base2014	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	ModVar1	Sc2	Sc3	Sc4	Sc5
Mean annual runoff	6.16	7.48	1.17	1.61	2.30	3.05	3.55	4.64	6.03	5.84	5.93	6.05	6.46
Dry season Min 5d Q	0.52	0.74	0.26	0.26	0.30	0.48	0.48	0.48	0.56	0.52	0.52	0.55	0.61
Dry season onset	12.00	12.50	22.00	11.50	10.00	11.00	11.00	11.00	13.00	13.00	13.00	13.00	13.00
Dry season duration	233.50	209.00	206.00	328.50	305.00	277.50	275.00	274.00	239.00	239.50	239.00	239.00	238.50
Dry season ave daily vol	0.27	0.32	0.06	0.11	0.13	0.17	0.20	0.25	0.28	0.27	0.28	0.27	0.29
Wet season Max 5d Q	41.48	48.87	2.26	12.81	21.72	22.60	22.93	26.45	41.13	40.69	40.82	41.50	44.18
Wet season onset	44.00	43.00	44.00	44.00	46.00	45.50	45.00	45.50	44.00	44.00	44.00	44.00	44.00
Wet season duration	99.50	116.50	151.00	8.00	26.50	36.00	40.50	58.00	96.00	89.00	89.00	96.00	96.50
Wet season ave daily vol	1.30	1.46	0.19	0.71	1.08	1.10	1.05	1.08	1.29	1.27	1.29	1.31	1.38
Flood volume	100.22	133.04	28.54	5.72	28.72	38.84	44.20	62.29	101.44	96.03	97.70	101.97	109.64
T1 ave daily vol	0.47	0.46	0.01	0.59	0.61	0.45	0.45	0.53	0.52	0.57	0.52	0.56	0.47
T2 ave daily vol	0.44	0.46	0.07	0.19	0.22	0.30	0.39	0.51	0.42	0.44	0.42	0.42	0.38
Dry season Min 5d Depth	0.16	0.19	0.13	0.13	0.14	0.15	0.15	0.15	0.17	0.16	0.16	0.17	0.18
Dry season Min 5d Velocity	0.25	0.29	0.21	0.21	0.21	0.24	0.24	0.24	0.26	0.25	0.25	0.26	0.27
Wet season Max 5d Depth	1.03	1.13	0.34	0.57	0.82	0.84	0.85	0.91	1.03	1.02	1.03	1.04	1.07
Wet season Max 5d Velocity	0.91	0.94	0.48	0.76	0.82	0.82	0.83	0.86	0.91	0.91	0.91	0.91	0.92
Wet season Min 5d Velocity	0.56	0.59	0.27	0.73	0.60	0.55	0.60	0.61	0.55	0.55	0.55	0.55	0.56
MAR-baseflow	4.46	5.42	1.16	1.32	1.45	2.02	2.02	3.15	4.23	4.10	4.16	4.26	4.53
Dry-Min 5d Q-baseflow	0.52	0.74	0.26	0.26	0.30	0.48	0.48	0.48	0.56	0.52	0.52	0.55	0.61
Dry-daily ave vol-baseflow	0.24	0.27	0.06	0.11	0.11	0.14	0.14	0.21	0.23	0.22	0.23	0.23	0.24
Wet-Max 5d Q-baseflow	17.21	19.48	2.22	2.20	2.55	3.56	3.58	6.13	14.15	13.95	14.06	14.32	14.94
Wet-daily ave vol-baseflow	0.77	0.85	0.19	0.19	0.22	0.30	0.30	0.48	0.68	0.67	0.68	0.69	0.72
T1-daily ave vol-baseflow	0.32	0.31	0.01	0.19	0.22	0.24	0.24	0.27	0.34	0.33	0.33	0.33	0.34
T2-daily ave vol-baseflow	0.40	0.45	0.07	0.19	0.22	0.30	0.30	0.49	0.38	0.39	0.39	0.39	0.37
Wet season max instantaneous Q	70.09	84.75	2.27	26.39	49.34	49.35	49.35	49.36	70.43	70.08	70.21	71.37	76.02
Wet season min instantaneous Q	2.84	3.43	1.66	2.17	2.50	3.50	3.74	3.04	2.50	2.54	2.47	2.38	2.55
1:2 Class5	0.81	0.98	0.54	0.76	0.81	0.78	0.76	0.85	0.78	0.78	0.78	0.80	0.87
1:5 Class6	0.13	0.15	0.11	0.13	0.13	0.13	0.13	0.13	0.11	0.11	0.11	0.11	0.13
1:10 Class7	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.04	0.04
1:20 Class8	0.04	0.07	0.06	0.04	0.04	0.04	0.04	0.04	0.07	0.06	0.06	0.07	0.07
Dry Class1	0.26	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.22	0.22	0.19	0.19
Dry Class2	0.19	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.19	0.19	0.20	0.19
Dry Class3	0.13	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.11	0.11	0.11	0.13
Dry Class4	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02
T1 Class1	0.20	0.24	0.00	0.00	0.09	0.15	0.15	0.26	0.43	0.44	0.44	0.44	0.37
T1 Class2	0.54	0.61	0.00	0.04	0.22	0.33	0.33	0.48	0.28	0.28	0.26	0.26	0.33
T1 Class3	0.30	0.35	0.00	0.09	0.11	0.19	0.19	0.35	0.30	0.28	0.30	0.28	0.26
T1 Class4	0.17	0.24	0.00	0.04	0.11	0.11	0.11	0.15	0.19	0.19	0.19	0.20	0.24
Wet Class1	1.50	1.61	0.00	0.00	0.87	0.89	0.89	2.06	2.07	2.26	2.09	2.02	1.69
Wet Class2	4.63	4.67	0.00	0.94	2.54	3.30	3.30	5.04	3.98	3.93	3.96	3.96	4.04
Wet Class3	4.15	4.57	0.00	0.87	2.02	2.85	2.85	4.35	3.78	3.63	3.76	3.81	3.89
Wet Class4	1.76	2.54	0.09	0.02	0.70	0.70	0.70	1.33	1.59	1.57	1.57	1.57	1.76
T2 Class1	0.35	0.41	0.00	0.00	0.06	0.06	0.06	0.17	0.56	0.57	0.57	0.56	0.48
T2 Class2	0.81	0.98	0.00	0.00	0.17	0.24	0.24	0.41	0.80	0.78	0.78	0.80	0.87
T2 Class3	0.35	0.48	0.00	0.02	0.04	0.07	0.07	0.20	0.30	0.31	0.31	0.30	0.33
T2 Class4	0.02	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.02

10 SCENARIO EVALUATION: EWR SITE MK1 (MKUZE RIVER)

River	Site	REC	AEC1	AEC2	AEC3
Mkuze	MK1	C	B	D	-

10.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site MK1 associated with each of the scenarios are summarised in Table 10-1

10.2 Overall ecosystem integrity

Figure 10-1 (Overall Ecological Integrity) shows that the baseline ecostatus for EWR Site MK1 is a C category (for details see EWR Ecoclassification Report). The reasons provided for this are partly flow related and include:

- elevated nutrients, EC and sulphates.
- reduced cover and abundance of woody species.
- sedimentation resulting in reduced quality of aquatic and floodplain habitats.

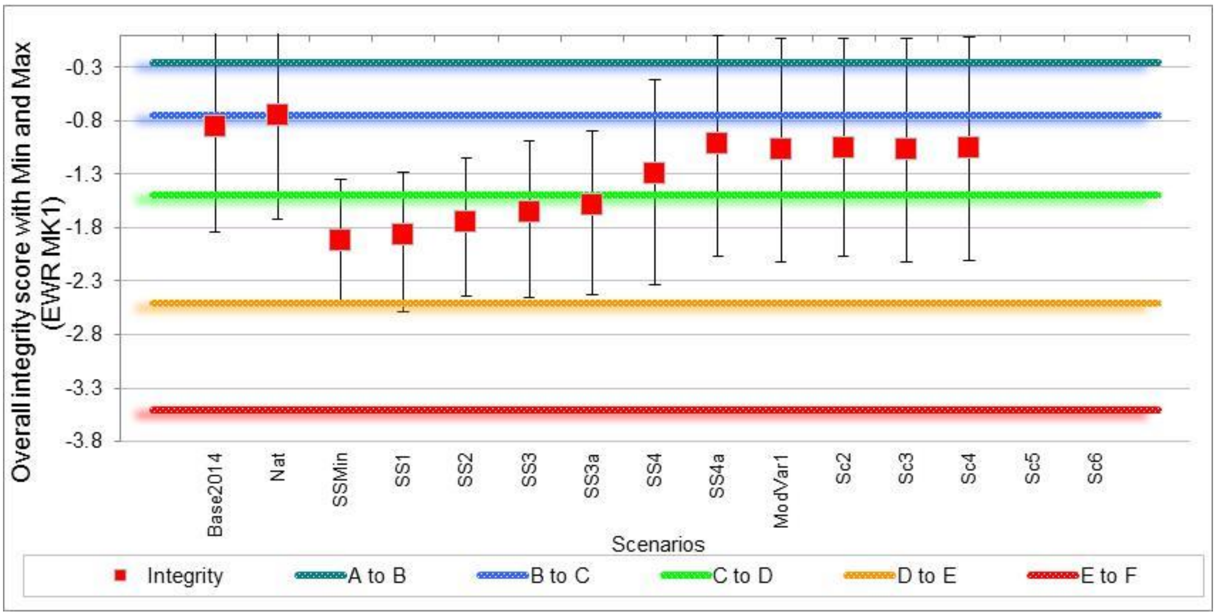


Figure 10-1 Overall ecosystem integrity scores for the scenarios at EWR Site MK1 (Mkuze River).

With this in mind, the results in Figure 10-1 suggest the following:

- SS4a, currently a C, should maintain the river in a B, provided all of the non-flow related impacts on Ecostatus, such as elevated nutrient levels, are addressed.
- SS4 (and SS4a) will maintain the river in a C condition.
- SSMin, SS1, SS2, SS3 or SS3a will maintain the river in a D category.

SS4 was selected as the EWR for maintenance of the REC – category C for use in the operational scenarios.

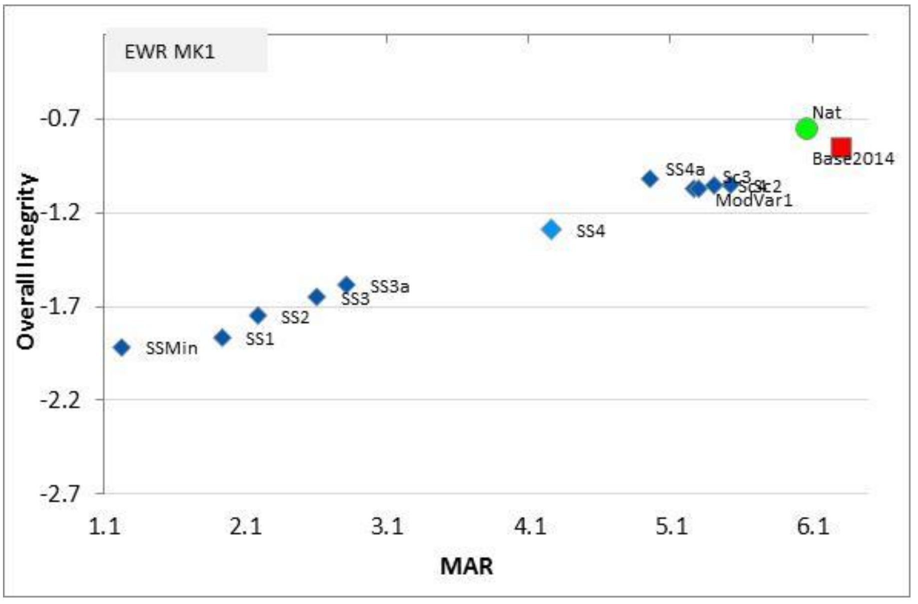


Figure 10-2 Overall ecosystem integrity scores for scenarios at EWR Site MK1 (Mkuze River) shown against MAR.

10.3 Identification of EWRs for Reserves

On the basis of the results in in Figure 10-1 and Figure 10-2 (Integrity vs. MAR), the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Mkuze	MK1	C	B	D	-
		SS4	SS4a	SS2	-

The details of these are provided in Section 16. A B-category (AEC1) will not be maintained through application of the AEC1 flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 10-1 Characteristics of the flow regime of each scenario at EWR Site MK1. Median values are given for the flow indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

	Base2014	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	SS4a	ModVar1	Sc2	Sc3	Sc4
Mean annual runoff	6.31	6.06	1.23	1.94	2.19	2.60	2.81	4.26	4.95	5.26	5.52	5.30	5.41
Dry season Min 5d Q	0.353	0.353	0.01	0.11	0.35	0.35	0.35	0.35	0.35	0.15	0.16	0.17	0.18
Dry season onset	15.00	12.00	18.00	15.00	15.00	11.00	11.00	12.00	20.00	18.00	16.00	18.00	18.00
Dry season duration	255.00	249.00	208.00	302.00	294.00	280.00	280.00	270.00	261.00	263.00	262.00	263.00	263.00
Dry season ave daily vol	0.193	0.229	0.01	0.05	0.06	0.08	0.10	0.16	0.18	0.16	0.17	0.16	0.17
Wet season Max 5d Q	88.86	87.52	79.96	80.02	80.03	80.10	80.17	80.60	81.25	82.33	85.44	82.44	84.65
Wet season onset	42.00	42.00	44.00	40.00	43.00	44.00	44.00	44.00	44.00	42.00	42.00	42.00	42.00
Wet season duration	122.00	122.00	61.00	14.00	32.00	38.00	39.00	72.00	106.00	119.00	119.00	119.00	119.00
Wet season ave daily vol	1.35	1.25	1.53	1.60	1.52	1.30	1.31	1.38	1.08	1.26	1.31	1.27	1.30
Flood volume	106.93	117.40	34.54	44.60	46.03	52.38	55.54	71.54	79.59	92.07	96.11	92.32	95.83
T1 ave daily vol	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.56	0.19	0.52	0.57
T2 ave daily vol	0.24	0.21	0.00	0.00	0.00	0.06	0.00	0.31	0.18	0.27	0.22	0.27	0.23
Dry season Min 5d Depth	0.11	0.11	0.03	0.08	0.11	0.11	0.11	0.11	0.11	0.08	0.08	0.08	0.08
Dry season Min 5d Velocity	0.08	0.08	0.02	0.05	0.08	0.08	0.08	0.08	0.08	0.06	0.06	0.06	0.06
Wet season Max 5d Depth	1.32	1.33	1.14	1.14	1.14	1.27	1.27	1.27	1.27	1.31	1.32	1.31	1.32
Wet season Max 5d Velocity	0.74	0.74	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Wet season Min 5d Velocity	0.14	0.13	0.04	0.26	0.12	0.13	0.16	0.17	0.14	0.12	0.12	0.12	0.12
MAR-baseflow	3.60	3.49	0.14	0.38	0.56	0.75	1.00	1.89	2.59	2.82	2.98	2.73	2.82
Dry-Min 5d Q-baseflow	0.35	0.35	0.01	0.11	0.35	0.35	0.35	0.35	0.35	0.15	0.16	0.17	0.18
Dry-daily ave vol-baseflow	0.17	0.19	0.01	0.03	0.04	0.05	0.08	0.13	0.17	0.13	0.14	0.13	0.14
Wet-Max 5d Q-baseflow	17.44	17.73	0.37	0.74	1.10	1.46	2.19	5.10	9.13	16.46	16.01	15.78	15.86
Wet-daily ave vol-baseflow	0.62	0.58	0.02	0.05	0.07	0.10	0.14	0.28	0.46	0.54	0.57	0.55	0.56
T1-daily ave vol-baseflow	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.00	0.05	0.05
T2-daily ave vol-baseflow	0.24	0.21	0.00	0.00	0.00	0.06	0.00	0.31	0.18	0.27	0.22	0.27	0.23
Wet season max instantaneous Q	143.86	138.21	143.86	143.86	143.86	143.86	143.86	143.86	143.86	130.82	134.28	130.98	132.71
Wet season min instantaneous Q	1.06	1.06	0.01	0.31	0.37	0.71	1.06	1.41	1.41	0.83	0.98	0.85	0.89
1:2 Class5	0.71	0.73	0.12	0.02	0.00	0.63	0.63	0.63	0.63	0.67	0.08	0.65	0.65
1:5 Class6	0.12	0.18	0.04	0.88	0.08	0.12	0.12	0.12	0.12	0.27	0.02	0.27	0.27
1:10 Class7	0.04	0.06	0.04	0.84	77.15	0.04	0.04	0.04	0.04	0.02	0.27	0.14	0.02
1:20 Class8	0.04	0.06	0.00	0.00	0.05	0.04	0.04	0.04	0.04	0.08	0.65	5.57	0.08
Dry Class1	0.12	0.16	0.00	1.19	0.84	0.02	0.02	0.00	0.00	0.18	0.04	0.27	0.29
Dry Class2	0.16	0.27	0.00	20.20	0.88	0.02	0.02	0.02	0.02	0.24	0.06	0.22	0.22
Dry Class3	0.10	0.12	0.00	0.02	0.02	0.02	0.02	0.04	0.04	0.06	0.10	0.06	0.06
Dry Class4	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.06
T1 Class1	0.12	0.20	0.00	0.02	0.06	0.18	0.18	0.24	0.29	0.24	0.20	0.24	0.25
T1 Class2	0.31	0.29	0.00	0.06	0.06	0.12	0.12	0.24	0.24	0.18	0.24	0.18	0.18
T1 Class3	0.08	0.06	0.00	0.06	0.06	0.06	0.06	0.10	0.10	0.06	0.06	0.06	0.06
T1 Class4	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Wet Class1	1.31	1.43	0.00	0.02	0.86	0.86	0.86	1.84	4.00	1.59	1.59	1.73	1.71
Wet Class2	2.10	2.24	0.00	0.90	0.90	1.71	1.71	2.43	2.37	2.02	2.14	2.08	2.06
Wet Class3	1.94	1.88	0.00	0.80	0.80	1.06	1.06	1.57	1.57	1.51	1.53	1.51	1.53
Wet Class4	1.04	1.06	0.00	0.00	0.00	0.49	0.49	0.49	0.49	0.98	1.02	0.98	1.00
T2 Class1	0.12	0.41	0.00	0.00	0.06	0.10	0.10	0.18	0.18	0.27	0.24	0.29	0.27
T2 Class2	0.41	0.14	0.00	0.04	0.04	0.10	0.10	0.16	0.14	0.22	0.27	0.24	0.25
T2 Class3	0.08	0.08	0.00	0.04	0.04	0.02	0.02	0.06	0.06	0.06	0.08	0.06	0.06
T2 Class4	0.04	0.04	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.06	0.04	0.06	0.04

11 SCENARIO EVALUATION: EWR SITE BM1 (BLACK MFOLOZI RIVER)

River	Site	REC	AEC1	AEC2	AEC3
Black Mfolozi	BM1	C	B	D	-

11.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site BM1 associated with each of the scenarios are summarised in Table 11-1

11.2 Overall ecosystem integrity

Figure 11-1 (Overall Ecological Integrity) shows that the baseline ecostatus for EWR Site BM1 is a C category (for details see EWR Ecoclassification Report). The reasons provided for this are partly flow related and include:

- elevated nutrients, EC and sulphates.
- reduced cover and abundance of woody species
- migration barrier to freshwater prawns;
- sedimentation resulting in reduced quality of aquatic and floodplain habitats.

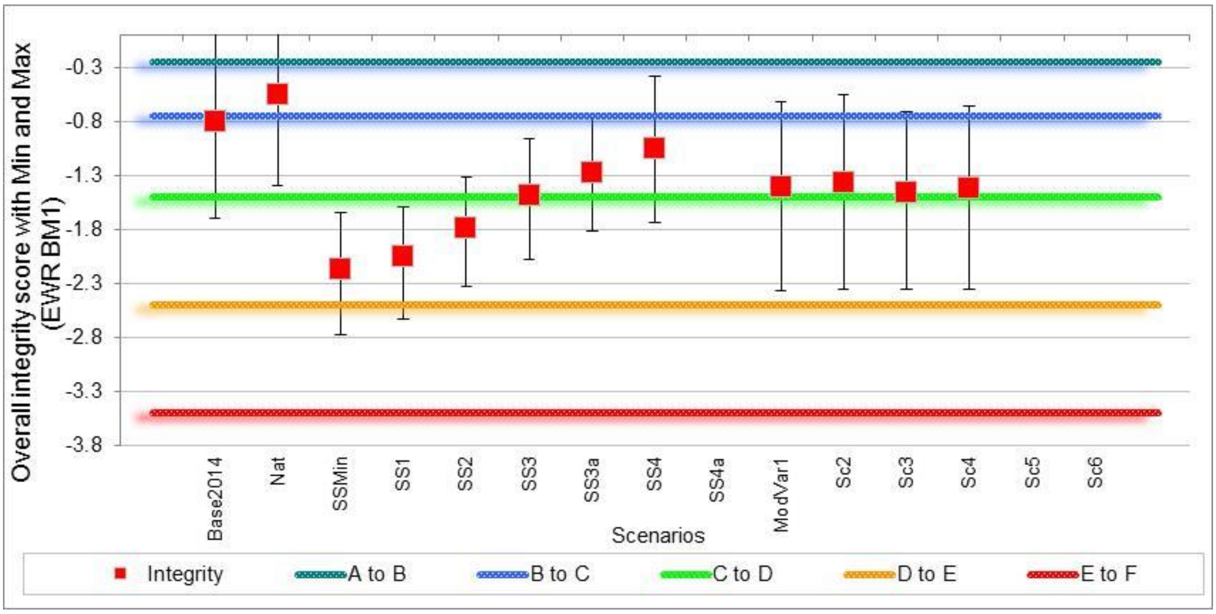


Figure 11-1 Overall ecosystem integrity scores for the scenarios at EWR Site BM1 (Black Mfolozi River).

With this in mind, the results in Figure 11-1 suggest the following:

- SS4, currently a C condition, should maintain the river in a B, provided all of the non-flow related impacts on Ecostatus, such as elevated nutrient levels, are addressed.
- SS3a (and SS4) will maintain the river in a C condition.
- SSMin, SS1 and SS2 will maintain the river in a D category.

SS3a was selected as the EWR for maintenance of the REC – category C for use in the operational scenarios.

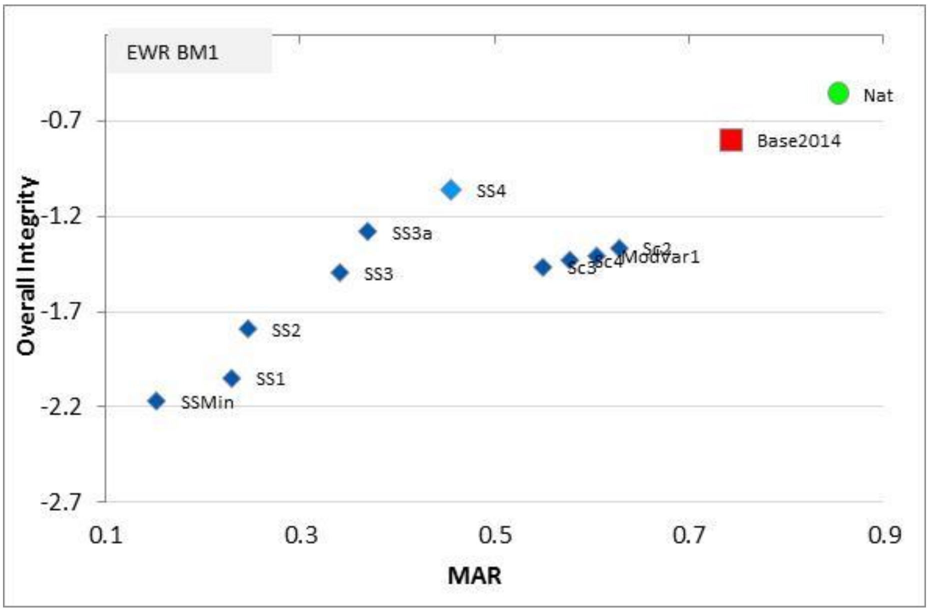


Figure 11-2 Overall ecosystem integrity scores for the scenarios at EWR Site BM1 (Black Mfolozi River) shown against MAR.

11.3 Identification of EWRs for Reserves

On the basis of the results in Figure 11-1 and Figure 11-2 (Integrity vs. MAR) the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Black Mfolozi	BM1	C	B	D	-
		SS3a	SS4	SS2	

The details of these are provided in Section 19. A B-category (AEC1) will not be maintained through application of the AEC1 flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 11-1 Characteristics of the flow regime of each scenario at EWR Site BM1. Median values are given for the flow indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

Site : EWR BM1	Base2014	Nat	SSMin	SS1	SS2	SS3	SS4	SS4a	ModVar1	Sc2	Sc3	Sc4
Mean annual runoff	0.7435	0.8528	0.1523	0.2298	0.2465	0.3410	0.45512	0.1523	0.6048	0.6282	0.5496	0.5773
Dry season Min 5d Q	0.012	0.012	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Dry season onset	12.00	10.00	18.00	9.00	9.00	8.00	8.00	18.00	9.00	9.00	9.00	9.00
Dry season duration	260.00	253.00	240.00	313.00	313.00	292.00	282.00	240.00	273.00	270.00	275.00	274.00
Dry season ave daily vol	0.016	0.017	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01
Wet season Max 5d Q	12.36	13.75	10.60	10.60	10.61	10.61	10.64	10.60	11.50	11.68	11.09	11.37
Wet season onset	44.00	44.00	44.00	44.00	44.00	45.00	44.00	44.00	44.00	44.00	45.00	44.00
Wet season duration	111.00	120.00	62.00	36.00	36.00	48.00	62.00	62.00	98.00	100.00	87.00	91.00
Wet season ave daily vol	0.17	0.20	0.14	0.17	0.17	0.15	0.15	0.14	0.15	0.15	0.16	0.17
Flood volume	14.25	16.11	4.58	5.57	5.59	8.04	9.64	4.58	12.19	12.35	11.62	11.91
T1 ave daily vol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T2 ave daily vol	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Dry season Min 5d Depth	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Dry season Min 5d Velocity	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Wet season Max 5d Depth	0.55	0.58	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
Wet season Max 5d Velocity	1.12	1.16	1.07	1.07	1.07	1.07	1.07	1.07	1.10	1.10	1.08	1.09
Wet season Min 5d Velocity	0.11	0.09	0.02	0.04	0.09	0.12	0.12	0.02	0.10	0.10	0.09	0.09
MAR-baseflow	0.34	0.42	0.01	0.02	0.04	0.06	0.17	0.01	0.26	0.27	0.24	0.23
Dry-Min 5d Q-baseflow	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Dry-daily ave vol-baseflow	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Wet-Max 5d Q-baseflow	2.02	2.53	0.01	0.03	0.08	0.15	0.60	0.01	1.82	1.83	1.54	1.58
Wet-daily ave vol-baseflow	0.06	0.06	0.00	0.00	0.01	0.01	0.02	0.00	0.05	0.05	0.05	0.05
T1-daily ave vol-baseflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T2-daily ave vol-baseflow	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Wet season max instantaneous Q	19.61	21.19	19.61	19.61	19.61	19.61	19.61	19.61	17.39	17.90	16.72	17.05
Wet season min instantaneous Q	0.08	0.08	0.01	0.03	0.06	0.03	0.11	0.01	0.07	0.07	0.07	0.07
1:2 Class5	0.61	0.61	0.59	0.59	0.59	0.59	0.59	0.59	0.47	0.49	0.45	0.45
1:5 Class6	0.10	0.14	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
1:10 Class7	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1:20 Class8	0.04	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Dry Class1	0.14	0.12	0.00	0.00	0.00	0.02	0.00	0.00	0.14	0.12	0.12	0.12
Dry Class2	0.06	0.14	0.00	0.02	0.02	0.02	0.02	0.00	0.14	0.14	0.18	0.18
Dry Class3	0.20	0.18	0.00	0.02	0.02	0.02	0.04	0.00	0.10	0.12	0.06	0.06
Dry Class4	0.12	0.14	0.00	0.00	0.00	0.02	0.02	0.00	0.08	0.08	0.08	0.08
T1 Class1	0.04	0.04	0.00	0.00	0.00	0.10	0.22	0.00	0.12	0.14	0.14	0.10
T1 Class2	0.12	0.10	0.00	0.08	0.08	0.16	0.22	0.00	0.06	0.06	0.02	0.04
T1 Class3	0.12	0.14	0.00	0.10	0.10	0.08	0.14	0.00	0.12	0.12	0.10	0.12
T1 Class4	0.08	0.08	0.00	0.00	0.00	0.06	0.06	0.00	0.06	0.06	0.08	0.08
Wet Class1	0.84	0.69	0.00	0.04	0.04	0.90	1.04	0.00	1.25	1.18	1.25	1.20
Wet Class2	1.49	1.37	0.00	0.90	0.92	1.02	1.86	0.00	1.25	1.33	1.25	1.24
Wet Class3	1.06	1.43	0.00	0.76	0.75	0.80	1.12	0.00	0.92	0.88	0.80	0.82
Wet Class4	0.76	0.88	0.00	0.00	0.00	0.51	0.51	0.00	0.73	0.75	0.67	0.73
T2 Class1	0.08	0.04	0.00	0.00	0.00	0.02	0.08	0.00	0.06	0.04	0.10	0.06
T2 Class2	0.10	0.10	0.00	0.04	0.04	0.10	0.08	0.00	0.14	0.16	0.14	0.16
T2 Class3	0.12	0.12	0.00	0.04	0.04	0.04	0.14	0.00	0.10	0.08	0.06	0.08
T2 Class4	0.06	0.06	0.00	0.00	0.00	0.04	0.04	0.00	0.02	0.04	0.02	0.02

12 SCENARIO EVALUATION: EWR SITE BM2 (BLACK MFOLOZI RIVER)

River	Site	REC	AEC1	AEC2	AEC3
Black Mfolozi	BM2	C	B	D	-

12.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site BM2 associated with each of the scenarios are summarised in Table 12-1.

12.2 Overall ecosystem integrity

Figure 12-1 (Overall Ecological Integrity) shows that the baseline ecostatus for EWR Site BM2 is a C category (for details see EWR Ecoclassification Report). The reasons provided for this are partly flow related and include:

- elevated nutrients, EC and sulphates.
- reduced cover and abundance of woody species
- migration barrier to freshwater prawns;.
- sedimentation resulting in reduced quality of aquatic and floodplain habitats.

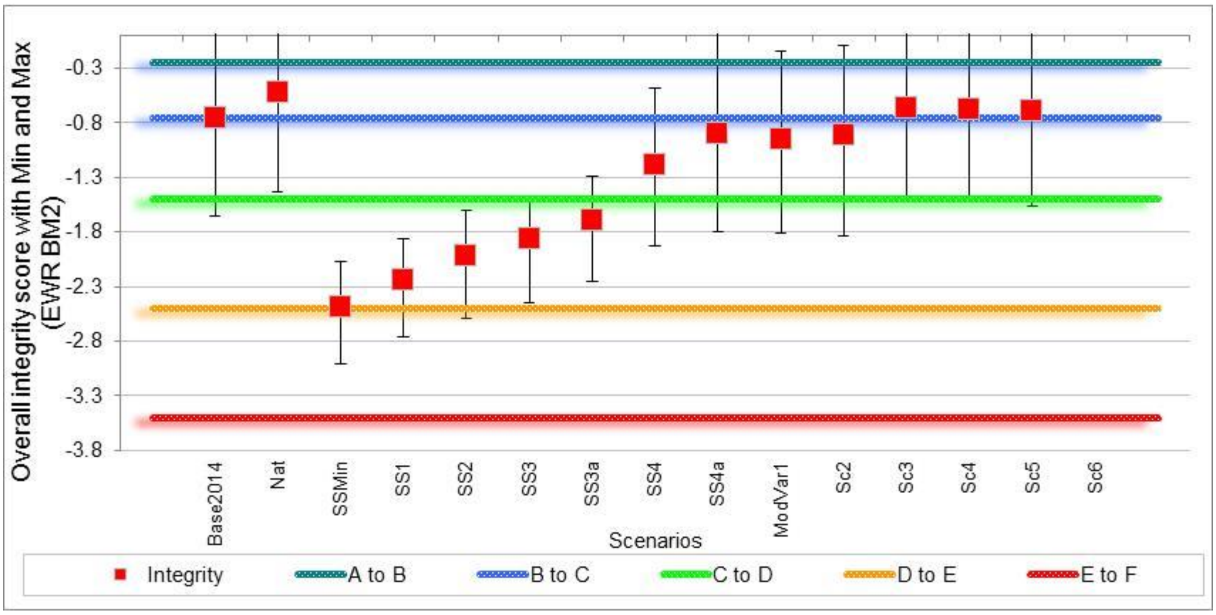


Figure 12-1 Overall ecosystem integrity scores for the scenarios at EWR Site BM2 (Black Mfolozi River).

With this in mind, the results in Figure 12-1 suggest the following:

- SS4a, currently in a C condition, should maintain the river in a B, provided the non-flow related impacts on Ecostatus, such as elevated nutrient levels, are addressed.
- SS4 (and SS4a) will maintain the river in a C condition.
- SS1, SS2, SS3, and SS3a will maintain the river in a D category.

SS4 was selected as the EWR for maintenance of the REC – category C for use in the operational scenarios.

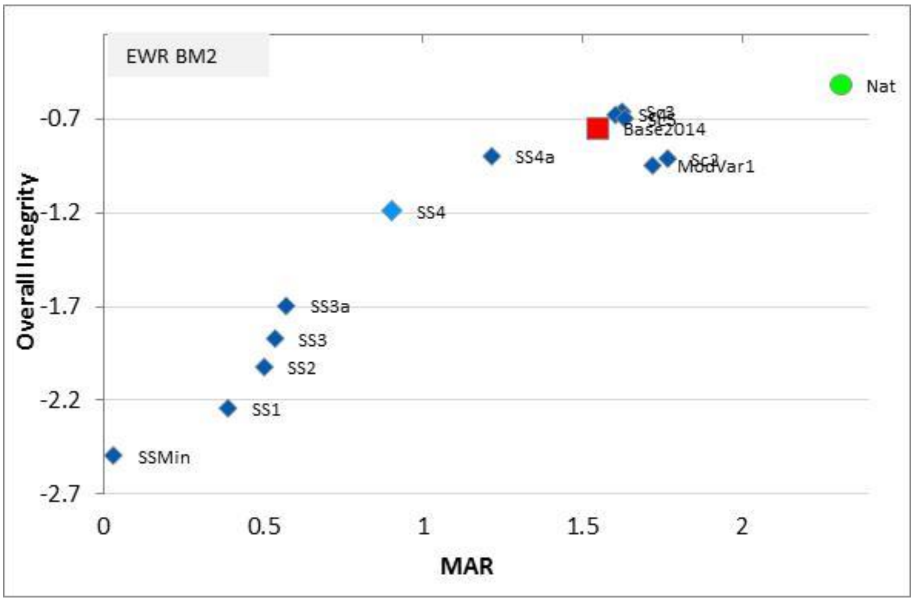


Figure 12-2 Overall ecosystem integrity scores for the scenarios at EWR Site BM2 (Black Mfolozi River) shown against MAR.

12.3 Identification of EWRs for Reserves

On the basis of the results in Figure 12-1 and Figure 12-2 (Integrity vs. MAR) the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Black Mfolozi	BM2	C	B	D	-
		SS4	SS4a	SS2	

The details of these are provided in Section 20. A B-category (AEC1) will not be maintained through application of the AEC1 flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 12-1 Characteristics of the flow regime of each scenario at EWR Site BM2. Median values are given for the flow indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

Site : EWR BM2	Base2014	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	SS4a	ModVar1	Sc2	Sc3	Sc4	Sc5
Mean annual runoff	1.549	2.311	0.0299	0.389	0.503	0.537	0.571	0.903	1.22	1.72	1.767	1.624	1.604	1.633
Dry season Min 5d Q	0.039	0.078	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.09	0.09	0.09	0.09	0.09
Dry season onset	12.00	14.00	18.00	9.00	9.00	9.00	9.00	9.00	11.00	12.00	12.00	11.00	12.00	12.00
Dry season duration	245.00	223.00	221.00	321.00	303.00	303.00	303.00	288.00	258.00	236.00	230.00	245.00	244.00	244.00
Dry season ave daily vol	0.035	0.047	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.05	0.05	0.05	0.05	0.05
Wet season Max 5d Q	21.53	23.47	0.06	8.69	14.50	14.54	14.57	14.90	15.29	23.72	23.29	23.34	22.78	22.78
Wet season onset	43.00	42.00	44.00	42.00	44.00	44.00	44.00	44.00	45.00	42.00	42.00	42.00	42.00	42.00
Wet season duration	112.00	139.00	151.00	15.00	47.00	48.00	48.00	58.00	100.00	99.00	107.00	95.00	94.00	95.00
Wet season ave daily vol	0.39	0.42	0.00	0.44	0.40	0.39	0.40	0.39	0.37	0.41	0.40	0.38	0.45	0.42
Flood volume	37.58	43.82	0.53	4.85	10.75	11.28	11.85	16.59	25.87	26.83	27.57	24.32	22.70	22.70
T1 ave daily vol	0.06	0.13	0.00	0.00	0.00	0.01	0.01	0.00	0.08	0.12	0.10	0.12	0.12	0.13
T2 ave daily vol	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.08	0.03	0.00	0.00	0.04	0.04	0.04
Dry season Min 5d Depth	0.07	0.09	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.09	0.09	0.09	0.09	0.09
Dry season Min 5d Velocity	0.17	0.20	0.15	0.12	0.12	0.12	0.12	0.12	0.12	0.20	0.20	0.20	0.20	0.20
Wet season Max 5d Depth	0.66	0.66	0.07	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Wet season Max 5d Velocity	0.64	0.64	0.18	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Wet season Min 5d Velocity	0.31	0.35	0.15	0.52	0.24	0.34	0.35	0.35	0.32	0.35	0.35	0.35	0.35	0.35
MAR-baseflow	0.92	1.16	0.03	0.05	0.08	0.14	0.19	0.42	0.64	0.85	0.92	0.73	0.69	0.73
Dry-Min 5d Q-baseflow	0.04	0.08	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.09	0.09	0.09	0.09	0.09
Dry-daily ave vol-baseflow	0.03	0.04	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.04	0.03	0.03	0.03	0.03
Wet-Max 5d Q-baseflow	5.06	4.76	0.05	0.08	0.13	0.33	0.47	1.46	3.37	3.77	3.82	3.43	3.12	3.12
Wet-daily ave vol-baseflow	0.15	0.18	0.00	0.01	0.01	0.02	0.03	0.06	0.12	0.13	0.14	0.11	0.11	0.11
T1-daily ave vol-baseflow	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.02	0.02	0.03	0.02
T2-daily ave vol-baseflow	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.07	0.03	0.00	0.00	0.04	0.04	0.04
Wet season max instantaneous Q	34.79	36.68	0.06	12.40	23.78	23.79	23.80	23.85	23.85	40.15	38.62	39.64	39.22	39.30
Wet season min instantaneous Q	0.16	0.31	0.02	0.08	0.06	0.08	0.20	0.16	0.16	0.26	0.26	0.26	0.26	0.26
1:2 Class5	0.71	0.73	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.67	0.65	0.65	0.65	0.65
1:5 Class6	0.12	0.18	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.27	0.27	0.27	0.27	0.27
1:10 Class7	0.04	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.02
1:20 Class8	0.04	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.08	0.08	0.08	0.08	0.08
Dry Class1	0.12	0.16	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.18	0.20	0.27	0.29	0.29
Dry Class2	0.16	0.27	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.24	0.27	0.22	0.22	0.20
Dry Class3	0.18	0.25	0.00	0.00	0.02	0.02	0.02	0.04	0.04	0.18	0.20	0.16	0.14	0.16
Dry Class4	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.08	0.12	0.10	0.10
T1 Class1	0.08	0.04	0.00	0.00	0.14	0.14	0.14	0.06	0.06	0.08	0.08	0.08	0.10	0.10
T1 Class2	0.10	0.14	0.00	0.04	0.14	0.14	0.14	0.25	0.25	0.10	0.14	0.12	0.10	0.10
T1 Class3	0.22	0.20	0.00	0.08	0.08	0.08	0.08	0.18	0.18	0.18	0.16	0.16	0.16	0.16
T1 Class4	0.08	0.12	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.08	0.08	0.08	0.08	0.08
Wet Class1	0.96	0.76	0.00	0.02	0.84	0.84	0.84	1.10	5.31	1.22	1.18	1.39	1.35	1.43
Wet Class2	1.63	1.78	0.00	0.88	0.88	0.88	0.90	1.76	1.76	1.45	1.63	1.51	1.45	1.41
Wet Class3	1.63	1.71	0.00	0.84	0.98	0.98	0.96	1.43	1.43	1.51	1.59	1.41	1.37	1.43
Wet Class4	1.16	1.18	0.00	0.00	0.61	0.61	0.61	0.61	0.61	0.86	0.82	0.78	0.75	0.75
T2 Class1	0.10	0.10	0.00	0.02	0.04	0.04	0.06	0.16	0.16	0.16	0.14	0.18	0.20	0.22
T2 Class2	0.18	0.20	0.00	0.06	0.04	0.04	0.02	0.06	0.06	0.20	0.22	0.18	0.18	0.18
T2 Class3	0.16	0.16	0.00	0.02	0.06	0.06	0.06	0.08	0.08	0.04	0.04	0.04	0.04	0.04
T2 Class4	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.06	0.06

13 SCENARIO EVALUATION: EWR SITE WM1 (WHITE MFOLOZI RIVER)

River	Site	REC	AEC1	AEC2	AEC3
White Mfolozi	WM1	B/C	B	C	D

13.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site WM1 associated with each of the scenarios are summarised in Table 13-1.

13.2 Overall ecosystem integrity

Figure 13-1 (Overall Ecological Integrity) shows that the baseline ecostatus for EWR Site WM1 is a B/C category (for details see EWR Ecoclassification Report). The reasons provided for this are partly flow related and include:

- slightly elevated nutrients;
- possibly be elevated suspended sediments;
- reduced cover and abundance of woody species;
- sedimentation resulting in reduced quality of aquatic and floodplain habitats.

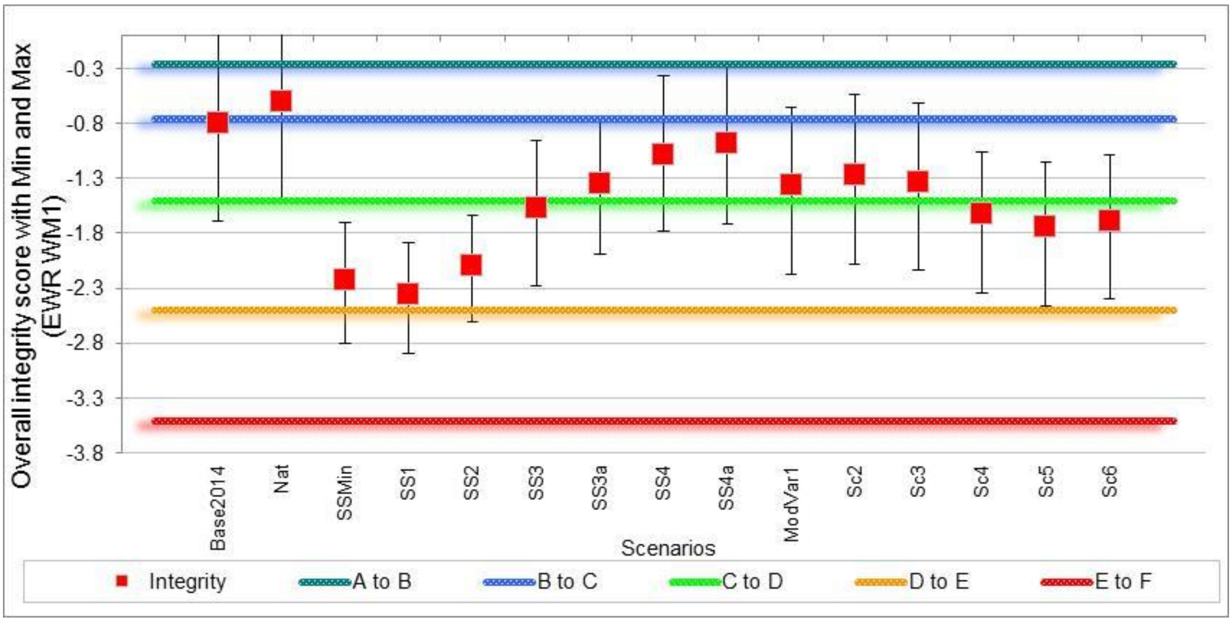


Figure 13-1 Overall ecosystem integrity scores for the scenarios at EWR Site WM1 (White Mfolozi River).

With this in mind, the results in Figure 13-1 suggest the following:

- SS4a, currently returns a C and should maintain the river, in a B/C and probably a B condition, provided all of the non-flow related impacts on Ecostatus, such as elevated nutrient levels, are addressed.
- SS4, currently returns a C and should maintain the river, in a B/C condition, provided all of the non-flow related impacts on Ecostatus, such as elevated nutrient levels, are addressed.
- SS3a and SS4 (and SS4a) will maintain the river in a C condition.
- SSMin, SS1 and SS2 will maintain the river in a D category.

SS4 was selected as the EWR, for maintenance of the REC – category B/C for use in the operational scenarios (see above). This will only be achieved if the non-flow related impacts are addressed.

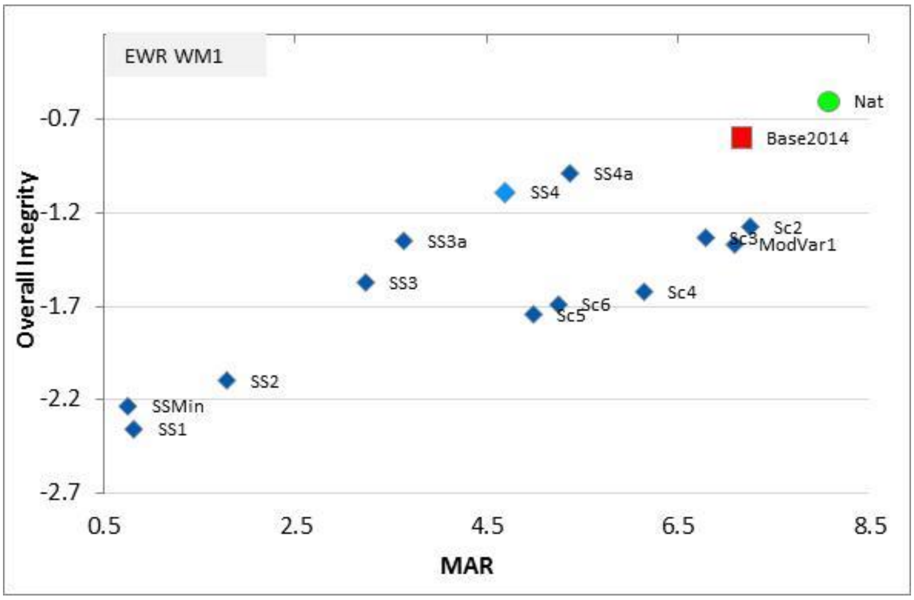


Figure 13-2 Overall ecosystem integrity scores for the scenarios at EWR Site WM1 (White Mfolozi River) shown against MAR.

13.3 Identification of EWRs for Reserves

On the basis of the results in Figure 13-1 and Figure 13-2 (Integrity vs. MAR) the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
White Mfolozi	WM1	C1[6]	B	D	-
		SS4	SS4a[27]	SS2	-

[6] Can be improved to a B/C provided non flow related impacts are addressed
[7] Should maintain a B, provided non-flow related impacts are addressed

The details of these are provided in Section 21. The B category (AEC1) will not be maintained through application of the AEC1 flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 13-1 Characteristics of the flow regime of each scenario at EWR Site WM1. Median values are given for the flow indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

Site : EWR WM1	Base2014	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	SS4a	ModVar1	Sc2	Sc3	Sc4	Sc5	Sc
Mean annual runoff	7.16	8.07	0.75	0.81	1.79	3.24	3.63	4.69	5.37	7.09	7.25	6.79	6.15	4.99	5.
Dry season Min 5d Q	0.339	0.362	0.26	0.30	0.32	0.34	0.34	0.34	0.34	0.10	0.16	0.12	0.05	0.12	0.
Dry season onset	9.00	10.00	18.00	8.00	9.00	8.00	8.00	9.00	10.00	10.00	10.00	10.00	10.00	9.00	9.
Dry season duration	266.00	244.00	234.00	335.00	315.00	310.00	309.00	293.00	280.00	246.00	246.00	246.00	247.00	272.00	272.
Dry season ave daily vol	0.189	0.213	0.04	0.04	0.07	0.12	0.15	0.20	0.18	0.22	0.23	0.23	0.20	0.16	0.
Wet season Max 5d Q	72.60	79.70	19.57	19.59	40.50	65.01	65.58	66.53	67.40	73.96	74.52	71.66	66.74	56.77	58.
Wet season onset	44.00	44.00	44.00	31.00	41.00	44.00	44.00	44.00	44.00	44.00	44.00	43.00	43.00	42.00	42.
Wet season duration	91.00	112.00	102.00	5.00	17.00	36.00	36.00	46.00	74.00	101.00	101.00	101.00	84.00	80.00	80.
Wet season ave daily vol	1.63	1.61	0.10	0.76	1.95	1.88	1.90	1.80	1.55	1.51	1.52	1.39	1.45	1.42	1.
Flood volume	112.01	132.37	12.16	3.82	32.86	56.90	59.69	75.70	93.48	113.71	115.70	115.41	90.94	68.93	69.
T1 ave daily vol	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
T2 ave daily vol	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.34	0.42	0.46	0.44	0.51	0.41	0.
Dry season Min 5d Depth	0.19	0.19	0.18	0.19	0.19	0.19	0.19	0.19	0.19	0.16	0.16	0.16	0.14	0.16	0.
Dry season Min 5d Velocity	0.06	0.07	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.03	0.03	0.03	0.01	0.03	0.
Wet season Max 5d Depth	0.73	0.77	0.50	0.50	0.60	0.69	0.69	0.70	0.70	0.74	0.74	0.72	0.70	0.65	0.
Wet season Max 5d Velocity	1.34	1.38	0.84	0.84	1.11	1.30	1.30	1.30	1.30	1.34	1.34	1.33	1.30	1.24	1.
Wet season Min 5d Velocity	0.36	0.28	0.12	0.57	0.52	0.29	0.35	0.24	0.27	0.26	0.24	0.23	0.31	0.35	0.
MAR-baseflow	3.48	4.17	0.57	0.47	0.72	1.25	1.61	2.42	2.93	3.88	3.98	3.85	3.49	2.57	2.
Dry-Min 5d Q-baseflow	0.34	0.36	0.26	0.30	0.32	0.34	0.34	0.34	0.34	0.10	0.16	0.12	0.05	0.12	0.
Dry-daily ave vol-baseflow	0.15	0.18	0.04	0.04	0.06	0.09	0.12	0.16	0.15	0.16	0.17	0.17	0.14	0.12	0.
Wet-Max 5d Q-baseflow	13.64	14.44	1.35	0.73	1.49	2.96	4.06	7.35	10.45	12.05	12.16	12.41	11.52	10.52	10.
Wet-daily ave vol-baseflow	0.63	0.61	0.06	0.06	0.13	0.22	0.26	0.39	0.48	0.54	0.57	0.56	0.53	0.50	0.
T1-daily ave vol-baseflow	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
T2-daily ave vol-baseflow	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.34	0.42	0.45	0.44	0.51	0.41	0.
Wet season max instantaneous Q	112.56	118.71	1.58	20.99	40.69	82.68	83.13	85.82	85.82	99.32	99.97	91.55	87.33	75.52	81.
Wet season min instantaneous Q	2.90	2.17	0.72	0.72	1.45	1.12	1.49	1.81	1.81	1.50	1.40	1.23	2.54	3.58	3.
1:2 Class5	0.59	0.63	0.59	0.59	0.59	0.59	0.59	0.59	0.61	0.45	0.47	0.41	0.37	0.33	0.
1:5 Class6	0.14	0.16	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.12	0.12	0.12	0.12	0.08	0.
1:10 Class7	0.04	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.
1:20 Class8	0.04	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.10	0.10	0.10	0.10	0.10	0.
Dry Class1	0.18	0.18	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.24	0.24	0.24	0.27	0.18	0.
Dry Class2	0.24	0.22	0.00	0.00	0.00	0.02	0.02	0.04	0.04	0.20	0.20	0.20	0.16	0.10	0.
Dry Class3	0.14	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.16	0.16	0.16	0.14	0.
Dry Class4	0.04	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.04	0.08	0.04	0.04	0.
T1 Class1	0.18	0.16	0.00	0.00	0.08	0.08	0.08	0.16	0.16	0.14	0.14	0.12	0.16	0.14	0.
T1 Class2	0.10	0.16	0.00	0.04	0.08	0.12	0.12	0.16	0.16	0.16	0.16	0.16	0.18	0.18	0.
T1 Class3	0.16	0.20	0.00	0.00	0.04	0.10	0.10	0.16	0.16	0.16	0.14	0.18	0.18	0.16	0.
T1 Class4	0.06	0.06	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.06	0.08	0.04	0.04	0.04	0.
Wet Class1	1.71	1.84	0.00	0.00	0.94	0.90	0.90	1.90	3.16	1.86	1.86	1.92	2.14	2.22	2.
Wet Class2	2.45	2.33	0.00	0.96	0.92	1.80	1.82	2.61	2.53	2.43	2.43	2.51	2.43	2.08	2.
Wet Class3	1.96	2.31	0.00	0.00	0.92	1.02	1.00	1.69	1.61	1.76	1.76	1.65	1.41	1.24	1.
Wet Class4	1.02	1.14	0.00	0.00	0.00	0.69	0.69	0.69	0.73	1.14	1.16	1.12	1.14	0.90	0.
T2 Class1	0.16	0.22	0.00	0.00	0.02	0.06	0.06	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.
T2 Class2	0.10	0.10	0.00	0.00	0.02	0.08	0.08	0.14	0.14	0.14	0.14	0.12	0.12	0.10	0.
T2 Class3	0.10	0.10	0.00	0.00	0.00	0.02	0.02	0.04	0.04	0.06	0.06	0.06	0.06	0.00	0.
T2 Class4	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.

14 SCENARIO EVALUATION: EWR SITE NS1 (NSELENI RIVER)

River	Site	REC	AEC1	AEC2	AEC3
Nseleni	NS1	C	B	D	-

14.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site NS1 associated with each of the scenarios are summarised in Table 14-1.

14.2 Overall ecosystem integrity

Figure 14-1 (Overall Ecological Integrity) shows that the baseline ecostatus for EWR Site NS1 is a C category (for details see EWR Ecoclassification Report). The reasons provided for this are mostly not flow related and include:

- elevated nutrients;
- limited catchment erosion, minor bank disturbance and invasive plant species;
- reduced cover and abundance of woody species and increased reeds;
- sedimentation resulting in a minor reduction in quality of interstitial habitat, reduced feeding opportunities.

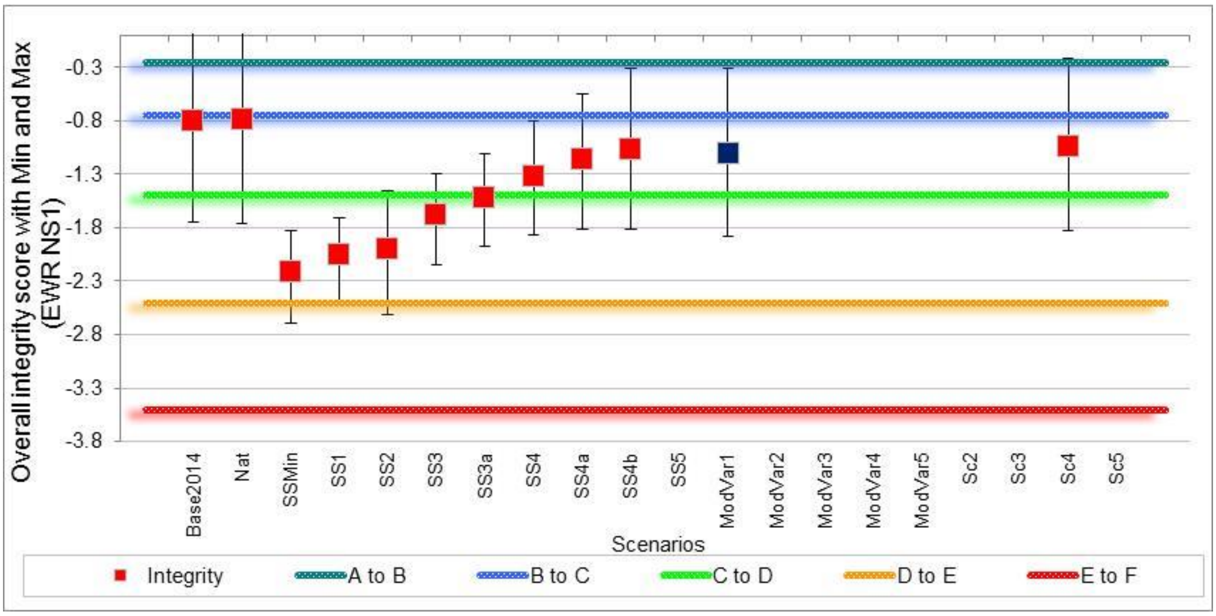


Figure 14-1 Overall ecosystem integrity scores for the scenarios at EWR Site NS1 (Nseleni River).

With this in mind, the results in Figure 14-1 suggest the following:

- Sc4, although currently a C, will probably maintain the river in a B category provided non-flow related impacts are addressed.
- SS4, SS4a and SS4b (and Sc4) will maintain the river in a C condition.
- SSMin, SS1, SS2 and SS3 will maintain the river in a D-category.

SS4a was selected as the EWR for maintenance of the REC – category C for use in the operational scenarios.

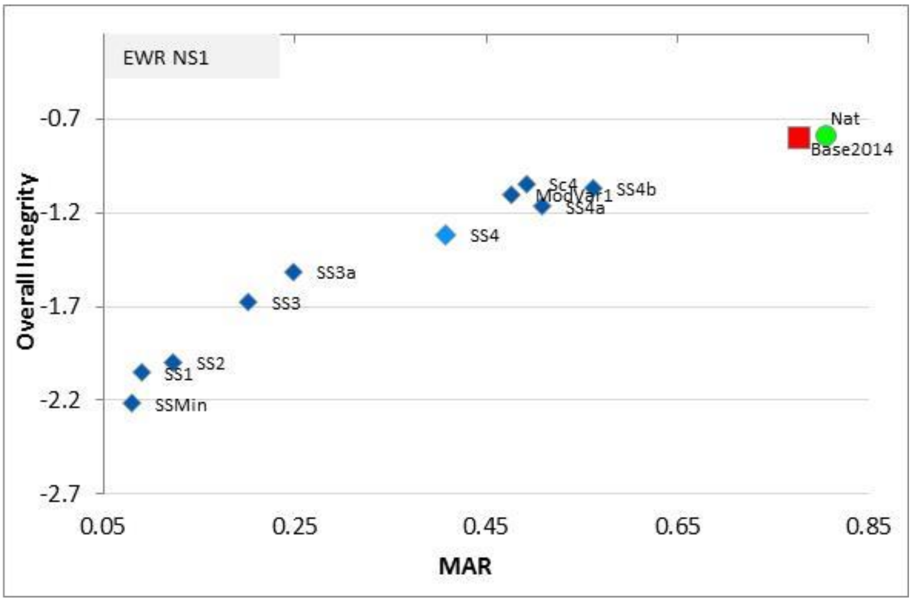


Figure 14-2 Overall ecosystem integrity scores for the scenarios at EWR Site NS1 (Nseleni River) shown against MAR.

14.3 Identification of EWRs for Reserves

On the basis of the results in Figure 14-1 and Figure 14-2 (Integrity vs. MAR), the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Nseleni	NS1	C	B	D	-
		SS4b	Sc4	SS2	-

The details of these are provided in Section 22. A B-category (AEC1) will not be maintained through application of the AEC1 flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 14-1 Characteristics of the flow regime of each scenario at EWR Site NS1. Median values are given for the flow indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

Site : EWR NS1	Base2014	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	SS4a	SS4b	SS5	ModVar1	Sc2	Sc3	Sc4
Mean annual runoff	0.78	0.81	0.08	0.09	0.12	0.20	0.25	0.41	0.51	0.56	0.08	0.48	0.49	0.49	0.49
Dry season Min 5d Q	0.028	0.029	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Dry season onset	14	14	22.00	22.00	22.00	22.00	22.00	14.00	11.50	10.50	22.00	21.00	21.00	21.00	21.00
Dry season duration	214	213	201.50	312.00	302.50	297.50	300.50	266.00	247.00	234.50	201.50	251.00	259.00	259.00	259.00
Dry season ave daily vol	0.022	0.023	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.00	0.01	0.01	0.01	0.01
Wet season Max 5d Q	9.32	9.65	5.07	5.33	5.56	6.17	6.17	5.90	6.18	6.25	5.07	7.08	7.38	7.38	7.38
Wet season onset	40.00	40.00	40.00	40.00	41.50	41.00	41.00	42.00	41.00	40.00	40.00	40.00	40.00	40.00	40.00
Wet season duration	129.50	130.00	126.50	10.00	33.00	35.00	35.00	76.00	96.00	118.50	126.50	93.00	95.00	95.00	95.00
Wet season ave daily vol	0.13	0.14	0.06	0.10	0.10	0.13	0.13	0.12	0.11	0.11	0.06	0.11	0.12	0.12	0.12
Flood volume	16.62	17.13	2.19	2.33	2.57	4.48	4.85	6.31	9.30	10.89	2.19	11.35	11.55	11.55	11.55
T1 ave daily vol	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.02	0.02	0.02	0.02
T2 ave daily vol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry season Min 5d Depth	0.10	0.10	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07
Dry season Min 5d Velocity	0.07	0.07	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05
Wet season Max 5d Depth	1.19	1.21	0.96	0.98	0.99	1.03	1.03	1.01	1.03	1.03	0.96	1.08	1.09	1.09	1.09
Wet season Max 5d Velocity	0.56	0.56	0.45	0.45	0.46	0.48	0.48	0.47	0.48	0.48	0.45	0.50	0.51	0.51	0.51
Wet season Min 5d Velocity	0.13	0.14	0.05	0.19	0.06	0.11	0.13	0.15	0.15	0.14	0.05	0.13	0.14	0.14	0.14
MAR-baseflow	0.45	0.46	0.01	0.01	0.02	0.04	0.08	0.20	0.31	0.36	0.01	0.26	0.27	0.27	0.27
Dry-Min 5d Q-baseflow	0.03	0.03	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Dry-daily ave vol-baseflow	0.02	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.00	0.01	0.01	0.01	0.01
Wet-Max 5d Q-baseflow	2.61	2.66	0.01	0.02	0.04	0.09	0.20	0.54	1.11	1.52	0.01	1.56	1.59	1.59	1.59
Wet-daily ave vol-baseflow	0.09	0.09	0.00	0.00	0.00	0.01	0.01	0.03	0.06	0.06	0.00	0.06	0.07	0.07	0.07
T1-daily ave vol-baseflow	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.02	0.02	0.02	0.02
T2-daily ave vol-baseflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet season max instantaneous Q	16.03	16.59	16.03	16.03	16.03	16.03	16.03	16.03	16.03	16.03	16.03	11.74	12.24	12.24	12.24
Wet season min instantaneous Q	0.10	0.11	0.01	0.01	0.01	0.02	0.05	0.21	0.12	0.11	0.01	0.05	0.07	0.07	0.07
1:2 Class5	0.69	0.70	0.52	0.52	0.57	0.52	0.52	0.52	0.52	0.52	0.52	0.37	0.37	0.37	0.37
1:5 Class6	0.11	0.11	0.09	0.09	0.11	0.09	0.09	0.09	0.09	0.09	0.09	0.11	0.13	0.13	0.13
1:10 Class7	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
1:20 Class8	0.04	0.06	0.06	0.06	0.04	0.06	0.06	0.06	0.06	0.06	0.06	0.04	0.04	0.04	0.04
Dry Class1	0.22	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.24	0.24	0.24
Dry Class2	0.28	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.17	0.17	0.17
Dry Class3	0.15	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02
Dry Class4	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04
T1 Class1	0.11	0.11	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.00	0.11	0.11	0.11	0.11
T1 Class2	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09
T1 Class3	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04
T1 Class4	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.07
Wet Class1	1.72	1.63	0.00	0.09	0.83	1.11	1.11	1.87	1.80	0.98	0.00	1.48	1.31	1.31	1.31
Wet Class2	1.94	1.98	0.00	0.72	0.83	1.63	1.63	2.28	2.30	2.24	0.00	1.48	1.59	1.59	1.59
Wet Class3	1.33	1.31	0.00	0.00	0.57	0.74	0.74	1.09	1.09	1.11	0.00	1.00	1.07	1.07	1.07
Wet Class4	0.67	0.74	0.06	0.06	0.00	0.43	0.43	0.06	0.06	0.06	0.06	0.54	0.57	0.57	0.57
T2 Class1	0.26	0.26	0.00	0.00	0.04	0.17	0.17	0.31	0.31	0.31	0.00	0.37	0.35	0.35	0.35
T2 Class2	0.43	0.41	0.00	0.09	0.11	0.17	0.17	0.20	0.22	0.22	0.00	0.22	0.26	0.26	0.26
T2 Class3	0.04	0.06	0.00	0.00	0.07	0.04	0.04	0.13	0.11	0.11	0.00	0.04	0.02	0.02	0.02
T2 Class4	0.07	0.07	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.07	0.09	0.09	0.09

15 SCENARIO EVALUATION: EWR SITE MA1 (MATIGULU RIVER)

River	Site	REC	AEC1	AEC2	AEC3
Matigulu	MA1	B/C	B	C	D

15.1 Hydrology and hydraulics

The main characteristics of the flow regimes at EWR Site MA1 associated with each of the synthetic EWR scenarios are summarised in Table 15-1.

15.2 Overall ecosystem integrity

Figure 15-1 (Overall Ecological Integrity) shows that the baseline ecostatus for EWR Site MA1 is a C category (for details see EWR Ecoclassification Report). The reasons provided for this are mostly not flow related and include:

- slightly elevated nutrients and turbidity;
- slightly elevated fines;
- change in species composition of plant community; reduced cover of woody species.
- minor reduction in quality of interstitial habitat due to sedimentation.

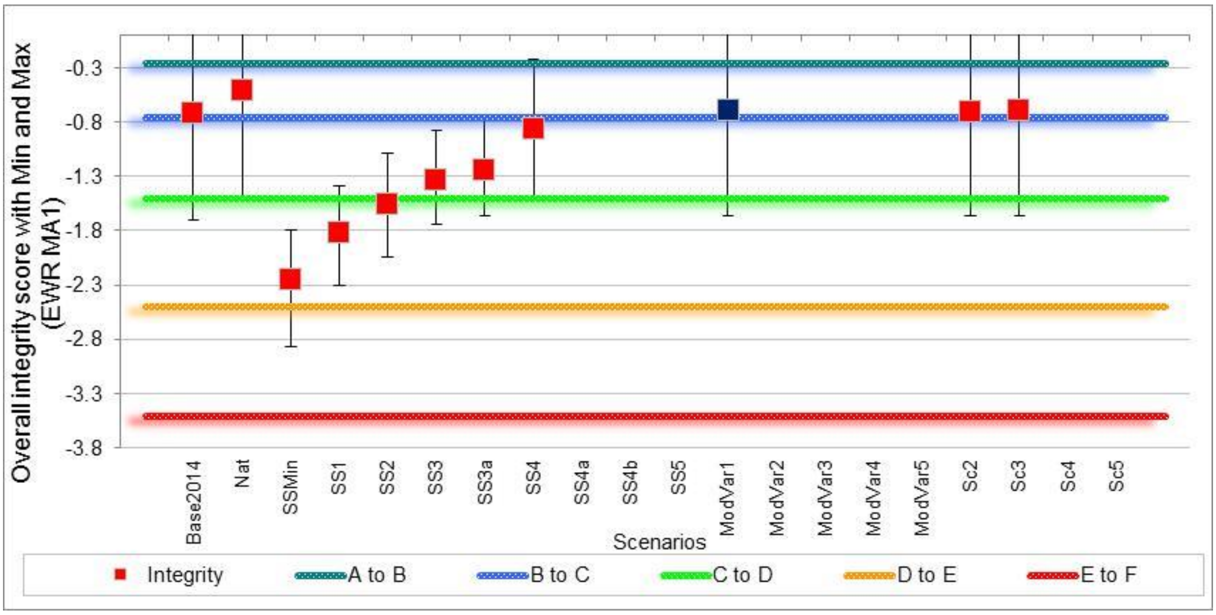


Figure 15-1 Overall ecosystem integrity scores for the scenarios at EWR Site MA1 (Matigulu River). Baseline (2013/4) integrity is shown as 2014.

With this in mind, the results in Figure 15-1 suggest the following:

- Sc3 should maintain the river in a B condition provided non-flow related impacts are addressed.
- SS3, SS3a, and SS4 will maintain the river in a C condition, and SS4 in a B/C.
- SSMin and SS1 will maintain the river in a D-category.

SS4 was selected as the EWR for maintenance of the REC – category B/C for use in the operational scenarios.

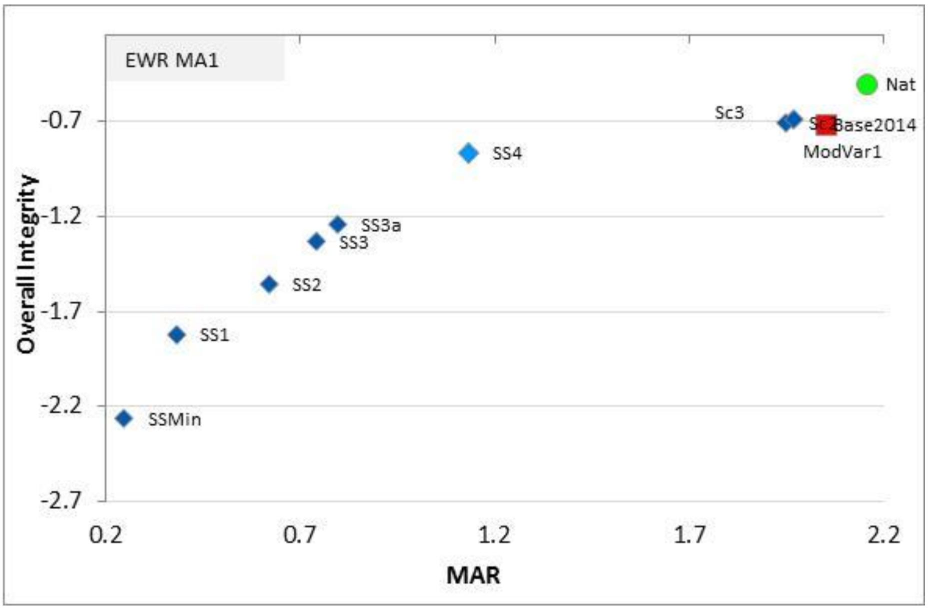


Figure 15-2 Overall ecosystem integrity scores for the scenarios at EWR Site MA1 (Matigulu River) shown against MAR.

15.3 Identification of EWRs for Reserves

On the basis of the results in Figure 15-1 and Figure 15-2 (Integrity vs. MAR), the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Matigulu	MA1	B/C	B	C	D
		SS4	Sc3	SS3a	SS1

The details for these are provided in Section 23. A B-category (AEC) will not be maintained through application of these flows alone. Many of the impacts that have resulted in the river systems being in a less than natural condition are not flow related. These would need to be addressed before the overall condition of the river can be improved.

Table 15-1 Characteristics of the flow regime of each scenario at EWR Site MA1. Median values are given for the flow indicators, except for flood numbers, which are given as means. MAR incl. floods ≥ 1:2.

Site : EWR MA1	PD	Nat	SSMin	SS1	SS2	SS3	SS3a	SS4	SS5	ModVar1	Sc2	Sc3
Mean annual runoff	2.05	2.16	0.25	0.38	0.62	0.74	0.80	1.13	0.25	1.97	1.95	1.97
Dry season Min 5d Q	0.211	0.260	0.01	0.09	0.16	0.21	0.21	0.22	0.01	0.17	0.17	0.17
Dry season onset	20	21	22.00	30.00	36.00	36.00	36.00	30.00	22.00	20.00	20.00	20.00
Dry season duration	237	235	182.00	303.50	297.50	293.50	293.50	265.00	182.00	237.50	238.50	238.00
Dry season ave daily vol	0.070	0.076	0.01	0.02	0.03	0.04	0.04	0.06	0.01	0.06	0.06	0.07
Wet season Max 5d Q	15.74	16.38	4.25	6.09	10.14	10.19	10.23	11.15	4.25	15.73	15.62	15.68
Wet season onset	40.00	40.00	40.00	41.50	41.00	41.50	42.00	41.00	40.00	40.00	40.00	40.00
Wet season duration	77.00	82.50	182.00	9.50	18.50	18.50	19.50	34.50	182.00	74.50	74.00	75.00
Wet season ave daily vol	0.40	0.42	0.05	0.21	0.30	0.29	0.30	0.33	0.05	0.40	0.40	0.40
Flood volume	44.47	46.91	3.45	5.78	9.42	10.10	11.02	15.38	3.45	42.83	42.57	42.79
T1 ave daily vol	0.12	0.13	0.01	0.10	0.07	0.09	0.10	0.11	0.01	0.11	0.11	0.11
T2 ave daily vol	0.00	0.00	0.00	0.03	0.03	0.04	0.05	0.10	0.00	0.00	0.00	0.00
Dry season Min 5d Depth	0.20	0.22	0.09	0.15	0.18	0.21	0.21	0.21	0.09	0.19	0.19	0.19
Dry season Min 5d Velocity	0.10	0.11	0.03	0.07	0.09	0.11	0.11	0.11	0.03	0.10	0.10	0.10
Wet season Max 5d Depth	0.60	0.61	0.37	0.42	0.52	0.52	0.52	0.53	0.37	0.60	0.60	0.60
Wet season Max 5d Velocity	0.49	0.49	0.27	0.36	0.42	0.42	0.42	0.44	0.27	0.49	0.49	0.49
Wet season Min 5d Velocity	0.23	0.23	0.07	0.26	0.25	0.23	0.23	0.24	0.07	0.24	0.25	0.23
MAR-baseflow	1.41	1.48	0.08	0.22	0.30	0.39	0.47	0.72	0.08	1.31	1.30	1.32
Dry-Min 5d Q-baseflow	0.21	0.26	0.01	0.09	0.16	0.21	0.21	0.22	0.01	0.17	0.17	0.17
Dry-daily ave vol-baseflow	0.07	0.07	0.00	0.02	0.02	0.03	0.04	0.05	0.00	0.06	0.06	0.06
Wet-Max 5d Q-baseflow	5.72	6.24	0.26	0.31	0.42	0.52	0.63	1.26	0.26	5.70	5.68	5.71
Wet-daily ave vol-baseflow	0.26	0.26	0.01	0.03	0.04	0.04	0.05	0.10	0.01	0.25	0.25	0.25
T1-daily ave vol-baseflow	0.10	0.10	0.01	0.03	0.03	0.04	0.05	0.09	0.01	0.10	0.10	0.10
T2-daily ave vol-baseflow	0.00	0.00	0.00	0.03	0.03	0.04	0.05	0.10	0.00	0.00	0.00	0.00
Wet season max instantaneous Q	33.50	34.51	17.54	20.49	29.36	29.36	29.36	29.36	17.54	34.04	33.81	33.92
Wet season min instantaneous Q	0.73	0.71	0.08	0.30	0.40	0.50	0.60	1.11	0.08	0.72	0.73	0.64
1:2 Class5	0.63	0.63	0.15	0.43	0.43	0.43	0.43	0.63	0.15	0.59	0.59	0.59
1:5 Class6	0.13	0.13	0.06	0.13	0.13	0.13	0.13	0.13	0.06	0.13	0.13	0.13
1:10 Class7	0.04	0.04	0.02	0.04	0.04	0.04	0.04	0.04	0.02	0.04	0.04	0.04
1:20 Class8	0.04	0.06	0.07	0.06	0.06	0.06	0.06	0.04	0.07	0.04	0.04	0.04
Dry Class1	0.31	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.30	0.30
Dry Class2	0.22	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.19	0.19
Dry Class3	0.07	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.07
Dry Class4	0.09	0.09	0.04	0.02	0.02	0.02	0.02	0.00	0.04	0.09	0.09	0.09
T1 Class1	0.31	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.30	0.30
T1 Class2	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.13
T1 Class3	0.04	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.04	0.04
T1 Class4	0.06	0.06	0.02	0.02	0.02	0.02	0.02	0.00	0.02	0.07	0.07	0.07
Wet Class1	1.94	1.94	0.00	0.83	1.11	2.00	2.00	2.87	0.00	2.04	2.06	1.96
Wet Class2	2.43	2.61	0.00	0.80	0.91	1.61	1.61	2.41	0.00	2.28	2.30	2.33
Wet Class3	1.69	1.72	0.06	0.00	0.81	0.81	0.81	1.31	0.06	1.63	1.56	1.61
Wet Class4	0.96	1.02	0.30	0.09	0.56	0.56	0.56	0.48	0.30	0.94	0.94	0.94
T2 Class1	0.35	0.39	0.00	0.15	0.06	0.17	0.17	0.20	0.00	0.31	0.31	0.31
T2 Class2	0.39	0.41	0.00	0.09	0.19	0.22	0.22	0.26	0.00	0.39	0.37	0.39
T2 Class3	0.19	0.22	0.00	0.00	0.11	0.11	0.11	0.22	0.00	0.19	0.19	0.19
T2 Class4	0.13	0.13	0.06	0.00	0.06	0.06	0.06	0.06	0.06	0.13	0.13	0.13

16 EWR SITE AS1 (ASSEGAAI RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site AS1. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

On the basis of the results in Figure 8-1 the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Assegaai	AS1	C	B	D	-
		SS4a	SS5[8]	SS2	-

16.1 Mean percentage changes

The mean percentage changes (relative to Baseline) in indicators for the EWRs that were selected as potential Reserves to maintain the REC and AECs at EWR Site AS1 are given in Table 16-1. The changes illustrate that some change is expected from baseline with each scenario. In addition, not all changes are positive even for the B-category, i.e., some indicators are expected to do less well (e.g., Hydropsychidae), while others (e.g., *Labeobarbus marequensis*) will do better. Overall, however, the B-scenario is expected to maintain a better ecological condition. The D-scenario will result in some significant declines, particularly in sensitive taxa.

[8] Should maintain a B provided non-flow related impacts are addressed.

Table 16-1 EWR Site AS1: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

Discipline	Indicator	REC SS4a C category	AEC1 SS5 B category	AEC2 SS2 D category
Geomorphology	Channel width	1.57	1.48	1.08
	Extent of cut banks	0.55	1.94	0.21
	Secondary channels	1.81	2.06	1.87
	Pool depth	1.02	4.15	15.26
	Bed sediment conditions	-1.7	-0.08	-13.75
Water quality	Summer water temperature	1.67	2.83	11.51
	Nutrients - phosphates	3.23	0.00	12.11
	Nutrients - nitrogen	5.23	1.92	35.07
	Electrical conductivity (salinity)	4.1	2.48	21
	Sulphates	1.56	3.21	6.68
Riparian Vegetation	Algae	6.2	2.11	18.12
	Marginal zone graminoids	-5.96	8.28	-60.7
	Marginal zone trees	-8.81	13.52	-62.8
	Lower zone graminoids	-13.03	2.10	-73.68
	Lower zone trees	-5.77	11.88	-53.5
	Upper zone trees - riparian	-5.82	0.16	-22.47
	Upper zone trees - terrestrial	10.47	2.94	46.71
Macro-invertebrates	Atyidae (Freshwater Shrimps)	-7.81	1.34	-39.73
	Perlidae (Stoneflies)	-30.5	-18.50	-86.67
	Hydropsychidae (Caddisflies)	-15.32	-7.33	-60.22
	Heptageniidae (Flatheaded mayfly)	-16.04	-7.66	-61.25
	Gomphidae (Clubtails)	10.07	10.61	42.77
	Leptophlebiidae (Prongills)	3.47	5.15	-9.11
	Baetidae (Minnow mayflies)	-4.02	1.19	-35.81
	Chironomidae (Midges)	-4.04	0.67	-25.7
	Simuliidae (Blackflies)	-10.89	-2.03	-52.84
Fish	Amphilius uranoscopus	-9.78	-3.96	-62.48
	Labeobarbus marequensis	-8.38	8.01	-79.85
	Barbus trimaculatus	0.04	0.52	-8.93
	Varicorhinus nelspruitensis	-9.06	-4.8	-57.25

16.2 Time series

The time series of predicted abundance changes relative to Baseline2014 for Base2014, Nat, and the EWRs for B-, C- and D-categories are provided for the indicators for each discipline (Figure 16-1 and Figure 16-5). The time-series illustrate the sorts of annual fluctuations that can be expected as a result of climatic variations, and as such may help to guide decisions based on future monitoring. The time-series also illustrate the responses of different indicators to different flow regimes, i.e., increased flow, such as that associated with a B-Category versus a D-Category river does not necessarily result in a universal improvement in all indicators. This is because changes in flow affect the balance between species.

Figure 16-1 Time series for the geomorphological indicators at EWR Site AS1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

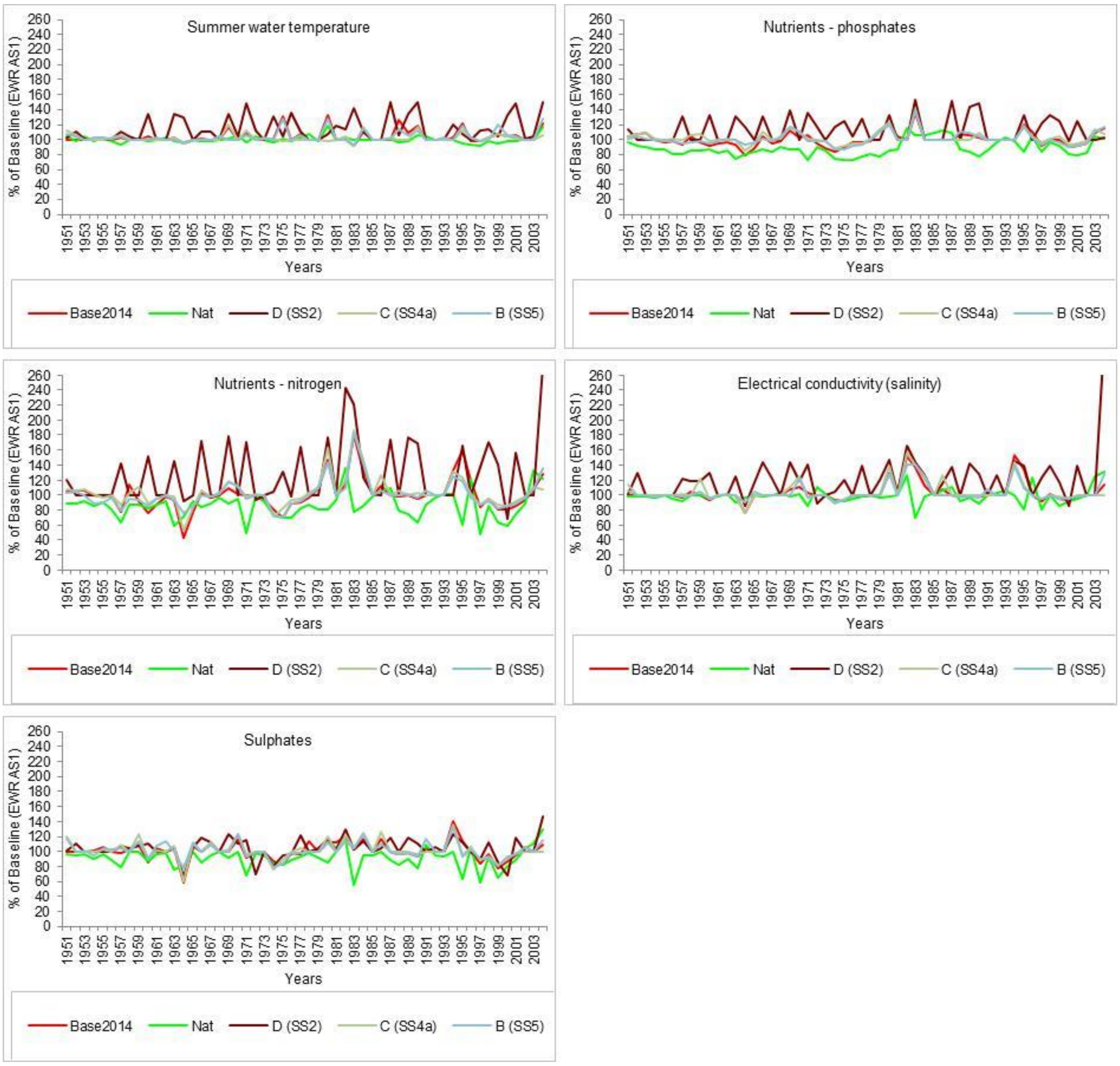


Figure 16-2 Time series for the water quality indicators at EWR Site AS1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

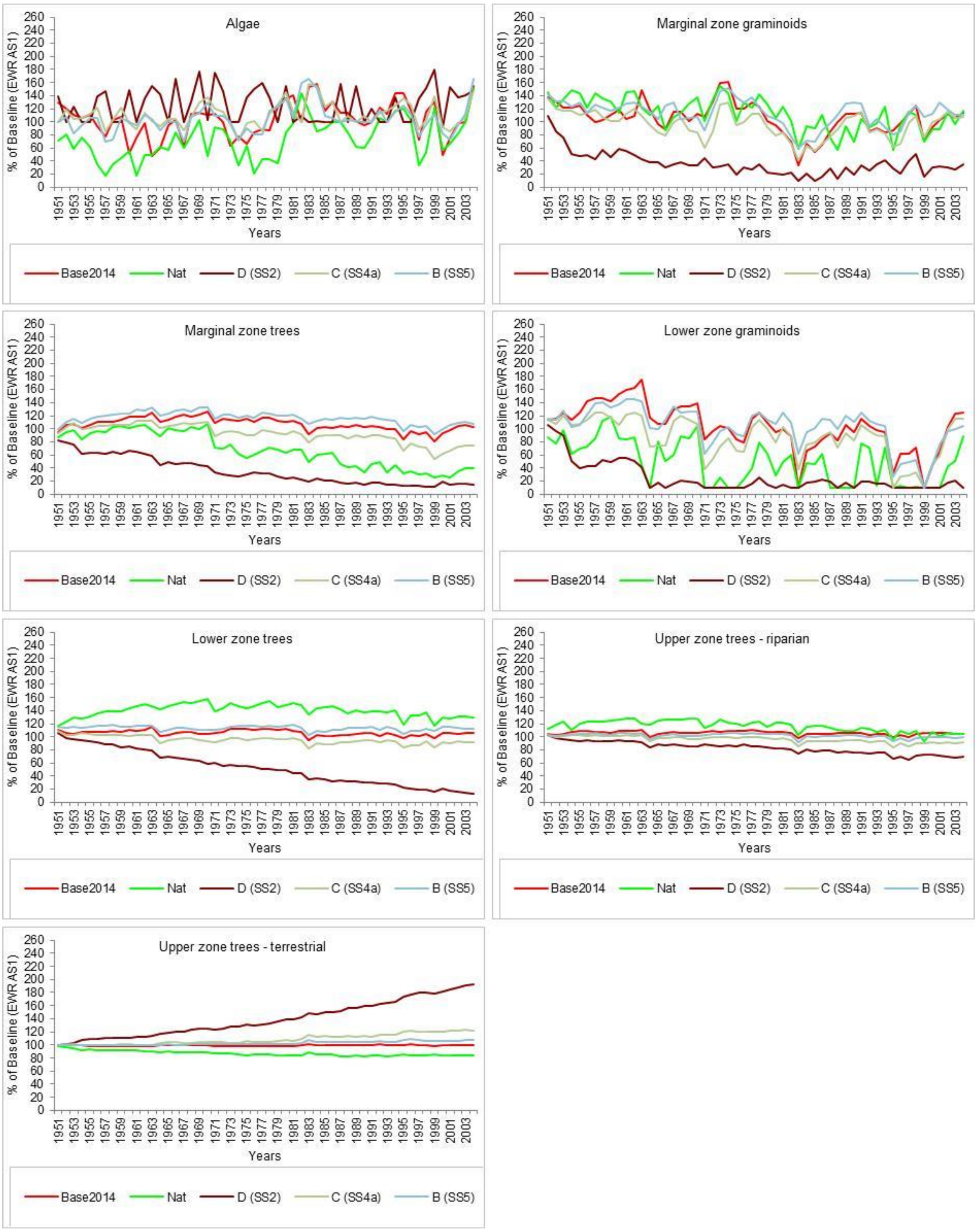


Figure 16-3 Time series for the riparian vegetation indicators at EWR Site AS1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

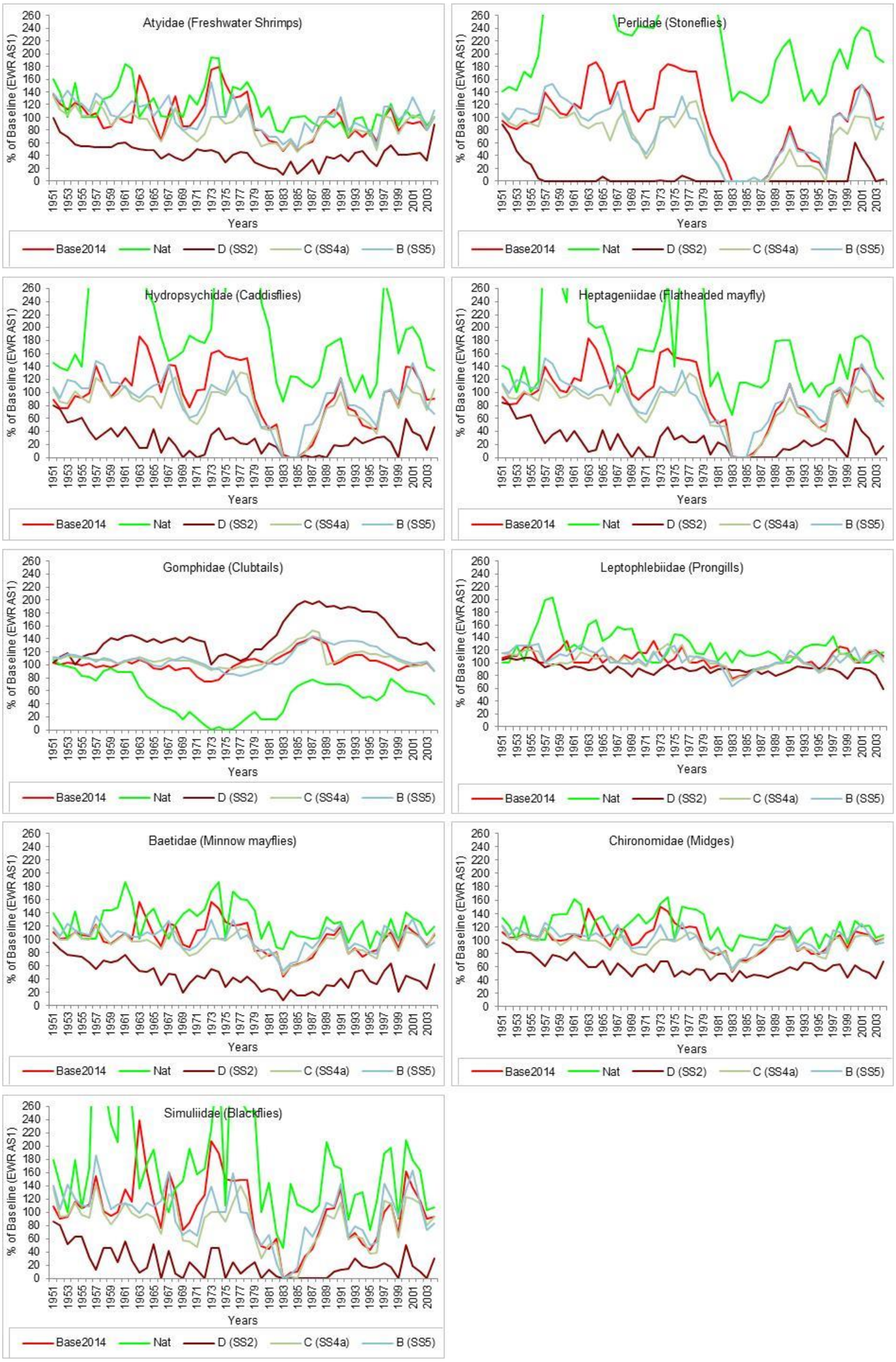


Figure 16-4 Time series for macroinvertebrate indicators at EWR Site AS1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

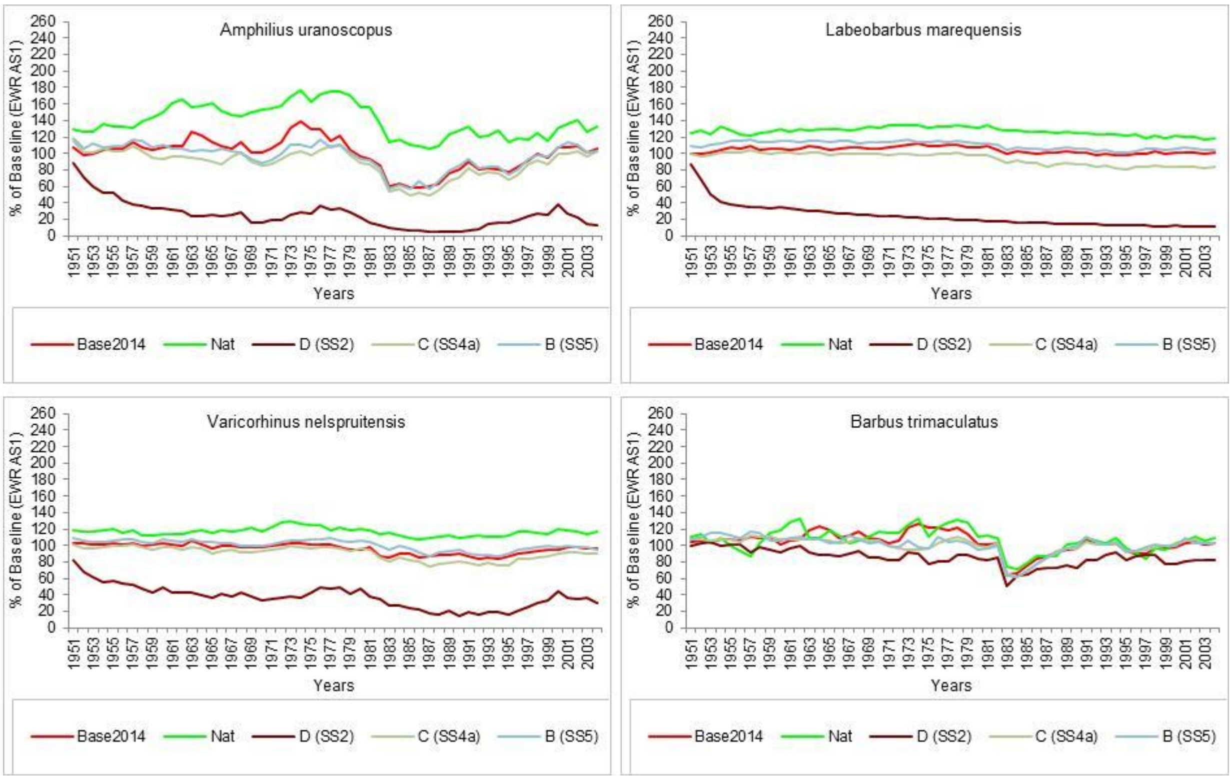


Figure 16-5 Time series for fish indicators at EWR Site AS1 Base2014, Nat, and the EWRs for B-, C- and D-category.

16.3 Hydrological summaries (AS1)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

16.3.1 Recommended Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C*		Discharge (m3/s)	3.50	6.40	11.90	23.10
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	2	3	4
			Number	3	6	4	1
Oct	1.519	4.068					
Nov	1.978	5.128		2	1	1	
Dec	2.884	7.723			3		1
Jan	3.112	8.334				2	
Feb	3.116	7.539		1	2		
Mar	2.841	7.610				1	
Apr	2.375	6.157					
May	2.098	5.620					
Jun	1.845	4.781					
Jul	1.734	4.643					
Aug	1.523	4.080					
Sep	1.390	3.603					

*See AEC2 (EC=D) for drought requirements

MAR	278.073	MCM	
S.Dev.	27.109		
CV	0.097		
Q75	8.917		
Ecological Category C			
	MCM	% MAR	
Total IFR	92.650	33.319	(excl. >=1:2)
Maint. Lowflow	69.287	24.917	
Drought Lowflow	37.450	13.468	
Maint. Highflow	23.363	8.402	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	14.687	4.068	2.065	1.291	5.359
Nov	26.904	5.128	2.155	3.021	8.149
Dec	46.557	7.723	4.804	5.749	13.472
Jan	53.472	8.334	4.741	5.043	13.378
Feb	45.222	7.539	3.922	4.377	11.916
Mar	32.229	7.610	3.966	2.520	10.130
Apr	18.970	6.157	2.681	1.203	7.359
May	11.874	5.620	2.782	0.141	5.760
Jun	8.255	4.781	2.555	0.000	4.781
Jul	7.349	4.643	2.662	0.000	4.643
Aug	6.086	4.080	2.626	0.000	4.080
Sep	6.467	3.603	2.492	0.018	3.622

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	3.436	2.815	2.035	1.727	1.539	1.305	1.247	1.133	1.036	0.671
Nov	4.807	4.382	3.770	3.352	2.992	2.185	1.703	1.560	1.123	0.601
Dec	10.850	6.371	5.466	4.594	4.239	3.374	2.735	2.300	2.057	1.100
Jan	8.512	7.307	6.588	5.320	4.334	3.745	3.037	2.459	1.709	1.190
Feb	9.236	7.159	5.635	4.733	4.184	3.680	3.324	2.992	1.526	0.550
Mar	5.749	5.426	4.703	3.883	3.445	2.722	2.446	2.029	1.531	0.547
Apr	4.728	3.627	3.422	3.107	2.523	2.362	2.253	1.960	1.252	0.579
May	2.862	2.642	2.375	2.306	2.113	2.030	1.875	1.584	1.278	0.687
Jun	2.490	2.171	2.090	1.994	1.844	1.666	1.547	1.348	1.056	0.683
Jul	2.269	2.031	1.900	1.803	1.684	1.543	1.481	1.332	1.187	0.757
Aug	2.035	1.744	1.620	1.563	1.540	1.414	1.310	1.161	1.021	0.725
Sep	1.986	1.623	1.444	1.401	1.337	1.243	1.185	1.059	0.944	0.643

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	2.320	2.071	1.684	1.544	1.335	1.244	1.122	1.052	0.944	0.671
Nov	2.873	2.579	2.474	2.318	2.035	1.697	1.549	1.347	1.081	0.601
Dec	4.468	4.135	3.703	3.356	2.650	2.257	2.120	1.863	1.472	0.931
Jan	4.569	4.387	3.979	3.658	3.201	2.591	2.345	1.971	1.458	1.080
Feb	4.592	4.252	3.864	3.520	3.114	2.939	2.655	2.312	1.310	0.550
Mar	4.232	3.939	3.670	3.212	2.950	2.675	2.270	1.807	1.156	0.547
Apr	3.257	3.119	3.067	2.761	2.403	2.263	2.073	1.854	1.252	0.579
May	2.862	2.642	2.375	2.292	2.113	2.026	1.871	1.513	1.266	0.687
Jun	2.490	2.171	2.090	1.994	1.844	1.666	1.547	1.348	1.056	0.683
Jul	2.269	2.031	1.900	1.803	1.684	1.543	1.481	1.332	1.187	0.757
Aug	2.035	1.744	1.620	1.563	1.540	1.414	1.310	1.161	1.021	0.725
Sep	1.986	1.623	1.437	1.376	1.312	1.239	1.154	1.059	0.944	0.643

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	12.768	6.868	5.023	3.649	3.099	2.444	2.008	1.437	1.003	0.714
Nov	22.358	15.644	10.774	8.772	7.681	6.998	5.453	4.634	2.833	1.804
Dec	37.225	21.578	18.221	14.977	13.609	10.903	9.051	7.388	5.580	2.508
Jan	29.424	25.203	19.661	17.115	15.110	11.741	9.629	7.829	6.593	2.971
Feb	37.847	27.990	21.914	16.067	14.364	11.626	8.981	6.964	5.635	2.499
Mar	19.674	15.939	13.638	12.413	10.872	7.833	6.720	5.110	3.660	1.997
Apr	13.139	9.340	8.567	7.847	6.103	5.271	4.430	3.814	3.054	1.740
May	6.517	5.809	4.406	3.967	3.737	3.432	3.138	2.566	1.652	1.378
Jun	5.664	4.134	3.466	3.238	2.990	2.593	2.312	1.946	1.338	1.103
Jul	4.864	3.315	2.800	2.654	2.449	2.138	1.992	1.690	1.433	1.005
Aug	3.937	2.837	2.315	2.070	1.867	1.791	1.616	1.330	1.136	0.809
Sep	4.123	2.878	2.292	2.033	1.879	1.708	1.502	1.341	1.001	0.588

16.3.2 Alternative Ecological Category B

<table>
<tr><td rowspan="4"></td><td colspan="2">Baseflows</td><td>High flows (excl. >1:2 yr)</td><td>Class1</td><td>Class2</td><td>Class3</td><td>Class4</td></tr>
<tr><td colspan="2">REC: B</td><td>Discharge (m3/s)</td><td>3.50</td><td>6.40</td><td>11.90</td><td>23.10</td></tr>
<tr><td rowspan="2">Discharge (m^3/s)</td><td rowspan="2">Monthly volume ($10^6 m^3$)</td><td>Duration (days)</td><td>3</td><td>4</td><td>4</td><td>4</td></tr>
<tr><td>Number</td><td>6</td><td>8</td><td>4</td><td>1</td></tr>
<tr><td>Oct</td><td>1.731</td><td>4.635</td><td rowspan="12"></td><td rowspan="3">3</td><td></td><td></td><td></td></tr>
<tr><td>Nov</td><td>2.627</td><td>6.810</td><td rowspan="2">3</td><td></td><td></td></tr>
<tr><td>Dec</td><td>4.308</td><td>11.538</td><td rowspan="2">2</td><td rowspan="3">1</td></tr>
<tr><td>Jan</td><td>4.408</td><td>11.807</td><td rowspan="3">2</td><td rowspan="2">3</td></tr>
<tr><td>Feb</td><td>3.999</td><td>9.676</td><td rowspan="2">2</td></tr>
<tr><td>Mar</td><td>3.617</td><td>9.688</td><td rowspan="2">2</td><td></td></tr>
<tr><td>Apr</td><td>2.558</td><td>6.632</td><td rowspan="2">1</td><td></td><td></td></tr>
<tr><td>May</td><td>2.395</td><td>6.415</td><td></td><td></td><td></td></tr>
<tr><td>Jun</td><td>2.147</td><td>5.566</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jul</td><td>1.863</td><td>4.990</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aug</td><td>1.706</td><td>4.569</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sep</td><td>1.501</td><td>3.890</td><td></td><td></td><td></td><td></td></tr>
</table>

AEC1	SS5		
MAR	278.073	MCM	
S.Dev.	27.109		
CV	0.097		
Q75	8.917		
Ecological Category B			
	MCM	% MAR	
Total IFR	110.217	39.636	(excl. >=1:2)
Maint. Lowflow	86.216	31.005	
Drought Lowflow	37.450	13.468	
Maint. Highflow	24.001	8.631	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)		High Flows	Total Flows
		Low flows			
	Mean	Maint.	Drought	Maint.	Maint.
Oct	14.687	4.635	2.065	1.431	6.066
Nov	26.904	6.810	2.155	2.979	9.788
Dec	46.557	11.538	4.804	5.456	16.995
Jan	53.472	11.807	4.741	4.752	16.559
Feb	45.222	9.676	3.922	4.203	13.878
Mar	32.229	9.688	3.966	3.009	12.697
Apr	18.970	6.632	2.681	1.548	8.180
May	11.874	6.415	2.782	0.472	6.887
Jun	8.255	5.566	2.555	0.028	5.594
Jul	7.349	4.990	2.662	0.033	5.022
Aug	6.086	4.569	2.626	0.010	4.580
Sep	6.467	3.890	2.492	0.080	3.970

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	3.926	3.261	2.538	2.126	1.902	1.510	1.358	1.216	1.142	0.675
Nov	6.158	5.047	4.532	4.034	3.431	2.751	2.213	1.695	1.175	0.679
Dec	12.182	8.622	7.319	6.500	5.270	4.618	3.421	2.976	2.165	1.136
Jan	11.789	9.114	7.961	6.690	5.262	4.446	3.457	2.860	1.768	1.200
Feb	11.173	8.623	6.533	5.443	5.064	4.213	3.677	3.272	1.569	0.554
Mar	7.930	6.755	6.365	5.489	4.536	3.393	2.844	2.170	1.535	0.546
Apr	6.129	4.153	3.755	3.120	2.576	2.362	2.253	1.957	1.254	0.575
May	3.476	3.212	2.898	2.756	2.577	2.374	2.180	1.717	1.315	0.683
Jun	2.863	2.610	2.568	2.479	2.302	2.061	1.907	1.548	1.092	0.685
Jul	2.410	2.240	2.125	2.023	1.913	1.728	1.616	1.478	1.194	0.758
Aug	2.220	2.029	1.916	1.862	1.791	1.678	1.461	1.266	1.065	0.729
Sep	2.094	1.828	1.653	1.592	1.491	1.441	1.310	1.181	1.009	0.641

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	2.767	2.594	1.989	1.768	1.513	1.321	1.177	1.102	0.920	0.609
Nov	4.458	3.424	3.000	2.899	2.370	1.855	1.571	1.432	1.100	0.631
Dec	7.295	6.160	5.304	4.610	3.538	2.939	2.595	1.989	1.418	0.866
Jan	7.866	7.292	5.390	4.509	3.871	3.120	2.466	1.996	1.424	1.095
Feb	7.283	5.564	4.673	4.083	3.341	3.144	2.745	2.305	1.334	0.554
Mar	6.288	5.240	4.534	4.243	3.581	2.779	2.260	1.836	1.162	0.546
Apr	3.743	3.475	3.201	2.773	2.313	2.228	2.009	1.833	1.254	0.575
May	3.380	3.044	2.704	2.540	2.430	2.287	2.006	1.540	1.276	0.683
Jun	2.863	2.608	2.564	2.479	2.302	2.029	1.883	1.548	1.092	0.685
Jul	2.410	2.240	2.125	2.023	1.913	1.728	1.580	1.407	1.194	0.758
Aug	2.220	2.019	1.916	1.862	1.791	1.670	1.461	1.266	1.065	0.729
Sep	2.051	1.828	1.650	1.574	1.484	1.390	1.285	1.180	1.009	0.641

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	12.768	6.868	5.023	3.649	3.099	2.444	2.008	1.437	1.003	0.714
Nov	22.358	15.644	10.774	8.772	7.681	6.998	5.453	4.634	2.833	1.804
Dec	37.225	21.578	18.221	14.977	13.609	10.903	9.051	7.388	5.580	2.508
Jan	29.424	25.203	19.661	17.115	15.110	11.741	9.629	7.829	6.593	2.971
Feb	37.847	27.990	21.914	16.067	14.364	11.626	8.981	6.964	5.635	2.499
Mar	19.674	15.939	13.638	12.413	10.872	7.833	6.720	5.110	3.660	1.997
Apr	13.139	9.340	8.567	7.847	6.103	5.271	4.430	3.814	3.054	1.740
May	6.517	5.809	4.406	3.967	3.737	3.432	3.138	2.566	1.652	1.378
Jun	5.664	4.134	3.466	3.238	2.990	2.593	2.312	1.946	1.338	1.103
Jul	4.864	3.315	2.800	2.654	2.449	2.138	1.992	1.690	1.433	1.005
Aug	3.937	2.837	2.315	2.070	1.867	1.791	1.616	1.330	1.136	0.809
Sep	4.123	2.878	2.292	2.033	1.879	1.708	1.502	1.341	1.001	0.588

16.3.3 Alternative Ecological Category D

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: D		Discharge (m3/s)	3.50	6.40	11.90	23.10
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	2	3	4
			Number	2	2	2	1
Oct	0.771	2.065					
Nov	0.831	2.155					
Dec	1.794	4.804		2	2		1
Jan	1.770	4.741				2	
Feb	1.621	3.922					
Mar	1.481	3.966					
Apr	1.034	2.681					
May	1.039	2.782					
Jun	0.986	2.555					
Jul	0.994	2.662					
Aug	0.980	2.626					
Sep	0.962	2.492					

MAR	278.073	MCM	
S.Dev.	27.109		
CV	0.097		
Q75	8.917		
Ecological Category D			
	MCM	% MAR	
Total IFR	53.656	19.296	(excl. >=1:2)
Maint. Lowflow	37.450	13.468	
Drought Lowflow	37.450	13.468	
Maint. Highflow	16.206	5.828	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	14.687	2.065	2.065	0.918	2.983
Nov	26.904	2.155	2.155	2.164	4.319
Dec	46.557	4.804	4.804	3.944	8.747
Jan	53.472	4.741	4.741	3.636	8.377
Feb	45.222	3.922	3.922	3.432	7.354
Mar	32.229	3.966	3.966	1.454	5.420
Apr	18.970	2.681	2.681	0.613	3.294
May	11.874	2.782	2.782	0.027	2.809
Jun	8.255	2.555	2.555	0.000	2.555
Jul	7.349	2.662	2.662	0.000	2.662
Aug	6.086	2.626	2.626	0.000	2.626
Sep	6.467	2.492	2.492	0.019	2.511

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category D
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	1.871	1.258	0.891	0.804	0.803	0.802	0.798	0.785	0.751	0.489
Nov	2.970	2.115	1.852	1.235	1.075	0.811	0.807	0.805	0.740	0.439
Dec	7.694	3.109	2.783	2.629	1.968	1.605	1.484	1.299	1.255	0.885
Jan	5.798	4.319	3.449	2.583	2.254	1.694	1.386	1.288	1.257	1.045
Feb	6.760	3.731	2.860	2.396	2.075	1.806	1.299	1.285	1.137	0.535
Mar	2.862	2.293	1.929	1.476	1.291	1.287	1.286	1.260	1.051	0.541
Apr	1.865	1.418	1.214	1.079	1.072	1.067	1.066	1.063	1.056	0.556
May	1.069	1.066	1.064	1.064	1.063	1.062	1.062	1.061	1.025	0.672
Jun	1.006	1.005	1.004	1.002	1.002	1.001	1.001	1.001	0.980	0.682
Jul	1.003	1.002	1.002	1.002	1.001	1.001	1.001	0.999	0.991	0.758
Aug	1.005	1.002	1.002	1.001	1.001	1.001	0.992	0.980	0.922	0.698
Sep	1.017	1.002	1.002	1.000	0.997	0.991	0.969	0.920	0.853	0.641

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.808	0.805	0.804	0.803	0.801	0.798	0.781	0.767	0.721	0.449
Nov	0.818	0.811	0.808	0.806	0.806	0.805	0.803	0.788	0.740	0.439
Dec	4.283	1.321	1.299	1.287	1.283	1.272	1.255	1.237	1.126	0.818
Jan	1.311	1.298	1.294	1.291	1.289	1.287	1.286	1.233	1.161	0.988
Feb	1.329	1.300	1.292	1.289	1.287	1.285	1.284	1.268	1.114	0.535
Mar	1.297	1.291	1.288	1.287	1.286	1.285	1.271	1.213	1.009	0.541
Apr	1.079	1.073	1.070	1.067	1.067	1.066	1.064	1.063	1.056	0.556
May	1.069	1.066	1.064	1.064	1.063	1.062	1.062	1.061	1.025	0.672
Jun	1.006	1.005	1.004	1.002	1.002	1.001	1.001	1.001	0.980	0.682
Jul	1.003	1.002	1.002	1.002	1.001	1.001	1.001	0.999	0.991	0.758
Aug	1.005	1.002	1.002	1.001	1.001	1.001	0.992	0.980	0.922	0.698
Sep	1.009	1.002	1.002	1.000	0.996	0.984	0.967	0.914	0.853	0.641

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	12.768	6.868	5.023	3.649	3.099	2.444	2.008	1.437	1.003	0.714
Nov	22.358	15.644	10.774	8.772	7.681	6.998	5.453	4.634	2.833	1.804
Dec	37.225	21.578	18.221	14.977	13.609	10.903	9.051	7.388	5.580	2.508
Jan	29.424	25.203	19.661	17.115	15.110	11.741	9.629	7.829	6.593	2.971
Feb	37.847	27.990	21.914	16.067	14.364	11.626	8.981	6.964	5.635	2.499
Mar	19.674	15.939	13.638	12.413	10.872	7.833	6.720	5.110	3.660	1.997
Apr	13.139	9.340	8.567	7.847	6.103	5.271	4.430	3.814	3.054	1.740
May	6.517	5.809	4.406	3.967	3.737	3.432	3.138	2.566	1.652	1.378
Jun	5.664	4.134	3.466	3.238	2.990	2.593	2.312	1.946	1.338	1.103
Jul	4.864	3.315	2.800	2.654	2.449	2.138	1.992	1.690	1.433	1.005
Aug	3.937	2.837	2.315	2.070	1.867	1.791	1.616	1.330	1.136	0.809
Sep	4.123	2.878	2.292	2.033	1.879	1.708	1.502	1.341	1.001	0.588

17 EWR SITE UP1 (UPPER PONGOLA RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site UP1. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

On the basis of the results in Figure 9-1 and Figure 9-2, the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Upper Pongola	BM1	C	B	D	-
		SS4	Sc5[9]	SS2	

17.1 Mean percentage changes

The mean percentage changes (relative to Baseline) in indicators for the EWRs that were selected as potential Reserves to maintain the REC and AECs at EWR Site UP1 are given in Table 17-1.

[9] Flow along returns a low B, if non-flow related impacts are addressed a higher B will be maintained

Table 17-1 EWR Site UP1: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

Discipline	Indicator	REC SS4 C category	AEC1 Sc5 B category	AEC2 SS2 D category
Geomorphology	Channel width	7.78	4.08	2.88
	Extent of cut banks	3.01	4.01	1.5
	Secondary channels	-0.03	3.64	-5.93
	Pool depth	0.98	1.24	0.56
	Bed sediment conditions	0.92	1.43	-11.57
Water quality	Summer water temperature	2.29	0.83	3.66
	Nutrients - phosphates	8.01	5.21	50.65
	Nutrients - nitrogen	7.32	5.76	49.06
	Electrical conductivity (salinity)	2.48	1.08	10.64
	Sulphates	6.8	5.01	27.4
Riparian Vegetation	Algae	3.53	-2.02	11.09
	Marginal zone graminoids	-19.52	-1.37	-55.78
	Marginal zone trees	-16.8	-3.3	-54.04
	Lower zone graminoids	-23.46	-7.87	-60.02
	Lower zone trees	-21.9	-3.1	-71.66
	Upper zone trees - riparian	-18.44	-0.08	-64.45
	Upper zone trees - terrestrial	74.65	-15.97	550.09
Macro-invertebrates	Perlidae (Stoneflies)	-10.84	2.77	-46.82
	Hydropsychidae (Caddisflies)	-1.84	10.4	-49.09
	Heptageniidae (Flatheaded mayfly)	-5.45	12.05	-51.88
	Gomphidae (Clubtails)	-3.24	5.94	2.97
	Leptophlebiidae (Prongills)	0.14	1.38	-16.81
	Baetidae (Minnow mayflies)	-4.24	2.15	-21.86
	Chironomidae (Midges)	-1.24	2.95	-9.13
	Simuliidae (Blackflies)	-0.12	6.62	-25.28
	Coenagrionidae (Sprites & Blues)	-13.67	2.65	-53.99
Fish	Amphilius uranoscopus	-9.52	3.41	-65.01
	Oreochromis mossambicus	11.23	4.04	19.7
	Labeobarbus marequensis	-14.35	1.84	-82.81
	Barbus trimaculatus	3.01	2.27	-10.32
	Varicorhinus nelspruitensis	-12.37	-3.49	-66.47

17.2 Time series

The time series of predicted abundance changes relative to Baseline2014 for Base2014, Nat, and the EWRs for B-, C- and D-categories are provided for the indicators for each discipline (Figure 17-1 to Figure 17-5). The time-series illustrate the sorts of annual fluctuations that can be expected as a result of climatic variations, and as such may help to guide decisions based on future monitoring. The time-series also illustrate the responses of different indicators to different flow regimes, i.e., increased flow, such as that associated with a B-Category versus a D-Category river does not necessarily result in a universal improvement in all indicators, as changes in flow affect the balance between species.

Figure 17-1 Time series for the geomorphological indicators at EWR Site UP1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

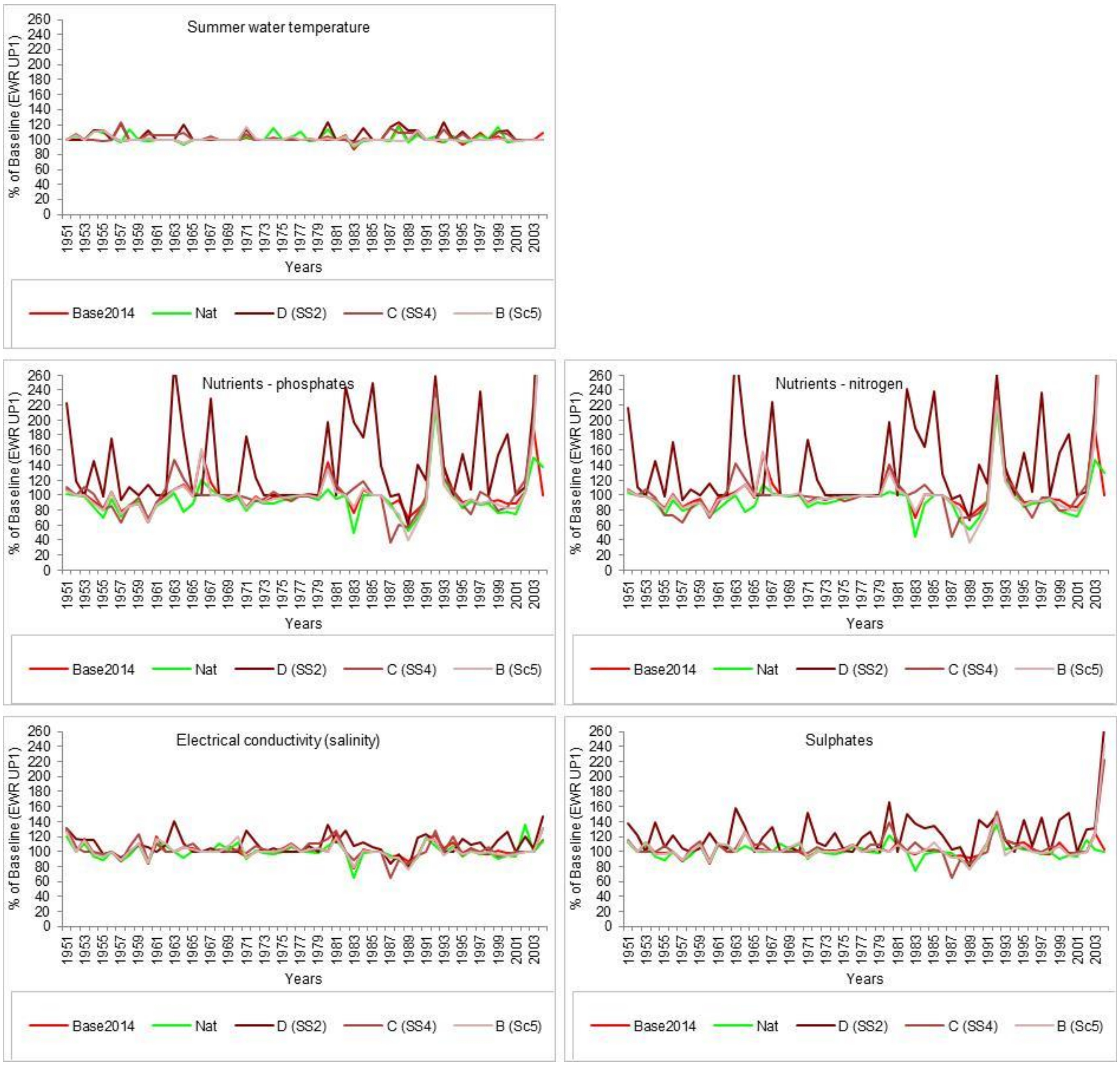


Figure 17-2 Time series for the water quality indicators at EWR Site UP1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

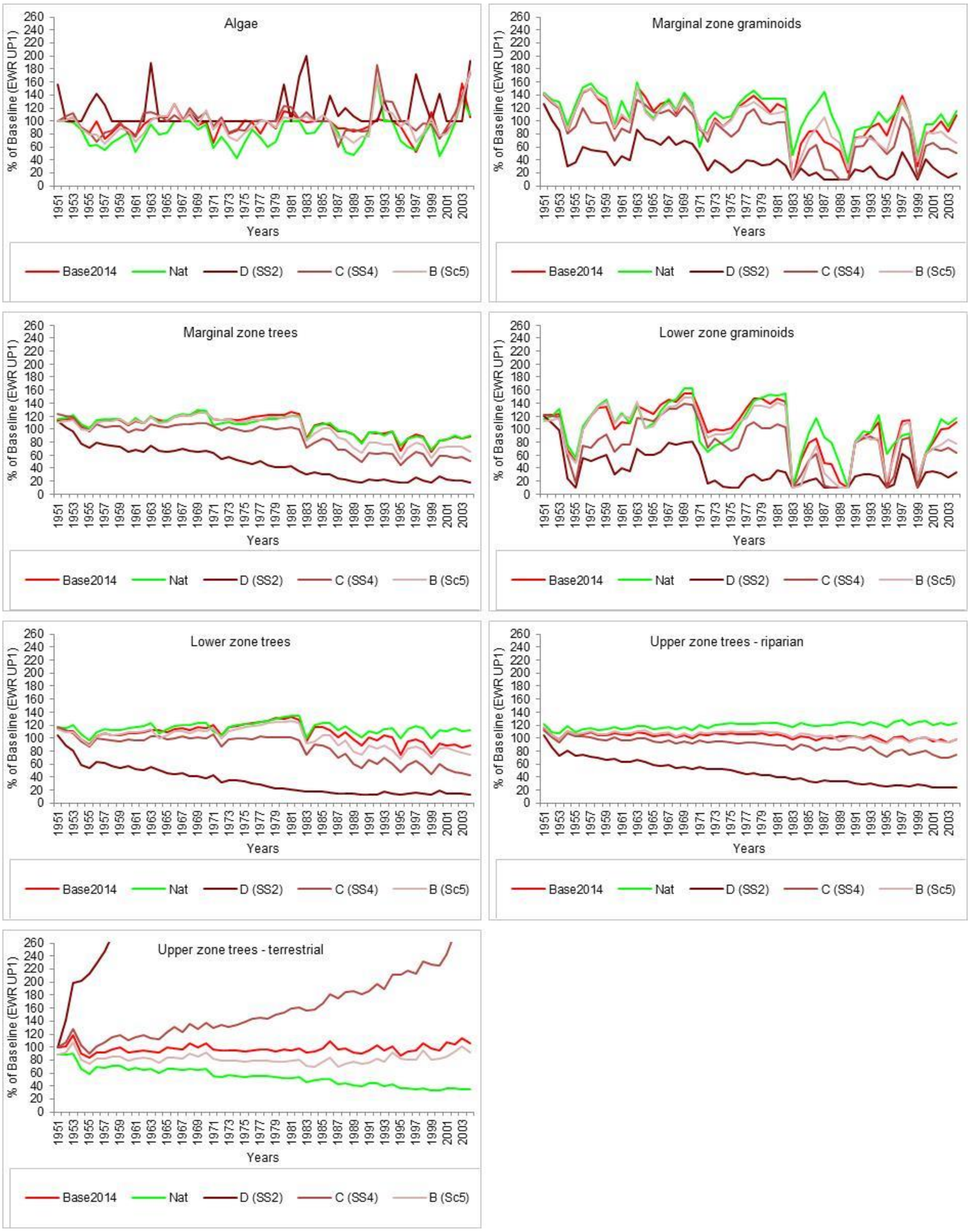


Figure 17-3 Time series for the vegetation indicators at EWR Site UP1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

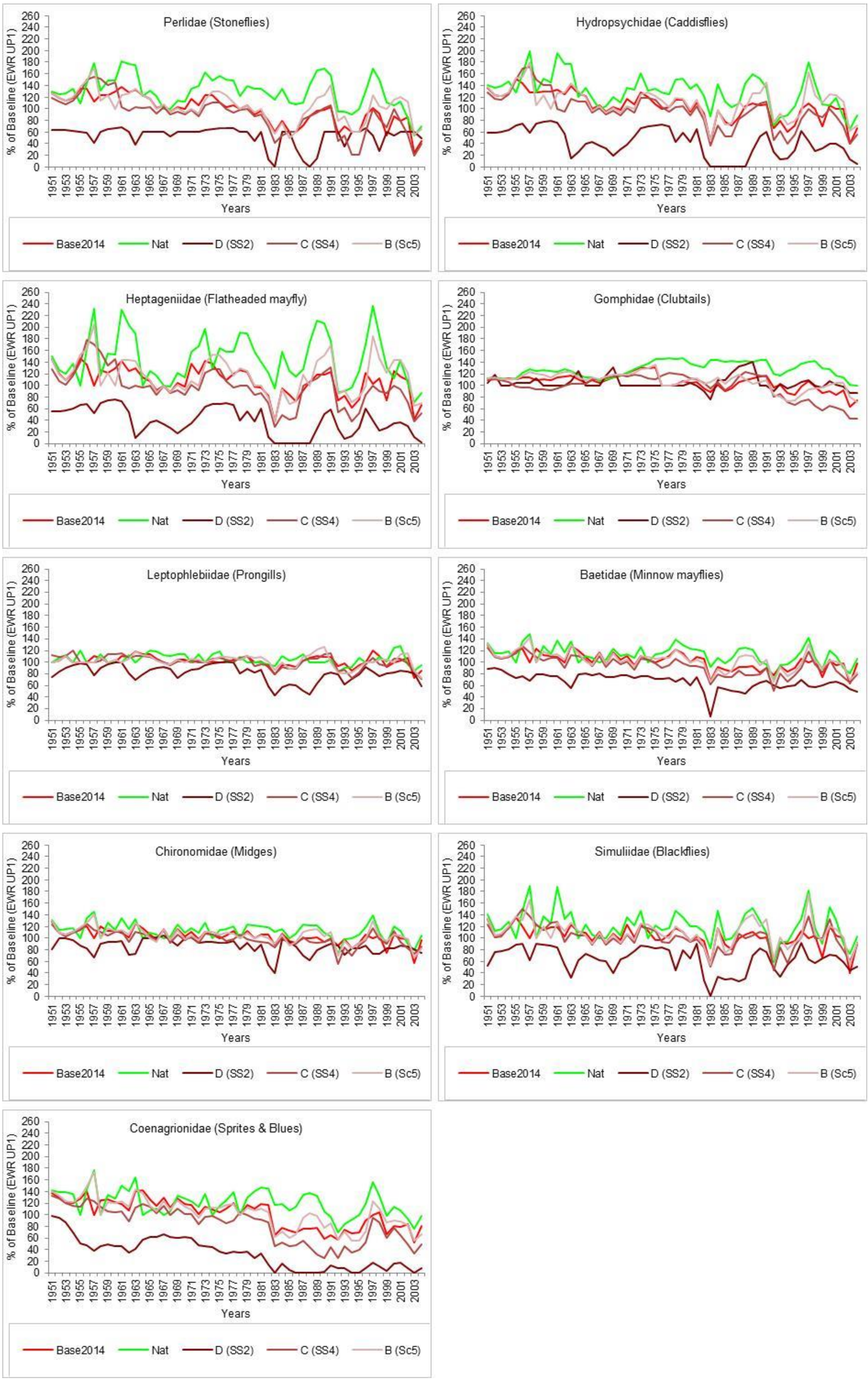


Figure 17-4 Time series for the macroinvertebrate indicators at EWR Site UP1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

Figure 17-5 Time series for the fish indicators at EWR Site UP1 for Base2014, Nat, and the EWRs for B-, C- and D-category.

17.3 Hydrological summaries (UP1)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

17.3.1 Recommended Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C*		Discharge (m3/s)	7.70	13.70	25.60	47.90
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	3	3	3	2
			Number	3	6	5	2
Oct	2.431	6.511			1		
Nov	4.652	12.057				4	2
Dec	4.964	13.295		3	3		
Jan	5.861	15.698					
Feb	6.201	15.001			2		
Mar	4.803	12.865				1	
Apr	3.394	8.797					
May	2.756	7.381					
Jun	1.272	3.298					
Jul	1.079	2.890					
Aug	0.945	2.531					
Sep	1.003	2.599					

*See AEC2 (EC=D) for drought requirements

```
MAR                  288.704         MCM
S.Dev.               27.109
CV                   0.094
Q75                  8.917
Ecological Category C
                     MCM             % MAR
Total IFR            148.195         51.331     (excl. >=1:2)
Maint. Lowflow       102.922         35.650
Drought Lowflow      50.553          17.510
Maint. Highflow      45.272          15.681
Monthly Distributions (MCM)
Distribution Type:   ?? KZN
Month                Natural Flows   Modified Flows (IFR)
                                     Low flows             High Flows   Total Flows
                     Mean            Maint.     Drought    Maint.       Maint.
Oct                  19.389          6.511      1.803      4.342        10.853
Nov                  35.092          12.057     7.193      7.453        19.510
Dec                  41.635          13.295     7.124      8.465        21.760
Jan                  56.683          15.698     8.759      8.746        24.443
Feb                  49.759          15.001     7.020      8.649        23.650
Mar                  30.083          12.865     6.407      5.185        18.050
Apr                  17.736          8.797      4.620      1.708        10.505
May                  11.033          7.381      4.513      0.128        7.509
Jun                  7.353           3.298      0.784      0.000        3.298
Jul                  7.093           2.890      0.812      0.519        3.410
Aug                  4.896           2.531      0.764      0.000        2.531
Sep                  7.951           2.599      0.752      0.077        2.676
```

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category C
Data are given in m^3/s mean monthly flow

Month	% Points 10	20	30	40	50	60	70	80	90	99
Oct	8.236	5.670	3.932	2.997	2.518	2.270	1.811	1.157	0.923	0.141
Nov	12.503	10.034	8.079	6.607	6.146	5.451	4.604	3.317	2.417	1.391
Dec	12.922	10.647	9.531	8.192	7.682	6.607	5.527	4.429	3.381	1.514
Jan	14.767	12.198	10.271	8.590	6.787	6.478	5.722	5.400	4.596	2.420
Feb	17.469	13.413	10.598	8.771	7.653	6.737	6.064	5.036	4.446	1.441
Mar	10.199	8.801	8.254	7.624	6.369	5.789	5.028	3.829	2.912	2.391
Apr	6.144	5.169	4.475	4.128	4.002	3.908	3.369	2.665	2.211	1.523
May	4.023	3.894	3.414	3.075	2.907	2.507	2.340	1.659	1.366	0.863
Jun	1.422	1.414	1.410	1.406	1.404	1.394	1.284	1.108	0.879	0.571
Jul	1.443	1.415	1.405	1.333	1.211	1.066	0.834	0.735	0.506	0.308
Aug	1.441	1.366	1.247	1.166	1.096	0.887	0.761	0.446	0.275	0.087
Sep	1.428	1.412	1.342	1.183	1.061	0.970	0.805	0.483	0.236	0.039

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	3.052	2.938	2.770	2.508	2.271	1.944	1.638	1.142	0.863	0.141
Nov	5.993	5.629	5.441	4.851	4.359	3.832	3.570	2.725	2.126	1.391
Dec	6.059	5.905	5.671	5.539	4.678	4.513	3.981	3.681	2.526	1.514
Jan	6.117	6.054	5.952	5.684	5.416	5.161	4.827	4.191	3.930	1.446
Feb	6.120	6.072	6.015	5.974	5.802	5.139	4.528	4.114	3.635	1.441
Mar	6.032	5.999	5.762	5.678	5.313	5.005	4.478	3.280	2.648	1.338
Apr	4.027	4.017	3.967	3.920	3.827	3.506	3.117	2.599	2.207	1.523
May	4.017	3.894	3.414	3.075	2.750	2.507	2.340	1.659	1.366	0.863
Jun	1.422	1.414	1.410	1.406	1.404	1.394	1.284	1.108	0.879	0.571
Jul	1.443	1.415	1.405	1.333	1.211	1.066	0.834	0.735	0.506	0.308
Aug	1.441	1.366	1.247	1.166	1.096	0.887	0.761	0.446	0.275	0.087
Sep	1.428	1.412	1.342	1.183	1.061	0.970	0.805	0.483	0.236	0.039

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	18.086	9.080	7.601	5.759	4.182	3.605	2.900	2.131	1.487	0.686
Nov	27.002	18.590	13.681	10.261	9.093	8.400	6.867	5.191	4.275	2.455
Dec	28.919	20.734	15.825	13.869	12.156	10.862	8.788	7.843	6.033	2.968
Jan	29.950	23.149	16.844	14.946	12.186	9.957	9.039	7.852	6.823	3.962
Feb	42.609	28.537	19.588	16.499	11.640	10.552	8.997	7.192	6.067	2.368
Mar	20.169	16.503	12.737	12.042	10.249	7.947	6.996	5.481	3.719	2.974
Apr	11.293	9.569	7.771	7.389	6.879	6.096	4.806	3.323	2.628	1.848
May	8.159	5.216	4.386	3.810	3.558	3.074	2.843	1.997	1.644	1.063
Jun	5.260	4.085	2.912	2.535	2.226	2.037	1.723	1.568	1.144	0.766
Jul	3.377	2.803	2.414	2.051	1.587	1.424	1.096	0.989	0.698	0.469
Aug	3.795	2.230	2.058	1.635	1.471	1.225	1.062	0.665	0.476	0.243
Sep	4.456	2.614	2.277	1.968	1.699	1.406	1.210	0.776	0.451	0.230

17.3.2 Alternative Ecological Category B

<table>
<tr><td rowspan="4"></td><td colspan="2">Baseflows</td><td>High flows (excl. >1:2 yr)</td><td>Class1</td><td>Class2</td><td>Class3</td><td>Class4</td></tr>
<tr><td colspan="2">REC: B</td><td>Discharge (m3/s)</td><td>7.30</td><td>13.20</td><td>26.60</td><td>47.70</td></tr>
<tr><td rowspan="2">Discharge (m^3/s)</td><td rowspan="2">Monthly volume ($10^6 m^3$)</td><td>Duration (days)</td><td>3</td><td>4</td><td>6</td><td>6</td></tr>
<tr><td>Number</td><td>3</td><td>6</td><td>5</td><td>2</td></tr>
<tr><td>Oct</td><td>3.729</td><td>9.988</td><td rowspan="12"></td><td rowspan="7">3</td><td></td><td></td><td></td></tr>
<tr><td>Nov</td><td>6.394</td><td>16.574</td><td>1</td><td></td><td rowspan="4">2</td></tr>
<tr><td>Dec</td><td>7.387</td><td>19.787</td><td rowspan="2">3</td><td rowspan="2">2</td></tr>
<tr><td>Jan</td><td>8.860</td><td>23.730</td></tr>
<tr><td>Feb</td><td>9.403</td><td>22.747</td><td rowspan="2">2</td><td rowspan="3">3</td></tr>
<tr><td>Mar</td><td>6.940</td><td>18.589</td><td></td></tr>
<tr><td>Apr</td><td>5.014</td><td>12.997</td><td></td><td></td></tr>
<tr><td>May</td><td>3.279</td><td>8.782</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jun</td><td>2.243</td><td>5.815</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jul</td><td>1.722</td><td>4.611</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aug</td><td>1.370</td><td>3.669</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sep</td><td>1.633</td><td>4.233</td><td></td><td></td><td></td><td></td></tr>
</table>

AEC1	Sc5				
MAR	288.704	MCM			
S.Dev.	27.109				
CV	0.094				
Q75	8.917				
Ecological Category	B				
	MCM	% MAR			
Total IFR	213.200	73.847	(excl. >=1:2)		
Maint. Lowflow	151.520	52.483			
Drought Lowflow	50.553	17.510			
Maint. Highflow	61.681	21.365			
Monthly Distributions (MCM)					
Distribution Type:	?? KZN				
Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	19.389	9.988	1.803	5.329	15.317
Nov	35.092	16.574	7.193	10.091	26.665
Dec	41.635	19.787	7.124	11.726	31.513
Jan	56.683	23.730	8.759	10.945	34.674
Feb	49.759	22.747	7.020	10.719	33.467
Mar	30.083	18.589	6.407	7.238	25.827
Apr	17.736	12.997	4.620	2.637	15.634
May	11.033	8.782	4.513	0.702	9.483
Jun	7.353	5.815	0.784	0.300	6.115
Jul	7.093	4.611	0.812	0.770	5.381
Aug	4.896	3.669	0.764	0.228	3.896
Sep	7.951	4.233	0.752	0.996	5.229

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	11.032	7.862	6.393	4.702	3.233	2.761	2.207	1.455	1.061	0.190
Nov	19.947	15.389	12.137	8.760	7.604	6.672	5.245	4.096	2.999	1.414
Dec	21.347	17.453	13.830	11.892	10.099	8.614	7.053	6.296	4.733	1.645
Jan	23.948	20.008	15.078	12.967	10.346	7.855	7.455	6.455	5.287	2.783
Feb	27.331	22.109	16.658	13.749	10.289	9.077	7.688	5.935	5.172	1.550
Mar	18.005	14.669	11.461	10.829	9.166	7.013	6.190	4.777	3.121	2.436
Apr	10.152	8.518	6.888	6.541	6.053	5.346	4.146	2.787	2.164	1.494
May	7.238	4.527	3.773	3.230	2.987	2.580	2.343	1.616	1.328	0.859
Jun	4.533	3.493	2.389	2.039	1.763	1.609	1.356	1.229	0.891	0.581
Jul	2.775	2.258	1.941	1.608	1.240	1.099	0.836	0.762	0.515	0.331
Aug	3.171	1.753	1.622	1.256	1.120	0.930	0.780	0.467	0.305	0.125
Sep	3.731	2.042	1.751	1.511	1.277	1.027	0.879	0.509	0.264	0.074

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	6.532	5.142	4.039	3.189	2.471	2.197	1.950	1.199	0.925	0.190
Nov	12.208	9.625	7.090	6.000	5.161	4.335	3.638	2.948	2.065	1.414
Dec	13.413	10.636	8.515	7.006	6.001	5.455	4.694	4.012	3.165	1.645
Jan	14.526	12.585	9.450	7.840	6.530	6.159	5.674	4.555	4.131	1.970
Feb	18.776	13.608	10.246	8.568	7.189	6.411	5.528	4.320	3.670	1.550
Mar	11.459	10.335	8.441	7.116	6.255	5.536	4.943	3.427	2.833	2.026
Apr	7.753	7.122	5.899	5.385	5.071	4.729	3.668	2.719	2.157	1.494
May	5.893	4.527	3.719	3.194	2.823	2.470	2.226	1.616	1.328	0.859
Jun	4.219	3.230	2.389	2.039	1.763	1.609	1.356	1.229	0.891	0.581
Jul	2.775	2.081	1.812	1.594	1.240	1.099	0.836	0.762	0.515	0.331
Aug	2.187	1.748	1.552	1.256	1.120	0.930	0.780	0.467	0.305	0.125
Sep	3.258	2.002	1.731	1.511	1.277	1.027	0.868	0.509	0.264	0.074

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	18.086	9.080	7.601	5.759	4.182	3.605	2.900	2.131	1.487	0.686
Nov	27.002	18.590	13.681	10.261	9.093	8.400	6.867	5.191	4.275	2.455
Dec	28.919	20.734	15.825	13.869	12.156	10.862	8.788	7.843	6.033	2.968
Jan	29.950	23.149	16.844	14.946	12.186	9.957	9.039	7.852	6.823	3.962
Feb	42.609	28.537	19.588	16.499	11.640	10.552	8.997	7.192	6.067	2.368
Mar	20.169	16.503	12.737	12.042	10.249	7.947	6.996	5.481	3.719	2.974
Apr	11.293	9.569	7.771	7.389	6.879	6.096	4.806	3.323	2.628	1.848
May	8.159	5.216	4.386	3.810	3.558	3.074	2.843	1.997	1.644	1.063
Jun	5.260	4.085	2.912	2.535	2.226	2.037	1.723	1.568	1.144	0.766
Jul	3.377	2.803	2.414	2.051	1.587	1.424	1.096	0.989	0.698	0.469
Aug	3.795	2.230	2.058	1.635	1.471	1.225	1.062	0.665	0.476	0.243
Sep	4.456	2.614	2.277	1.968	1.699	1.406	1.210	0.776	0.451	0.230

17.3.3 Alternative Ecological Category D

<table>
<tr><td rowspan="4"></td><td colspan="2">Baseflows</td><td>High flows (excl. >1:2 yr)</td><td>Class1</td><td>Class2</td><td>Class3</td><td>Class4</td></tr>
<tr><td colspan="2">REC: D</td><td>Discharge (m3/s)</td><td>7.70</td><td>13.70</td><td>25.60</td><td>47.90</td></tr>
<tr><td rowspan="2">Discharge (m^3/s)</td><td rowspan="2">Monthly volume (10^6m^3)</td><td>Duration (days)</td><td>3</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td>Number</td><td>1</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Oct</td><td>0.673</td><td>1.803</td><td rowspan="12"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Nov</td><td>2.775</td><td>7.193</td><td rowspan="3">1</td><td rowspan="2">1</td><td rowspan="4">2</td><td rowspan="2">1</td></tr>
<tr><td>Dec</td><td>2.660</td><td>7.124</td></tr>
<tr><td>Jan</td><td>3.270</td><td>8.759</td><td rowspan="3">2</td><td></td></tr>
<tr><td>Feb</td><td>2.902</td><td>7.020</td><td></td><td></td></tr>
<tr><td>Mar</td><td>2.392</td><td>6.407</td><td></td><td></td><td></td></tr>
<tr><td>Apr</td><td>1.782</td><td>4.620</td><td></td><td></td><td></td><td></td></tr>
<tr><td>May</td><td>1.685</td><td>4.513</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jun</td><td>0.303</td><td>0.784</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jul</td><td>0.303</td><td>0.812</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aug</td><td>0.285</td><td>0.764</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sep</td><td>0.290</td><td>0.752</td><td></td><td></td><td></td><td></td></tr>
</table>

MAR	288.704	MCM	
S.Dev.	27.109		
CV	0.094		
Q75	8.917		
Ecological Category D			
	MCM	% MAR	
Total IFR	85.273	29.537	(excl. >=1:2)
Maint. Lowflow	50.553	17.510	
Drought Lowflow	50.553	17.510	
Maint. Highflow	34.720	12.026	

Monthly Distributions (MCM)

Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	19.389	1.803	1.803	3.508	5.311
Nov	35.092	7.193	7.193	5.878	13.071
Dec	41.635	7.124	7.124	6.464	13.588
Jan	56.683	8.759	8.759	6.449	15.208
Feb	49.759	7.020	7.020	7.360	14.381
Mar	30.083	6.407	6.407	3.586	9.993
Apr	17.736	4.620	4.620	0.763	5.383
May	11.033	4.513	4.513	0.081	4.595
Jun	7.353	0.784	0.784	0.000	0.784
Jul	7.093	0.812	0.812	0.531	1.343
Aug	4.896	0.764	0.764	0.000	0.764
Sep	7.951	0.752	0.752	0.100	0.852

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category D
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	1.871	1.258	0.891	0.804	0.803	0.802	0.798	0.785	0.751	0.489
Nov	2.970	2.115	1.852	1.235	1.075	0.811	0.807	0.805	0.740	0.439
Dec	7.694	3.109	2.783	2.629	1.968	1.605	1.484	1.299	1.255	0.885
Jan	5.798	4.319	3.449	2.583	2.254	1.694	1.386	1.288	1.257	1.045
Feb	6.760	3.731	2.860	2.396	2.075	1.806	1.299	1.285	1.137	0.535
Mar	2.862	2.293	1.929	1.476	1.291	1.287	1.286	1.260	1.051	0.541
Apr	1.865	1.418	1.214	1.079	1.072	1.067	1.066	1.063	1.056	0.556
May	1.069	1.066	1.064	1.064	1.063	1.062	1.062	1.061	1.025	0.672
Jun	1.006	1.005	1.004	1.002	1.002	1.001	1.001	1.001	0.980	0.682
Jul	1.003	1.002	1.002	1.002	1.001	1.001	1.001	0.999	0.991	0.758
Aug	1.005	1.002	1.002	1.001	1.001	1.001	0.992	0.980	0.922	0.698
Sep	1.017	1.002	1.002	1.000	0.997	0.991	0.969	0.920	0.853	0.641

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.440	0.425	0.410	0.407	0.407	0.406	0.405	0.405	0.365	0.140
Nov	2.565	2.531	2.526	2.481	2.461	2.336	2.220	2.131	1.720	1.322
Dec	2.537	2.529	2.521	2.517	2.511	2.495	2.455	2.303	2.126	1.355
Jan	2.571	2.539	2.525	2.522	2.519	2.516	2.513	2.484	2.402	1.375
Feb	2.554	2.537	2.527	2.522	2.519	2.516	2.509	2.501	2.392	1.045
Mar	2.527	2.519	2.516	2.514	2.512	2.510	2.492	2.374	2.086	1.183
Apr	1.817	1.813	1.811	1.810	1.809	1.808	1.808	1.802	1.705	1.378
May	1.818	1.814	1.811	1.807	1.807	1.802	1.768	1.557	1.364	0.861
Jun	0.305	0.304	0.303	0.303	0.303	0.302	0.302	0.301	0.301	0.282
Jul	0.309	0.306	0.305	0.304	0.303	0.302	0.302	0.302	0.301	0.271
Aug	0.312	0.309	0.306	0.303	0.302	0.301	0.301	0.294	0.225	0.087
Sep	0.309	0.306	0.305	0.304	0.304	0.303	0.302	0.298	0.215	0.039

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	18.086	9.080	7.601	5.759	4.182	3.605	2.900	2.131	1.487	0.686
Nov	27.002	18.590	13.681	10.261	9.093	8.400	6.867	5.191	4.275	2.455
Dec	28.919	20.734	15.825	13.869	12.156	10.862	8.788	7.843	6.033	2.968
Jan	29.950	23.149	16.844	14.946	12.186	9.957	9.039	7.852	6.823	3.962
Feb	42.609	28.537	19.588	16.499	11.640	10.552	8.997	7.192	6.067	2.368
Mar	20.169	16.503	12.737	12.042	10.249	7.947	6.996	5.481	3.719	2.974
Apr	11.293	9.569	7.771	7.389	6.879	6.096	4.806	3.323	2.628	1.848
May	8.159	5.216	4.386	3.810	3.558	3.074	2.843	1.997	1.644	1.063
Jun	5.260	4.085	2.912	2.535	2.226	2.037	1.723	1.568	1.144	0.766
Jul	3.377	2.803	2.414	2.051	1.587	1.424	1.096	0.989	0.698	0.469
Aug	3.795	2.230	2.058	1.635	1.471	1.225	1.062	0.665	0.476	0.243
Sep	4.456	2.614	2.277	1.968	1.699	1.406	1.210	0.776	0.451	0.230

18 EWR SITE MK1 (MKUZE RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site MK1. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

On the basis of the results in Figure 10-1 and Figure 10-2, the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Mkuze	MK1	C	B	D	-
		SS4	SS4a[10]	SS2	-

18.1 Mean percentage changes

The mean percentage changes (relative to Baseline) in indicators for the EWRs that were selected as potential Reserves to maintain the REC and AECs at EWR Site MK1 are given in Table 18-1.

[10] Should maintain a B provided non-flow related impacts are addressed.

Table 18-1 EWR Site MK1: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

Discipline	Indicator	REC SS4 C category	AEC1 SS4a B category	AEC2 SS2 D category
Geomorphology	Channel width	-9.41	-2.48	-23.18
	Extent of cut banks	-2.57	-2.49	-5.93
	Secondary channels	1.80	1.97	0.77
	Pool depth	-5.22	-3.08	4.01
	Bed sediment conditions	-3.97	-1.09	-13.46
	Inundated Floodplain pans	-23.35	-12.13	-39.43
Water quality	Summer water temperature	5.36	4.43	12.74
	Nutrients - phosphates	22.37	16.73	43.26
	Nutrients - nitrogen	21.80	16.36	42.51
	Electrical conductivity (salinity)	2.71	-0.07	5.18
	Sulphates	1.67	-1.17	3.89
Riparian Vegetation	Algae	16.16	-0.56	36.16
	Marginal zone graminoids	2.79	9.28	-14.28
	Marginal zone trees	-4.89	7.89	-55.89
	Lower zone graminoids	-19.06	5.58	-70.66
	Lower zone trees	-26.70	-3.06	-79.41
	Upper zone trees - riparian	-10.54	-8.37	-12.86
	Upper zone trees - terrestrial	20.96	13.80	29.00
Macro-invertebrates	Gomphidae (Clubtails)	-0.77	8.69	3.50
	Baetidae (Minnow mayflies)	-0.80	2.51	-9.36
	Chironomidae (Midges)	-1.01	1.85	-8.96
	Simuliidae (Blackflies)	-6.64	-0.29	-24.81
	Coenagrionidae (Sprites & Blues)	-1.39	4.90	-28.55
Fish	Oreochromis mossambicus	24.18	13.09	37.20
	Labeobarbus natalensis	-11.88	4.45	-56.69
	Barbus paludinosus	-11.78	-2.79	-37.82
	Brycinus lateralis	-6.19	2.53	-24.60

18.2 Time series

The time series of predicted abundance changes to Baseline2014 for Base2014, Nat, and the EWRs for B-, C- and D-categories are provided for the indicators for each discipline (Figure 18-1 to Figure 18-5). The time-series illustrate the sorts of annual fluctuations that can be expected as a result of climatic variations, and as such may help to guide decisions based on future monitoring. The time-series also illustrate the responses of different indicators to different flow regimes, i.e., increased flow, such as that associated with a B-Category versus a D-Category river does not necessarily result in a universal improvement in all indicators, as changes in flow affect the balance between species.

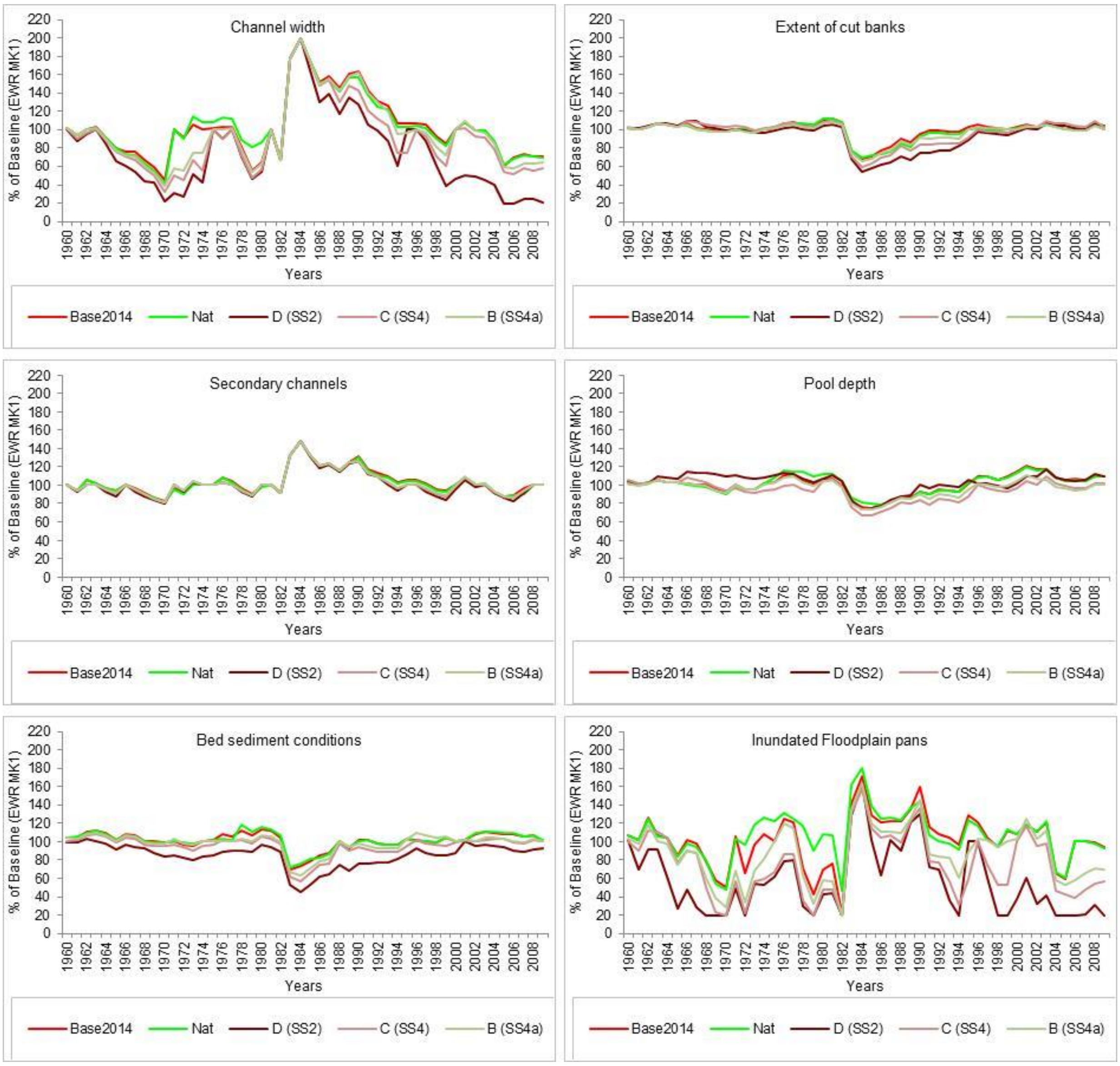


Figure 18-1 Time series for the geomorphological indicators at EWR Site MK1 for Base2014, Nat and the EWRs for B-, C- and D-category.

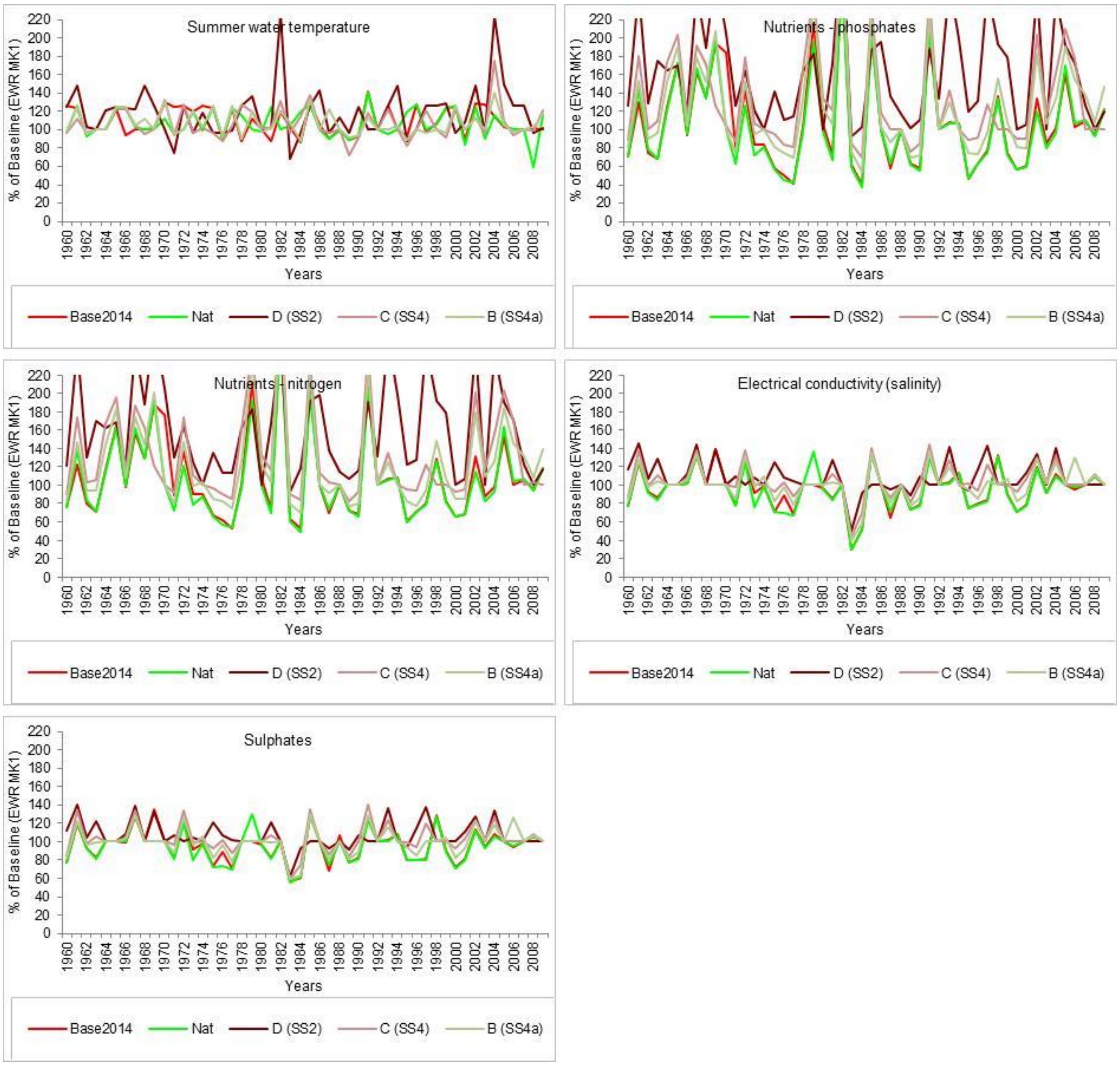


Figure 18-2 Time series for the water quality indicators at EWR Site MK1 for Base2014, Nat and the EWRs for B-, C- and D-category.

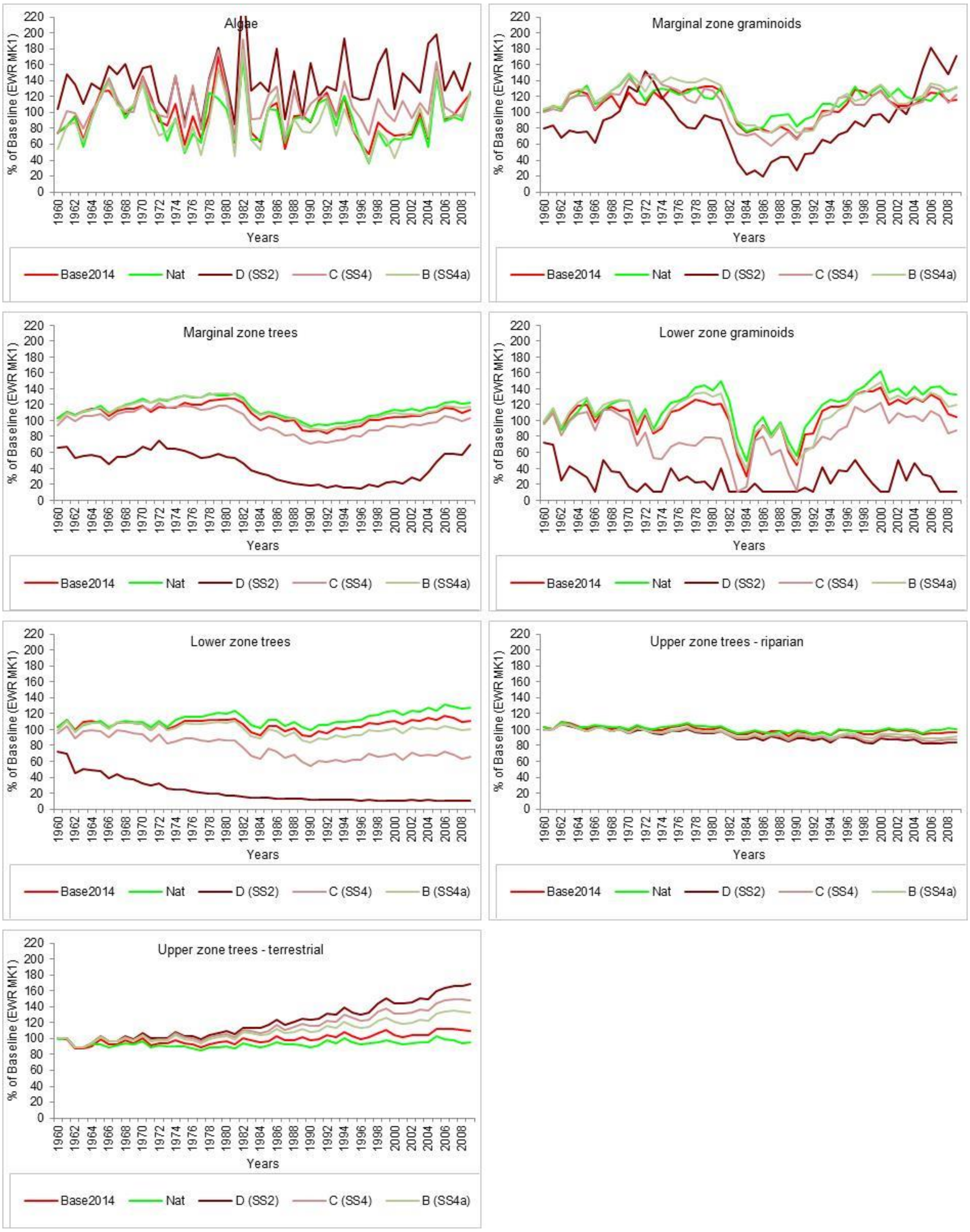


Figure 18-3 Time series for the vegetation indicators at EWR Site MK1 for Base2014, Nat and the EWRs for B-, C- and D-category.

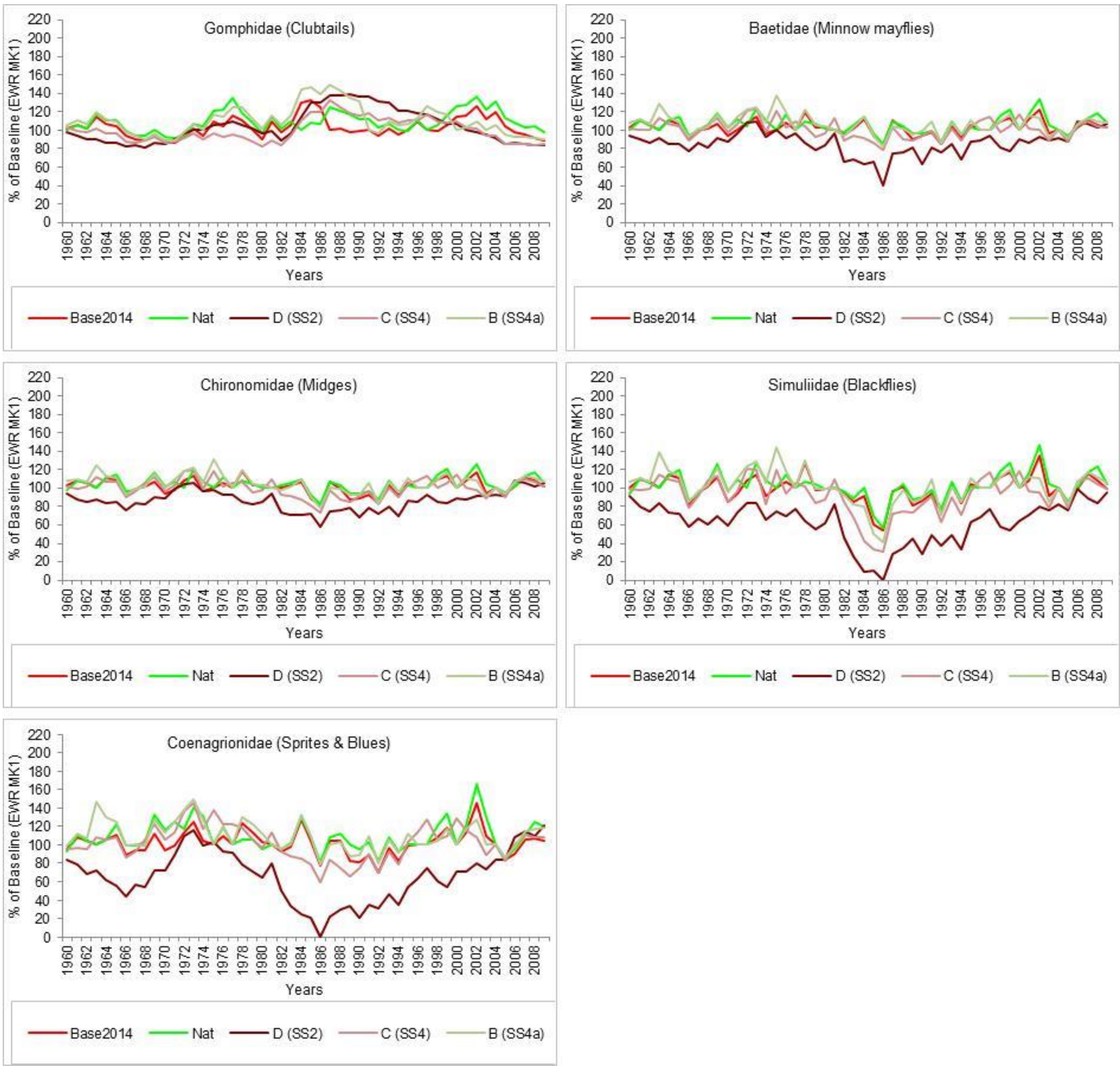


Figure 18-4 Time series for the macroinvertebrate indicators at EWR Site MK1 for Base2014, Nat and the EWRs for B-, C- and D-category.

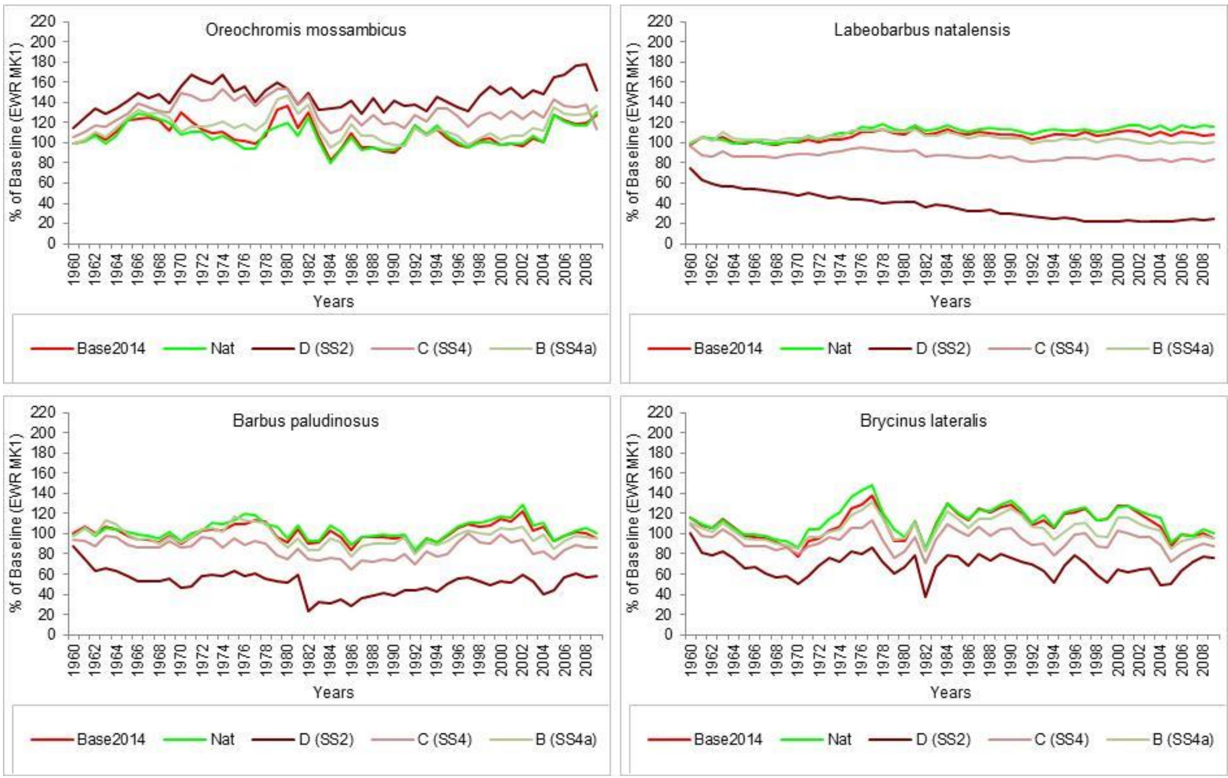


Figure 18-5 Time series for the fish indicators at EWR Site MK1 for Base2014, Nat and the EWRs for B-, C- and D-category.

18.3 Hydrological summaries (MK1)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

18.3.1 Recommended Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C		Discharge (m3/s)	12.50	23.20	45.80	83.60
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	2	3	3
			Number	2	3	2	1
Oct	1.474	3.949					
Nov	2.164	5.609					
Dec	3.206	8.587			1		
Jan	3.378	9.047		2			
Feb	3.526	8.531			2	2	1
Mar	3.215	8.611					
Apr	2.224	5.765					
May	1.742	4.666					
Jun	0.885	2.295					
Jul	0.809	2.167					
Aug	0.744	1.994					
Sep	0.280	0.726					

MAR	275.487	MCM	
S.Dev.	3.916		
CV	0.014		
Q75	0.719212963		
Ecological Category C			
	MCM	% MAR	
Total IFR	122.684	44.534	(excl. >=1:2)
Maint. Lowflow	61.948	22.487	
Drought Lowflow	17.042	6.186	
Maint. Highflow	60.736	22.047	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	16.147	3.949	0.820	3.954	7.903
Nov	21.469	5.609	0.937	6.367	11.976
Dec	30.312	8.587	2.629	8.008	16.596
Jan	40.440	9.047	2.654	9.908	18.955
Feb	60.100	8.531	2.474	14.738	23.269
Mar	33.211	8.611	2.609	10.234	18.845
Apr	17.331	5.765	0.910	2.602	8.367
May	17.078	4.666	0.928	1.834	6.500
Jun	6.698	2.295	0.863	0.000	2.295
Jul	15.424	2.167	0.810	1.435	3.602
Aug	5.608	1.994	0.734	0.000	1.994
Sep	11.667	0.726	0.675	1.657	2.383

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	7.978	4.845	3.350	2.576	1.591	1.032	0.527	0.331	0.061	0.020
Nov	10.445	6.181	5.158	3.799	3.358	3.059	2.530	1.327	0.909	0.511
Dec	14.091	7.783	6.047	5.388	4.555	3.793	2.829	2.385	1.406	0.399
Jan	13.578	11.610	8.451	6.761	5.496	4.787	3.709	2.927	1.985	0.628
Feb	20.556	17.107	9.046	7.759	6.919	6.116	4.639	3.120	1.699	0.858
Mar	14.291	12.831	9.497	7.362	6.164	4.066	2.666	1.631	0.972	0.395
Apr	5.966	3.669	3.260	3.237	3.233	2.847	1.710	1.196	0.780	0.176
May	3.312	3.232	3.180	2.517	1.582	0.900	0.716	0.476	0.350	0.198
Jun	1.444	1.436	1.431	1.324	0.885	0.493	0.350	0.342	0.281	0.135
Jul	1.480	1.444	1.435	1.316	0.935	0.468	0.350	0.219	0.088	0.018
Aug	1.449	1.410	1.223	0.964	0.671	0.366	0.350	0.186	0.053	0.007
Sep	0.766	0.447	0.398	0.363	0.351	0.350	0.254	0.093	0.036	0.002

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	3.240	2.929	2.293	1.629	1.317	0.740	0.483	0.331	0.061	0.020
Nov	3.280	3.262	3.174	2.364	2.183	1.976	1.595	1.148	0.864	0.511
Dec	5.046	4.820	4.296	3.812	3.139	2.691	2.346	1.819	1.232	0.399
Jan	5.063	4.787	4.166	3.628	3.403	2.975	2.684	2.240	1.776	0.628
Feb	5.098	5.043	4.677	4.275	3.527	3.229	2.780	2.085	1.626	0.680
Mar	5.083	5.020	4.553	4.133	3.546	2.666	2.020	1.402	0.972	0.395
Apr	3.252	3.236	3.229	2.903	2.493	1.989	1.512	1.196	0.780	0.176
May	3.232	3.184	2.986	2.309	1.581	0.889	0.580	0.476	0.350	0.198
Jun	1.444	1.436	1.431	1.324	0.885	0.493	0.350	0.342	0.281	0.135
Jul	1.458	1.437	1.431	1.142	0.800	0.468	0.350	0.219	0.088	0.018
Aug	1.449	1.410	1.223	0.964	0.671	0.366	0.350	0.186	0.053	0.007
Sep	0.448	0.412	0.366	0.353	0.350	0.308	0.212	0.088	0.034	0.002

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	13.887	6.887	5.665	3.147	2.480	1.193	0.564	0.321	0.245	0.048
Nov	18.846	12.230	8.011	6.153	5.267	4.532	3.753	2.027	0.845	0.445
Dec	23.003	15.094	10.560	9.339	6.907	5.378	3.779	2.342	1.348	0.415
Jan	33.876	18.038	15.849	13.021	9.635	7.822	4.686	4.025	2.611	0.828
Feb	63.410	27.407	16.891	11.526	9.973	8.685	6.186	4.485	2.197	0.710
Mar	29.783	26.043	14.299	11.699	8.620	4.914	2.394	1.551	1.083	0.369
Apr	15.140	10.958	8.047	5.832	4.430	2.851	1.803	1.437	0.672	0.230
May	11.334	8.244	6.376	4.025	2.095	1.459	0.935	0.673	0.353	0.317
Jun	5.997	4.536	3.346	2.521	1.072	0.707	0.577	0.353	0.346	0.265
Jul	6.898	5.599	3.079	2.258	1.767	0.775	0.536	0.353	0.270	0.188
Aug	4.723	2.675	2.054	1.343	1.032	0.680	0.353	0.336	0.174	0.098
Sep	11.878	4.440	1.942	1.355	0.872	0.559	0.352	0.275	0.157	0.087

18.3.2 Alternative Ecological Category B

<table>
<tr><td rowspan="4"></td><td colspan="2">Baseflows</td><td>High flows (excl. >1:2 yr)</td><td>Class1</td><td>Class2</td><td>Class3</td><td>Class4</td></tr>
<tr><td colspan="2">REC: B</td><td>Discharge (m3/s)</td><td>12.70</td><td>23.70</td><td>46.00</td><td>83.80</td></tr>
<tr><td rowspan="2">Discharge (m^3/s)</td><td rowspan="2">Monthly volume (10^{6}m^3)</td><td>Duration (days)</td><td>2</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>Number</td><td>2</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Oct</td><td>2.146</td><td>5.748</td><td rowspan="12"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Nov</td><td>3.419</td><td>8.861</td><td rowspan="3">3</td><td rowspan="3">1</td><td rowspan="2">1</td><td></td></tr>
<tr><td>Dec</td><td>4.338</td><td>11.618</td><td></td></tr>
<tr><td>Jan</td><td>4.796</td><td>12.846</td><td rowspan="3">2</td><td></td></tr>
<tr><td>Feb</td><td>5.160</td><td>12.482</td><td rowspan="2">2</td><td rowspan="2">2</td><td rowspan="2">1</td></tr>
<tr><td>Mar</td><td>4.922</td><td>13.183</td></tr>
<tr><td>Apr</td><td>3.598</td><td>9.326</td><td></td><td></td><td></td><td></td></tr>
<tr><td>May</td><td>2.708</td><td>7.254</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jun</td><td>1.401</td><td>3.632</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jul</td><td>1.226</td><td>3.283</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aug</td><td>1.019</td><td>2.729</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sep</td><td>0.842</td><td>2.183</td><td></td><td></td><td></td><td></td></tr>
</table>

AEC1	SS4a		
MAR	275.487	MCM	
S.Dev.	3.916		
CV	0.014		
Q75	0.719212963		
Ecological Category B			
	MCM	% MAR	
Total IFR	149.744	54.356	(excl. >=1:2)
Maint. Lowflow	89.327	32.425	
Drought Lowflow	17.042	6.186	
Maint. Highflow	60.416	21.931	

Monthly Distributions (MCM)

Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	16.147	5.727	0.820	3.904	9.631
Nov	21.469	8.793	0.937	6.079	14.872
Dec	30.312	10.689	2.629	8.250	18.939
Jan	40.440	11.783	2.654	10.146	21.929
Feb	60.100	11.503	2.474	14.950	26.453
Mar	33.211	12.451	2.609	9.698	22.150
Apr	17.331	9.304	0.910	2.419	11.723
May	17.078	7.251	0.928	1.709	8.960
Jun	6.698	3.632	0.863	0.000	3.632
Jul	15.424	3.283	0.810	1.642	4.925
Aug	5.608	2.729	0.734	0.000	2.729
Sep	11.667	2.183	0.675	1.620	3.803

Summary of IFR rule curves (without >=1:2 year floods)

Ecological Category B

Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	9.677	5.722	4.011	2.668	1.724	1.073	0.534	0.331	0.061	0.020
Nov	12.660	8.087	6.532	5.647	4.536	4.044	3.134	1.929	1.037	0.511
Dec	16.817	9.043	8.139	6.535	5.112	4.137	2.971	2.410	1.460	0.399
Jan	15.842	12.320	10.013	8.827	6.638	5.943	3.852	3.158	2.061	0.628
Feb	24.206	19.349	10.934	8.669	7.987	6.875	6.086	3.714	1.699	0.863
Mar	17.299	15.383	11.958	8.865	7.275	4.320	2.666	1.631	1.019	0.395
Apr	7.640	6.999	6.502	5.292	4.039	3.132	1.984	1.294	0.798	0.176
May	6.735	6.422	5.335	2.995	1.729	0.900	0.716	0.476	0.350	0.198
Jun	2.880	2.871	2.664	1.555	0.907	0.542	0.350	0.342	0.281	0.135
Jul	2.929	2.751	1.839	1.696	0.935	0.468	0.350	0.219	0.088	0.018
Aug	2.459	1.869	1.346	1.008	0.742	0.427	0.350	0.201	0.053	0.007
Sep	2.711	1.760	1.137	0.820	0.664	0.402	0.283	0.110	0.036	0.002

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	5.885	3.851	3.016	2.063	1.602	0.838	0.534	0.331	0.061	0.020
Nov	6.425	5.693	4.645	3.301	2.955	2.653	2.136	1.428	0.918	0.511
Dec	7.501	6.606	5.122	4.287	3.252	2.874	2.421	2.002	1.226	0.399
Jan	8.284	6.198	5.136	4.476	3.992	3.256	2.816	2.147	1.617	0.628
Feb	8.889	7.768	6.045	5.094	4.192	3.613	3.077	2.133	1.626	0.685
Mar	9.636	8.706	6.412	4.855	4.192	2.666	2.138	1.402	0.946	0.395
Apr	6.999	6.502	5.340	3.979	3.321	2.520	1.743	1.294	0.798	0.176
May	6.543	5.555	3.794	2.707	1.581	0.889	0.716	0.476	0.350	0.198
Jun	2.880	2.871	2.664	1.555	0.907	0.542	0.350	0.342	0.281	0.135
Jul	2.926	2.590	1.719	1.547	0.935	0.468	0.350	0.219	0.088	0.018
Aug	2.459	1.869	1.346	1.008	0.742	0.427	0.350	0.201	0.053	0.007
Sep	2.171	1.528	0.930	0.800	0.605	0.364	0.254	0.093	0.034	0.002

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	13.887	6.887	5.665	3.147	2.480	1.193	0.564	0.321	0.245	0.048
Nov	18.846	12.230	8.011	6.153	5.267	4.532	3.753	2.027	0.845	0.445
Dec	23.003	15.094	10.560	9.339	6.907	5.378	3.779	2.342	1.348	0.415
Jan	33.876	18.038	15.849	13.021	9.635	7.822	4.686	4.025	2.611	0.828
Feb	63.410	27.407	16.891	11.526	9.973	8.685	6.186	4.485	2.197	0.710
Mar	29.783	26.043	14.299	11.699	8.620	4.914	2.394	1.551	1.083	0.369
Apr	15.140	10.958	8.047	5.832	4.430	2.851	1.803	1.437	0.672	0.230
May	11.334	8.244	6.376	4.025	2.095	1.459	0.935	0.673	0.353	0.317
Jun	5.997	4.536	3.346	2.521	1.072	0.707	0.577	0.353	0.346	0.265
Jul	6.898	5.599	3.079	2.258	1.767	0.775	0.536	0.353	0.270	0.188
Aug	4.723	2.675	2.054	1.343	1.032	0.680	0.353	0.336	0.174	0.098
Sep	11.878	4.440	1.942	1.355	0.872	0.559	0.352	0.275	0.157	0.087

18.3.3 Alternative Ecological Category D

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: D		Discharge (m3/s)	12.50	23.20	45.80	83.60
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	2	3	3
			Number	1	1	1	0
Oct	0.306	0.820					
Nov	0.362	0.937					
Dec	0.982	2.629					
Jan	0.991	2.654				1	
Feb	1.023	2.474		1	1		
Mar	0.974	2.609					
Apr	0.351	0.910					
May	0.347	0.928					
Jun	0.333	0.863					
Jul	0.302	0.810					
Aug	0.274	0.734					
Sep	0.261	0.675					

MAR 275.487 MCM
S.Dev. 3.916
CV 0.014
Q75 0.719212963
Ecological Category D

	MCM	% MAR	
Total IFR	60.043	21.795	(excl. >=1:2)
Maint. Lowflow	17.042	6.186	
Drought Lowflow	17.042	6.186	
Maint. Highflow	43.001	15.609	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	16.147	0.820	0.820	2.908	3.728
Nov	21.469	0.937	0.937	4.150	5.088
Dec	30.312	2.629	2.629	4.935	7.564
Jan	40.440	2.654	2.654	6.560	9.214
Feb	60.100	2.474	2.474	11.598	14.072
Mar	33.211	2.609	2.609	6.386	8.994
Apr	17.331	0.910	0.910	1.940	2.850
May	17.078	0.928	0.928	1.499	2.427
Jun	6.698	0.863	0.863	0.000	0.863
Jul	15.424	0.810	0.810	1.451	2.261
Aug	5.608	0.734	0.734	0.000	0.734
Sep	11.667	0.675	0.675	1.573	2.249

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category D
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	5.473	1.542	0.403	0.385	0.372	0.356	0.327	0.213	0.061	0.020
Nov	4.613	2.922	2.147	0.387	0.380	0.378	0.365	0.354	0.337	0.252
Dec	6.459	3.206	2.171	1.092	1.082	1.080	1.073	0.969	0.834	0.378
Jan	9.778	4.853	4.239	2.509	1.084	1.082	1.077	1.031	0.789	0.511
Feb	14.276	6.838	5.520	3.455	2.722	1.876	1.093	1.080	0.984	0.616
Mar	7.558	5.435	3.251	2.172	1.438	1.070	1.063	0.976	0.758	0.330
Apr	2.354	0.384	0.366	0.360	0.358	0.358	0.357	0.356	0.353	0.170
May	0.906	0.366	0.361	0.360	0.356	0.352	0.350	0.350	0.350	0.198
Jun	0.361	0.358	0.356	0.355	0.351	0.350	0.350	0.337	0.257	0.101
Jul	0.396	0.378	0.370	0.365	0.360	0.350	0.341	0.219	0.088	0.018
Aug	0.366	0.358	0.353	0.350	0.350	0.349	0.271	0.152	0.052	0.008
Sep	0.398	0.377	0.355	0.352	0.350	0.346	0.205	0.085	0.034	0.003

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.407	0.396	0.386	0.377	0.365	0.352	0.306	0.199	0.061	0.020
Nov	0.387	0.382	0.380	0.378	0.368	0.362	0.356	0.353	0.327	0.252
Dec	1.093	1.084	1.081	1.079	1.076	1.042	0.969	0.881	0.779	0.378
Jan	1.084	1.082	1.079	1.077	1.063	1.016	0.991	0.952	0.780	0.476
Feb	1.092	1.091	1.085	1.083	1.081	1.076	1.065	0.990	0.838	0.434
Mar	1.092	1.071	1.068	1.065	1.064	1.060	0.989	0.866	0.726	0.330
Apr	0.366	0.360	0.359	0.358	0.358	0.357	0.356	0.355	0.351	0.170
May	0.366	0.361	0.360	0.358	0.356	0.350	0.350	0.350	0.350	0.103
Jun	0.361	0.358	0.356	0.355	0.351	0.350	0.350	0.337	0.257	0.101
Jul	0.389	0.376	0.370	0.363	0.354	0.350	0.318	0.219	0.088	0.018
Aug	0.366	0.358	0.353	0.350	0.350	0.349	0.271	0.152	0.052	0.008
Sep	0.385	0.359	0.353	0.351	0.350	0.297	0.205	0.085	0.034	0.003

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	13.887	6.887	5.665	3.147	2.480	1.193	0.564	0.321	0.245	0.048
Nov	18.846	12.230	8.011	6.153	5.267	4.532	3.753	2.027	0.845	0.445
Dec	23.003	15.094	10.560	9.339	6.907	5.378	3.779	2.342	1.348	0.415
Jan	33.876	18.038	15.849	13.021	9.635	7.822	4.686	4.025	2.611	0.828
Feb	63.410	27.407	16.891	11.526	9.973	8.685	6.186	4.485	2.197	0.710
Mar	29.783	26.043	14.299	11.699	8.620	4.914	2.394	1.551	1.083	0.369
Apr	15.140	10.958	8.047	5.832	4.430	2.851	1.803	1.437	0.672	0.230
May	11.334	8.244	6.376	4.025	2.095	1.459	0.935	0.673	0.353	0.317
Jun	5.997	4.536	3.346	2.521	1.072	0.707	0.577	0.353	0.346	0.265
Jul	6.898	5.599	3.079	2.258	1.767	0.775	0.536	0.353	0.270	0.188
Aug	4.723	2.675	2.054	1.343	1.032	0.680	0.353	0.336	0.174	0.098
Sep	11.878	4.440	1.942	1.355	0.872	0.559	0.352	0.275	0.157	0.087

19 EWR SITE BM1 (BLACK MFOLOZI RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site BM1. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

Please see Appendix B for a discussion on the relationship between the EWRs for BM1 determined using the data prepared for this study (see Report No. RDM/WMA6/CON/COMP/1013) and WR2012 data.

On the basis of the results in Figure 11-1 and Figure 11-2, the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Black Mfolozi	BM1	C	B	D	-
		SS3a	SS4[11]	SS2	

19.1 Mean percentage changes

The mean percentage changes (relative to Baseline) in indicators for the EWRs that were selected as potential Reserves to maintain the REC and AECs at EWR Site BM1 are given in Table 19-1.

[11] Should maintain a B provided non-flow related impacts are addressed.

Table 19-1 EWR Site BM1: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

Discipline	Indicator	AEC2 SS2 D category	REC SS3a C category	AEC1 SS4 B category
Geomorphology	Channel width	-4.65	-1.82	-0.95
	Extent of cut banks	-4.57	-2.62	-1.96
	Secondary channels	-1.03	-0.13	-0.05
	Pool depth	8.86	-0.54	-0.64
	Bed sediment conditions	-10.87	-4.49	-3.08
Water quality	Summer water temperature	-3.07	-1.77	-2.24
	Nutrients - phosphates	39.31	8.38	6.33
	Nutrients - nitrogen	39.12	9.05	5.22
	Electrical conductivity (salinity)	7.03	0.96	0.51
	Sulphates	13.31	2.84	0.90
Riparian Vegetation	Algae	16.01	14.35	4.53
	Marginal zone graminoids	-46.38	-36.26	-18.96
	Marginal zone trees	-64.19	-51.13	-27.16
	Lower zone graminoids	-76.41	-68.87	-57.78
	Lower zone trees	-75.62	-62.16	-41.31
	Upper zone trees - riparian	-52.89	-28.07	-21.54
	Upper zone trees - terrestrial	210.47	91.23	66.65
Macro-invertebrates	Atyidae (Freshwater Shrimps)	-24.79	-15.83	-6.16
	Palaemonidae (Freshwater Prawns)	-19.55	-11.23	-6.08
	Perlidae (Stoneflies)	-46.52	-26.93	-12.37
	Hydropsychidae (Caddisflies)	-27.00	-14.54	-8.92
	Heptageniidae (Flatheaded mayfly)	-18.75	-10.52	-4.91
	Gomphidae (Clubtails)	-2.72	-7.59	-2.05
	Leptophlebiidae (Prongills)	-18.77	-8.85	-1.44
	Baetidae (Minnow mayflies)	-13.22	-8.46	-4.18
	Chironomidae (Midges)	-12.94	-8.68	-3.78
	Simuliidae (Blackflies)	-24.61	-13.64	-7.28
Fish	Amphilius uranoscopus	-63.16	-34.77	-19.59
	Oreochromis mossambicus	14.11	11.03	8.92
	Labeo molybdinus	-75.05	-39.20	-33.32
	Labeobarbus natalensis	-82.98	-59.20	-34.25
	Barbus eutaenia	-32.92	-16.81	-10.04

19.2 Time series

The time series of predicted abundance changes relative to Baseline2014 for Base2014, Nat, and the EWRs for maintaining a B-, C- and D-category are provided for the indicators for each discipline (Figure 19-1 to Figure 19-5).

Figure 19-1 Time series for the geomorphological indicators at EWR Site BM1 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

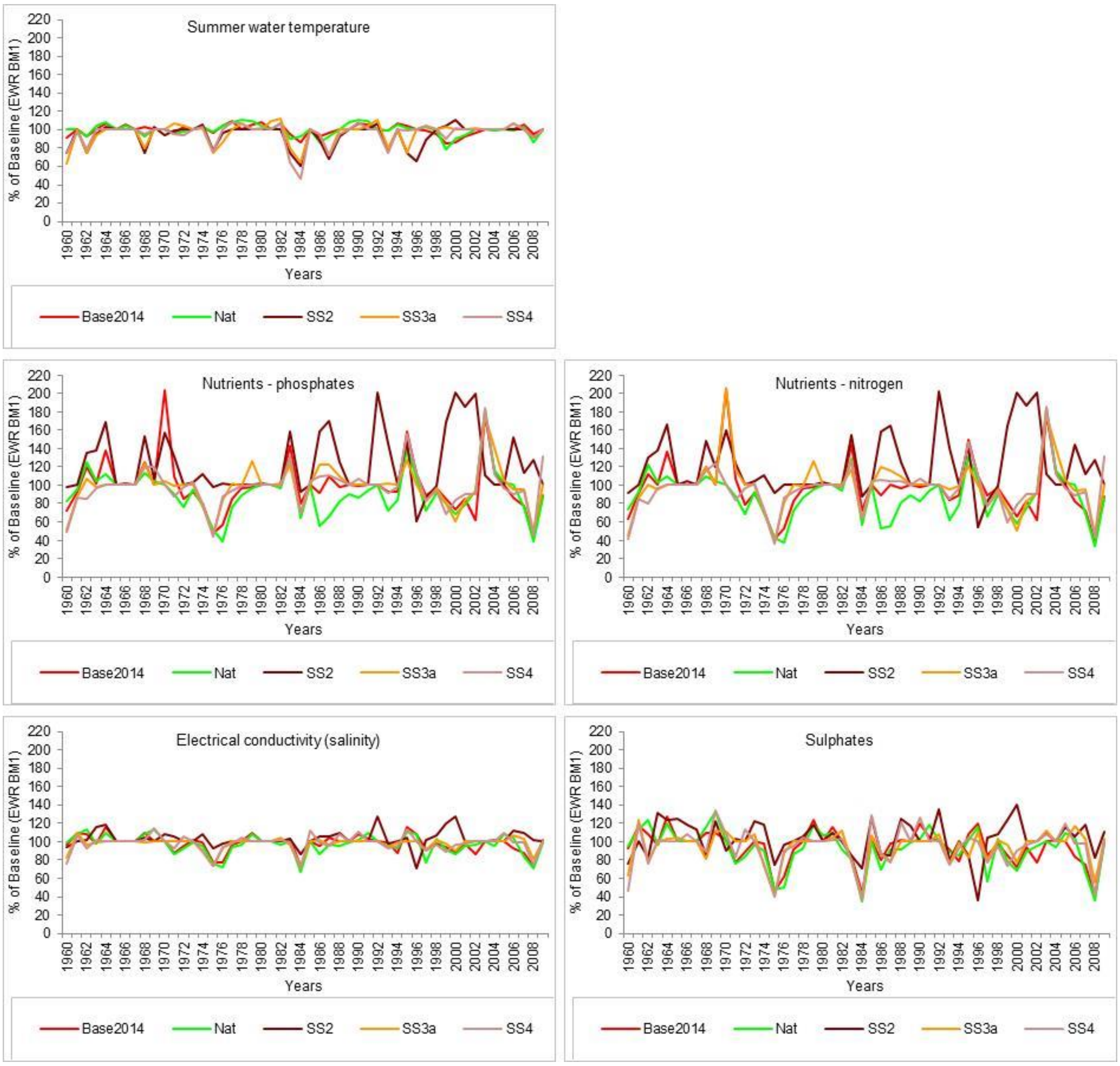


Figure 19-2 Time series for the water quality indicators at EWR Site BM1 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

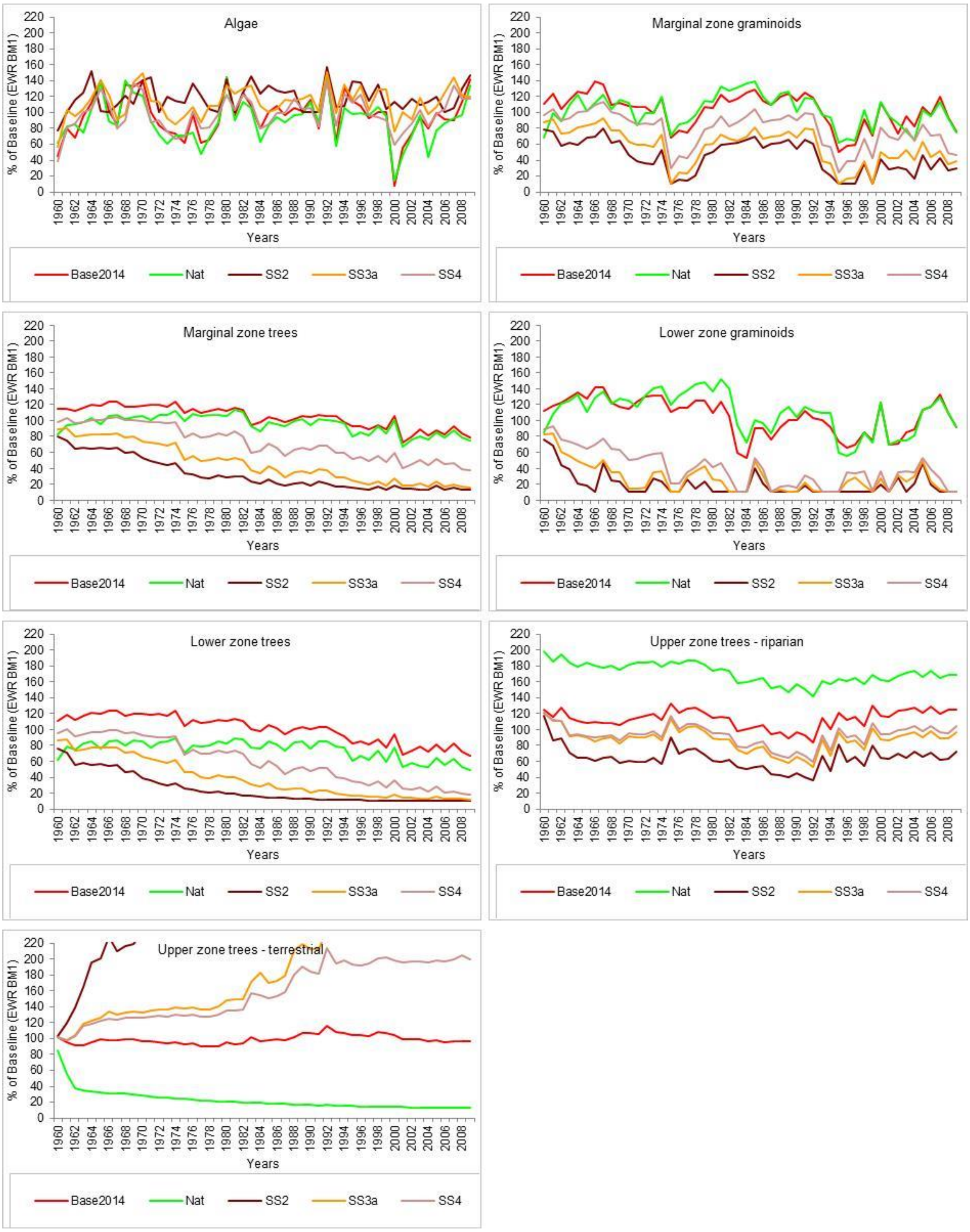


Figure 19-3 Time series for the vegetation indicators at EWR Site BM1 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

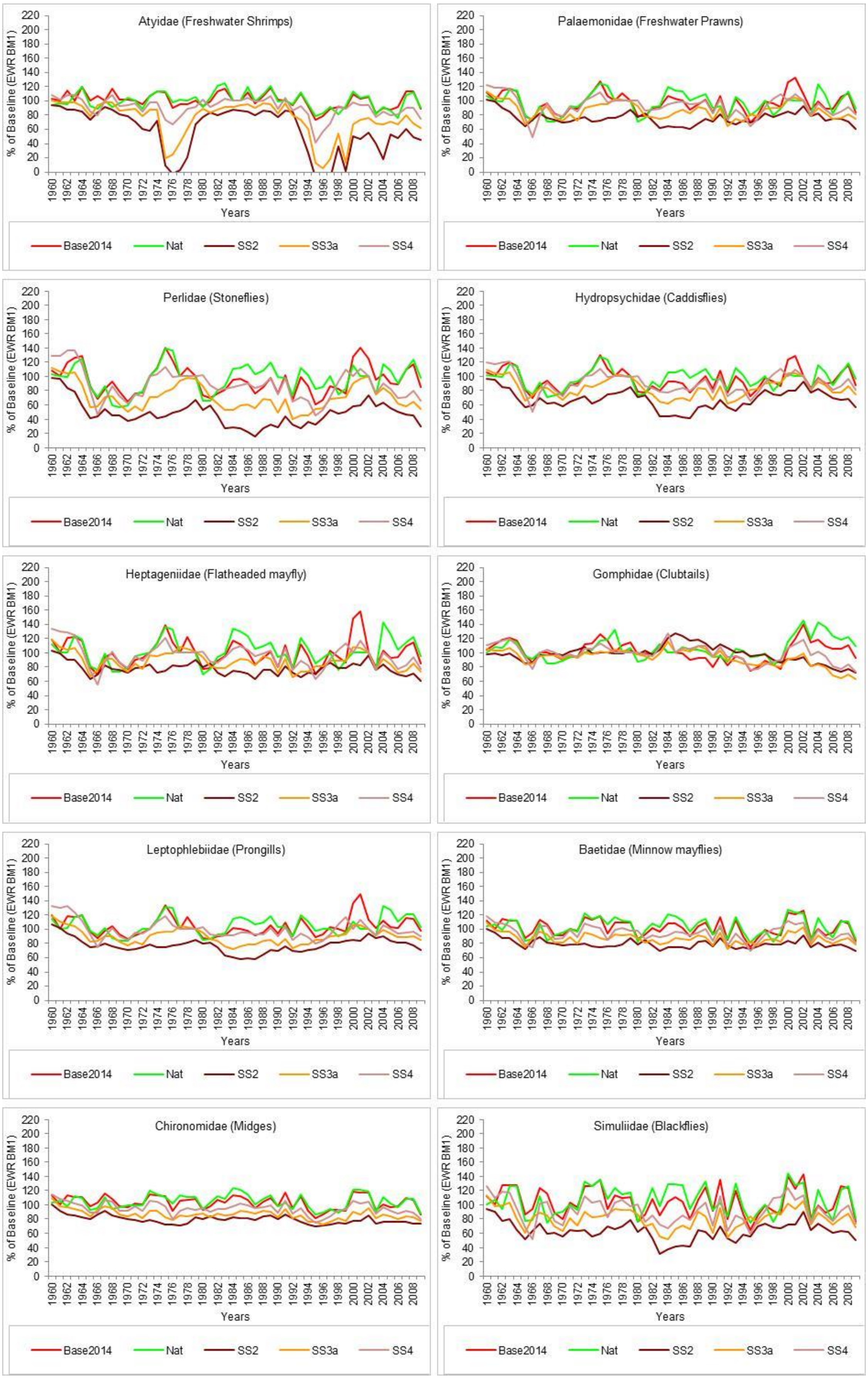


Figure 19-4 Time series for the macroinvertebrate indicators at EWR Site BM1 for for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

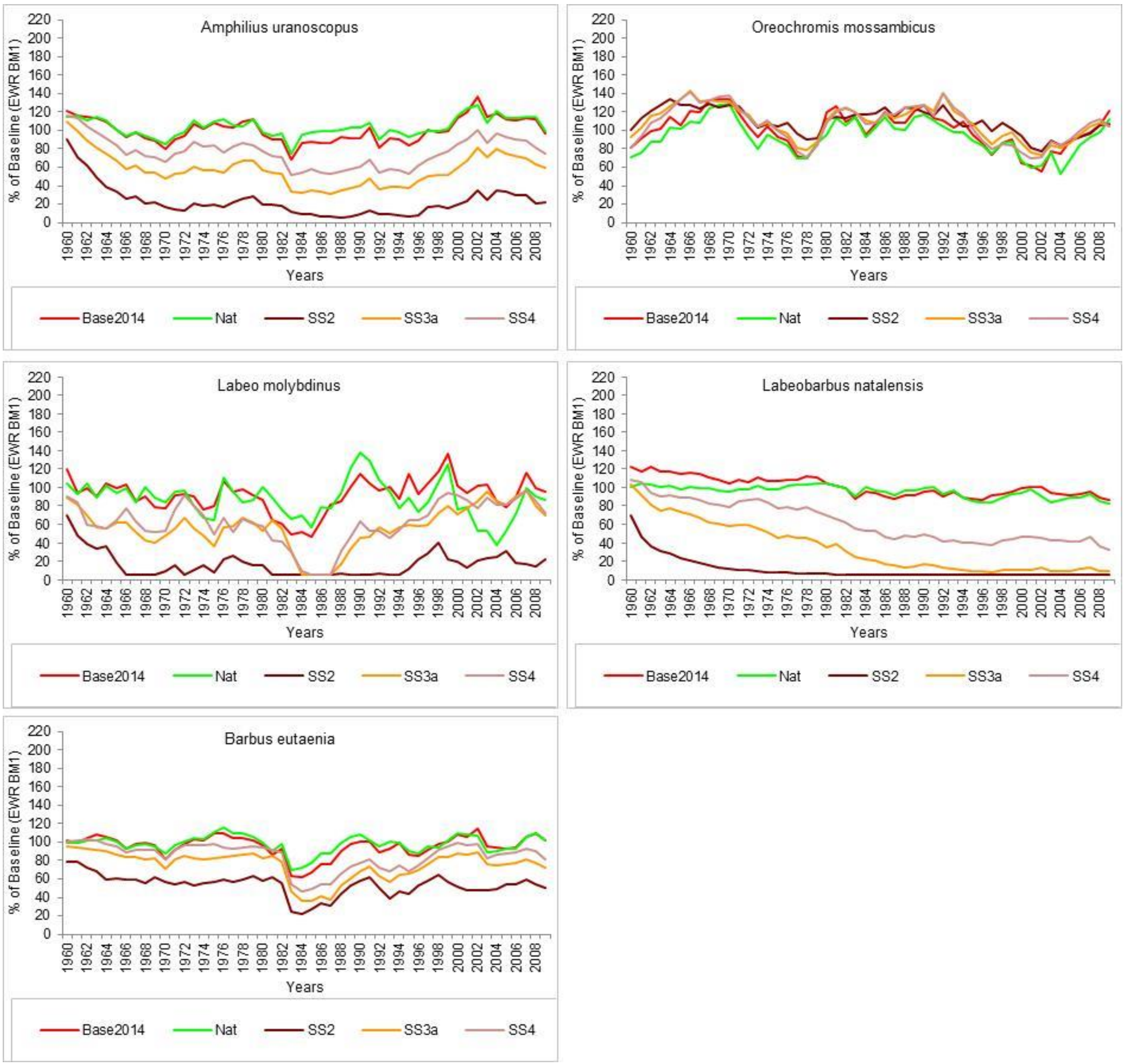


Figure 19-5 Time series for the fish indicators at EWR Site BM1 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

19.3 Hydrological summaries (BM1)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required

volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

19.3.1 Recommended Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C		Discharge (m3/s)	1.60	3.40	6.10	11.50
	Discharge (m^3/s)	Monthly volume ($10^6 m^3$)	Duration (days)	3	3	3	3
			Number	1	1	1	1
Oct	0.057	0.152					
Nov	0.074	0.192					
Dec	0.176	0.470					
Jan	0.191	0.512		1	1	1	1
Feb	0.194	0.469					
Mar	0.169	0.452					
Apr	0.081	0.211					
May	0.040	0.107					
Jun	0.036	0.093					
Jul	0.034	0.090					
Aug	0.032	0.085					
Sep	0.030	0.077					

```
MAR                 31.784         MCM
S.Dev.              3.916
CV                  0.123
Q75                 0.719212963
Ecological Category C
                    MCM            % MAR
Total IFR           9.568          30.103      (excl. >=1:2)
Maint. Lowflow      2.910          9.156
Drought Lowflow     1.143          3.597
Maint. Highflow     6.658          20.947
Monthly Distributions (MCM)
Distribution Type:  ?? KZN
Month               Natural Flows  Modified Flows (IFR)
                                   Low flows             High Flows  Total Flows
                    Mean           Maint.     Drought    Maint.      Maint.
Oct                 2.328          0.152      0.061      0.624       0.776
Nov                 2.562          0.192      0.072      0.618       0.810
Dec                 4.815          0.470      0.184      1.378       1.848
Jan                 5.319          0.512      0.196      1.217       1.729
Feb                 6.474          0.469      0.175      1.597       2.067
Mar                 2.894          0.452      0.174      0.515       0.967
Apr                 1.957          0.211      0.070      0.280       0.490
May                 1.223          0.107      0.047      0.115       0.222
Jun                 0.621          0.093      0.044      0.000       0.093
Jul                 1.540          0.090      0.043      0.142       0.232
Aug                 0.679          0.085      0.041      0.071       0.155
Sep                 1.374          0.077      0.038      0.101       0.178
```

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	0.940	0.367	0.285	0.110	0.090	0.051	0.032	0.023	0.001	0.001
Nov	0.815	0.565	0.294	0.109	0.106	0.103	0.075	0.048	0.028	0.001
Dec	1.388	1.123	0.823	0.573	0.409	0.256	0.190	0.106	0.065	0.013
Jan	1.290	1.026	0.726	0.662	0.427	0.300	0.254	0.219	0.143	0.078
Feb	2.181	1.649	1.286	0.703	0.490	0.274	0.255	0.254	0.088	0.023
Mar	0.819	0.541	0.258	0.254	0.238	0.175	0.110	0.038	0.018	0.003
Apr	0.420	0.189	0.113	0.112	0.111	0.110	0.073	0.030	0.004	0.001
May	0.054	0.053	0.052	0.052	0.051	0.050	0.038	0.019	0.009	0.001
Jun	0.054	0.052	0.052	0.051	0.047	0.035	0.028	0.014	0.001	0.001
Jul	0.055	0.053	0.052	0.052	0.042	0.028	0.028	0.001	0.001	0.001
Aug	0.058	0.053	0.051	0.049	0.033	0.027	0.015	0.009	0.001	0.001
Sep	0.088	0.056	0.052	0.047	0.036	0.021	0.012	0.003	0.001	0.001

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.109	0.103	0.098	0.073	0.051	0.036	0.025	0.014	0.001	0.001
Nov	0.108	0.107	0.104	0.101	0.078	0.067	0.056	0.044	0.029	0.001
Dec	0.256	0.254	0.245	0.222	0.190	0.172	0.130	0.093	0.058	0.013
Jan	0.255	0.255	0.254	0.225	0.196	0.176	0.155	0.127	0.107	0.069
Feb	0.256	0.255	0.255	0.254	0.221	0.194	0.150	0.118	0.088	0.023
Mar	0.257	0.254	0.253	0.246	0.211	0.173	0.110	0.039	0.018	0.003
Apr	0.114	0.113	0.112	0.112	0.111	0.095	0.066	0.031	0.004	0.001
May	0.053	0.053	0.052	0.051	0.051	0.050	0.038	0.019	0.009	0.001
Jun	0.054	0.052	0.052	0.051	0.047	0.035	0.028	0.015	0.001	0.001
Jul	0.054	0.053	0.052	0.051	0.039	0.028	0.028	0.001	0.001	0.001
Aug	0.056	0.053	0.051	0.047	0.030	0.028	0.015	0.009	0.001	0.001
Sep	0.056	0.052	0.050	0.040	0.030	0.016	0.010	0.002	0.001	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	2.535	0.953	0.589	0.409	0.199	0.111	0.041	0.029	0.008	0.001
Nov	2.679	1.370	1.021	0.818	0.607	0.456	0.203	0.157	0.030	0.004
Dec	4.693	2.970	2.285	1.645	1.143	0.804	0.460	0.159	0.082	0.020
Jan	3.340	3.011	2.339	1.778	1.398	1.081	0.915	0.520	0.264	0.135
Feb	6.367	3.915	2.676	1.658	1.358	0.928	0.570	0.437	0.257	0.025
Mar	2.983	2.100	1.465	0.897	0.367	0.279	0.139	0.059	0.030	0.009
Apr	1.646	1.352	0.803	0.624	0.427	0.178	0.119	0.034	0.024	0.010
May	1.314	0.593	0.393	0.266	0.155	0.086	0.068	0.027	0.020	0.012
Jun	0.842	0.331	0.227	0.158	0.091	0.057	0.028	0.023	0.016	0.002
Jul	0.931	0.562	0.240	0.138	0.095	0.040	0.028	0.017	0.010	0.001
Aug	0.774	0.255	0.156	0.085	0.059	0.028	0.027	0.016	0.002	0.001
Sep	1.213	0.577	0.418	0.164	0.069	0.045	0.023	0.014	0.002	0.001

19.3.2 Alternative Ecological Category B

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: B		Discharge (m3/s)	1.60	3.30	6.00	11.50
	Discharge (m^3/s)	Monthly volume ($10^6 m^3$)	Duration (days)	3	3	3	3
			Number	1	2	1	1
Oct	0.090	0.242					
Nov	0.123	0.318					
Dec	0.323	0.865					
Jan	0.366	0.980		1	2	1	1
Feb	0.363	0.877					
Mar	0.308	0.824					
Apr	0.166	0.431					
May	0.069	0.183					
Jun	0.059	0.154					
Jul	0.055	0.148					
Aug	0.049	0.132					
Sep	0.047	0.121					

MAR	31.784	MCM	
S.Dev.	3.916		
CV	0.123		
Q75	0.719212963		
Ecological Category	B		
	MCM	% MAR	
Total IFR	12.467	39.225	(excl. >=1:2)
Maint. Lowflow	5.276	16.600	
Drought Lowflow	1.143	3.597	
Maint. Highflow	7.191	22.624	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	2.328	0.242	0.061	0.699	0.941
Nov	2.562	0.318	0.072	0.681	0.999
Dec	4.815	0.865	0.184	1.489	2.354
Jan	5.319	0.980	0.196	1.284	2.264
Feb	6.474	0.877	0.175	1.683	2.560
Mar	2.894	0.824	0.174	0.567	1.391
Apr	1.957	0.431	0.070	0.340	0.771
May	1.223	0.183	0.047	0.121	0.305
Jun	0.621	0.154	0.044	0.000	0.154
Jul	1.540	0.148	0.043	0.142	0.290
Aug	0.679	0.132	0.041	0.071	0.203
Sep	1.374	0.121	0.038	0.114	0.235

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	1.069	0.353	0.305	0.233	0.155	0.071	0.032	0.024	0.001	0.001
Nov	0.955	0.745	0.384	0.230	0.201	0.183	0.130	0.062	0.028	0.001
Dec	1.721	1.397	1.015	0.830	0.591	0.522	0.286	0.151	0.083	0.013
Jan	1.535	1.218	1.039	0.859	0.694	0.583	0.463	0.311	0.200	0.099
Feb	2.384	1.989	1.390	0.900	0.648	0.587	0.397	0.336	0.135	0.023
Mar	1.258	0.941	0.589	0.524	0.292	0.210	0.110	0.040	0.018	0.003
Apr	0.631	0.458	0.291	0.283	0.280	0.134	0.073	0.030	0.004	0.001
May	0.107	0.106	0.103	0.103	0.082	0.064	0.040	0.025	0.009	0.001
Jun	0.104	0.103	0.102	0.093	0.055	0.037	0.028	0.014	0.001	0.001
Jul	0.109	0.105	0.102	0.083	0.056	0.028	0.028	0.001	0.001	0.001
Aug	0.111	0.100	0.074	0.059	0.037	0.028	0.018	0.009	0.001	0.001
Sep	0.140	0.110	0.100	0.064	0.050	0.029	0.014	0.003	0.001	0.001

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.203	0.193	0.146	0.090	0.071	0.044	0.029	0.014	0.001	0.001
Nov	0.201	0.198	0.174	0.154	0.123	0.100	0.077	0.062	0.029	0.001
Dec	0.590	0.556	0.432	0.364	0.325	0.255	0.185	0.111	0.071	0.013
Jan	0.589	0.583	0.488	0.420	0.342	0.300	0.240	0.197	0.162	0.091
Feb	0.592	0.587	0.462	0.397	0.363	0.322	0.268	0.230	0.135	0.023
Mar	0.594	0.586	0.564	0.403	0.292	0.210	0.110	0.040	0.018	0.003
Apr	0.287	0.284	0.281	0.249	0.162	0.132	0.073	0.031	0.004	0.001
May	0.107	0.105	0.103	0.102	0.079	0.064	0.040	0.025	0.009	0.001
Jun	0.104	0.103	0.102	0.093	0.055	0.037	0.028	0.015	0.001	0.001
Jul	0.107	0.104	0.097	0.074	0.055	0.028	0.028	0.001	0.001	0.001
Aug	0.109	0.100	0.071	0.058	0.037	0.028	0.018	0.009	0.001	0.001
Sep	0.107	0.101	0.064	0.050	0.036	0.016	0.010	0.002	0.001	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	2.535	0.953	0.589	0.409	0.199	0.111	0.041	0.029	0.008	0.001
Nov	2.679	1.370	1.021	0.818	0.607	0.456	0.203	0.157	0.030	0.004
Dec	4.693	2.970	2.285	1.645	1.143	0.804	0.460	0.159	0.082	0.020
Jan	3.340	3.011	2.339	1.778	1.398	1.081	0.915	0.520	0.264	0.135
Feb	6.367	3.915	2.676	1.658	1.358	0.928	0.570	0.437	0.257	0.025
Mar	2.983	2.100	1.465	0.897	0.367	0.279	0.139	0.059	0.030	0.009
Apr	1.646	1.352	0.803	0.624	0.427	0.178	0.119	0.034	0.024	0.010
May	1.314	0.593	0.393	0.266	0.155	0.086	0.068	0.027	0.020	0.012
Jun	0.842	0.331	0.227	0.158	0.091	0.057	0.028	0.023	0.016	0.002
Jul	0.931	0.562	0.240	0.138	0.095	0.040	0.028	0.017	0.010	0.001
Aug	0.774	0.255	0.156	0.085	0.059	0.028	0.027	0.016	0.002	0.001
Sep	1.213	0.577	0.418	0.164	0.069	0.045	0.023	0.014	0.002	0.001

19.3.3 Alternative Ecological Category D

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: D		Discharge (m3/s)	1.60	3.40	6.10	11.50
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	3	3	3	3
			Number	0	1	1	0
Oct	0.023	0.061					
Nov	0.028	0.072					
Dec	0.069	0.184			1		
Jan	0.073	0.196				1	
Feb	0.072	0.175					
Mar	0.065	0.174					
Apr	0.027	0.070					
May	0.018	0.047					
Jun	0.017	0.044					
Jul	0.016	0.043					
Aug	0.015	0.041					
Sep	0.015	0.038					

MAR 31.784 MCM
S.Dev. 3.916
CV 0.123
Q75 0.719212963
Ecological Category D

	MCM	% MAR	
Total IFR	5.979	18.811	(excl. >=1:2)
Maint. Lowflow	1.143	3.597	
Drought Lowflow	1.143	3.597	
Maint. Highflow	4.836	15.214	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	2.328	0.061	0.061	0.449	0.510
Nov	2.562	0.072	0.072	0.422	0.494
Dec	4.815	0.184	0.184	1.003	1.187
Jan	5.319	0.196	0.196	0.862	1.058
Feb	6.474	0.175	0.175	1.204	1.379
Mar	2.894	0.174	0.174	0.387	0.561
Apr	1.957	0.070	0.070	0.159	0.229
May	1.223	0.047	0.047	0.048	0.095
Jun	0.621	0.044	0.044	0.000	0.044
Jul	1.540	0.043	0.043	0.143	0.185
Aug	0.679	0.041	0.041	0.071	0.112
Sep	1.374	0.038	0.038	0.087	0.125

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category D
Data are given in m^3/s mean monthly flow
Month % Points

	10	20	30	40	50	60	70	80	90	99
Oct	0.564	0.249	0.033	0.032	0.032	0.028	0.022	0.012	0.001	0.001
Nov	0.598	0.349	0.102	0.033	0.033	0.032	0.031	0.028	0.018	0.001
Dec	1.048	0.658	0.400	0.315	0.083	0.082	0.081	0.053	0.040	0.013
Jan	0.979	0.630	0.389	0.388	0.263	0.083	0.082	0.081	0.058	0.043
Feb	1.619	1.369	0.703	0.411	0.241	0.082	0.082	0.075	0.055	0.021
Mar	0.570	0.209	0.082	0.082	0.081	0.081	0.072	0.037	0.018	0.003
Apr	0.041	0.032	0.031	0.031	0.031	0.030	0.030	0.028	0.004	0.001
May	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.014	0.008	0.001
Jun	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.013	0.001	0.001
Jul	0.022	0.022	0.021	0.021	0.021	0.020	0.020	0.001	0.001	0.001
Aug	0.023	0.022	0.021	0.020	0.020	0.020	0.011	0.007	0.001	0.001
Sep	0.027	0.022	0.021	0.021	0.020	0.014	0.010	0.002	0.001	0.001

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.033	0.032	0.032	0.031	0.029	0.026	0.019	0.009	0.001	0.001
Nov	0.033	0.033	0.032	0.032	0.031	0.031	0.029	0.025	0.017	0.001
Dec	0.082	0.082	0.082	0.082	0.079	0.073	0.061	0.051	0.040	0.013
Jan	0.083	0.082	0.082	0.082	0.081	0.077	0.071	0.059	0.051	0.040
Feb	0.084	0.082	0.082	0.082	0.082	0.075	0.071	0.062	0.050	0.021
Mar	0.082	0.082	0.081	0.081	0.081	0.081	0.065	0.037	0.018	0.003
Apr	0.032	0.031	0.031	0.031	0.031	0.030	0.029	0.028	0.004	0.001
May	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.014	0.008	0.001
Jun	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.013	0.001	0.001
Jul	0.022	0.022	0.021	0.021	0.021	0.020	0.020	0.001	0.001	0.001
Aug	0.022	0.021	0.020	0.020	0.020	0.020	0.011	0.007	0.001	0.001
Sep	0.022	0.021	0.021	0.021	0.020	0.014	0.010	0.002	0.001	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	2.535	0.953	0.589	0.409	0.199	0.111	0.041	0.029	0.008	0.001
Nov	2.679	1.370	1.021	0.818	0.607	0.456	0.203	0.157	0.030	0.004
Dec	4.693	2.970	2.285	1.645	1.143	0.804	0.460	0.159	0.082	0.020
Jan	3.340	3.011	2.339	1.778	1.398	1.081	0.915	0.520	0.264	0.135
Feb	6.367	3.915	2.676	1.658	1.358	0.928	0.570	0.437	0.257	0.025
Mar	2.983	2.100	1.465	0.897	0.367	0.279	0.139	0.059	0.030	0.009
Apr	1.646	1.352	0.803	0.624	0.427	0.178	0.119	0.034	0.024	0.010
May	1.314	0.593	0.393	0.266	0.155	0.086	0.068	0.027	0.020	0.012
Jun	0.842	0.331	0.227	0.158	0.091	0.057	0.028	0.023	0.016	0.002
Jul	0.931	0.562	0.240	0.138	0.095	0.040	0.028	0.017	0.010	0.001
Aug	0.774	0.255	0.156	0.085	0.059	0.028	0.027	0.016	0.002	0.001
Sep	1.213	0.577	0.418	0.164	0.069	0.045	0.023	0.014	0.002	0.001

20 EWR SITE BM2 (BLACK MFOLOZI RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site BM2. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

Please see Appendix B for a discussion on the relationship between the EWRs for BM1 determined using the data prepared for this study (see Report No. RDM/WMA6/CON/COMP/1013) and WR2012 data.

On the basis of the results in Figure 12-1 and Figure 12-2, the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Black Mfolozi	BM2	C	B	D	-
		SS4	SS4a[12]	SS2	

20.1 Mean percentage changes

The mean percentage changes (relative to Base2014) in indicators for the EWRs that were selected as potential Reserves to maintain the REC and AECs at EWR Site BM2 are given in Table 20-1.

[12] Should maintain a B provided non-flow related impacts are addressed.

Table 20-1 EWR Site BM2: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

Discipline	Indicator	AEC2 SS2 D category	REC SS4 C category	AEC1 SS4a B category
Geomorphology	Channel width	-1.36	-0.88	-0.44
	Extent of cut banks	-5.68	-4.99	-3.09
	Secondary channels	0.58	0.55	0.90
	Pool depth	10.73	-3.29	-0.78
	Bed sediment conditions	-8.41	-3.61	-2.39
Water quality	Summer water temperature	4.91	2.84	2.62
	Nutrients - phosphates	44.25	6.55	5.95
	Nutrients - nitrogen	45.84	3.90	4.60
	Electrical conductivity (salinity)	16.08	4.77	6.05
	Sulphates	24.15	7.61	9.75
Riparian Vegetation	Algae	28.91	12.05	-5.11
	Marginal zone graminoids	-59.71	-15.98	-0.36
	Marginal zone trees	-75.05	-21.52	-10.92
	Lower zone graminoids	-85.94	-44.99	-20.47
	Lower zone trees	-79.25	-27.34	-4.14
	Upper zone trees - riparian	-24.76	-17.07	-13.89
	Upper zone trees - terrestrial	28.97	14.42	11.31
Macro-invertebrates	Palaemonidae (Freshwater Prawns)	-34.89	-7.75	0.64
	Perlidae (Stoneflies)	-59.32	-12.76	2.83
	Hydropsychidae (Caddisflies)	-33.51	-9.38	-0.78
	Heptageniidae (Flatheaded mayfly)	-29.13	-6.92	-0.09
	Gomphidae (Clubtails)	-20.29	-1.97	4.91
	Leptophlebiidae (Prongills)	-26.01	-3.67	2.49
	Baetidae (Minnow mayflies)	-17.67	-5.60	0.46
	Chironomidae (Midges)	-17.24	-4.46	1.62
	Simuliidae (Blackflies)	-28.14	-9.04	-1.25
	Coenagrionidae (Sprites & Blues)	-94.52	-22.41	-0.72
Fish	Amphilius uranoscopus	-68.45	-23.36	-4.81
	Oreochromis mossambicus	27.80	19.13	8.97
	Labeo molybdinus	-55.59	-20.15	-11.90
	Labeobarbus natalensis	-78.36	-29.79	-12.13
	Barbus trimaculatus	-43.38	-16.11	-7.25

20.2 Time series

The time series of predicted abundance changes relative to Baseline2014 for Base2014, Nat, and the EWRs for maintaining a B-, C- and D-category are provided for the indicators for each discipline (Figure 20-1 and Figure 20-5).

Figure 20-1 Time series for the geomorphological indicators at EWR Site BM2 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

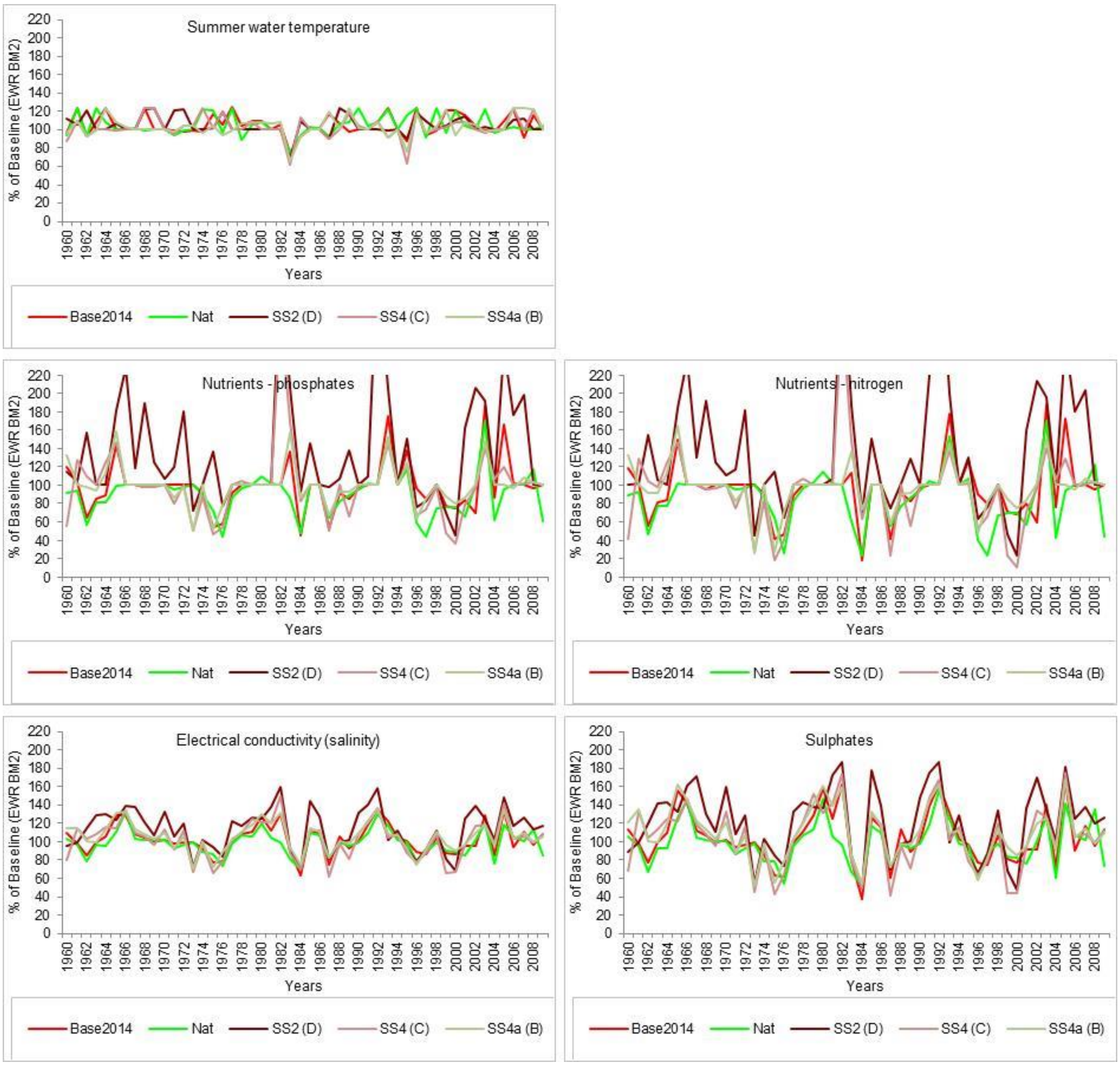


Figure 20-2 Time series for the water quality indicators at EWR Site BM2 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

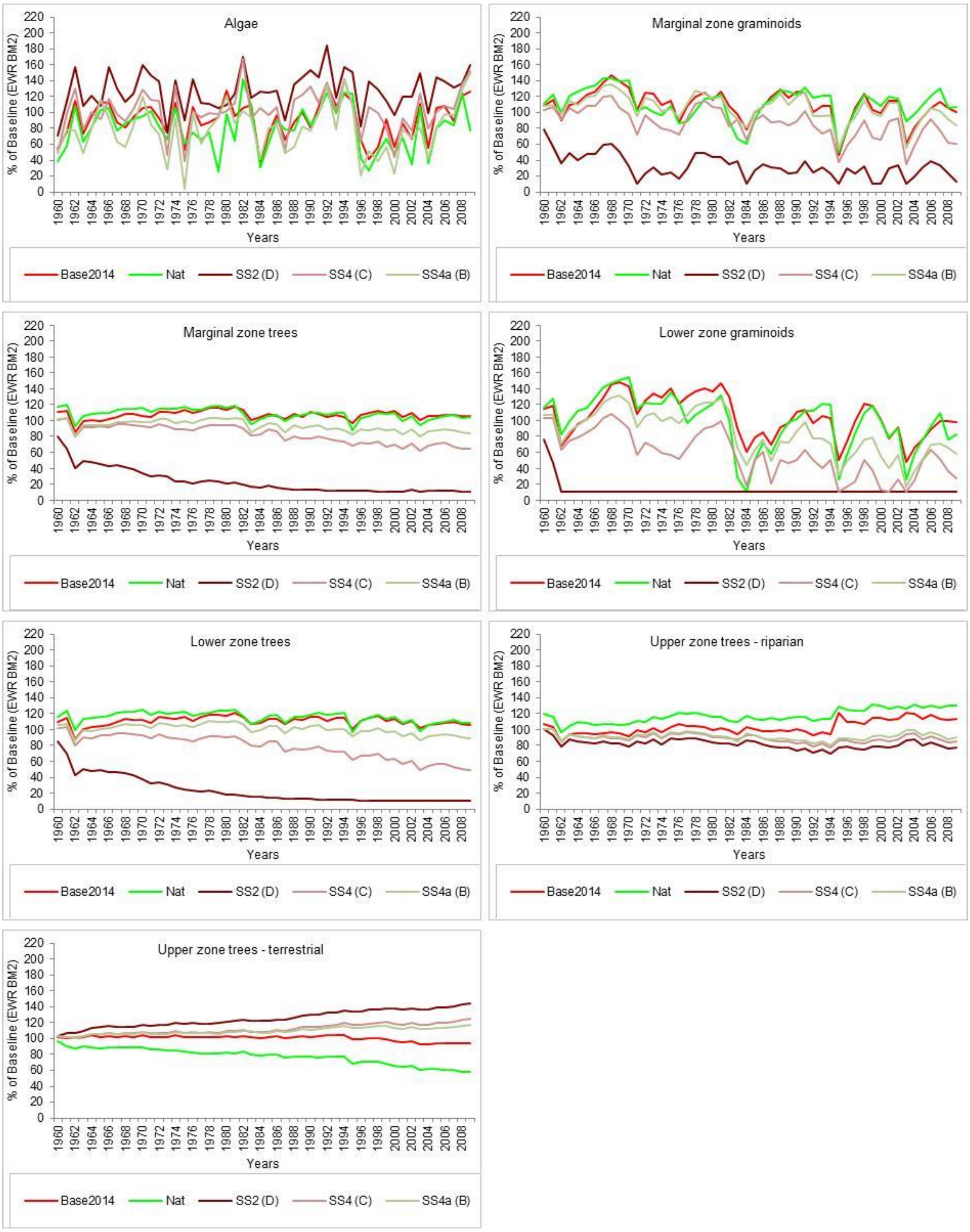


Figure 20-3 Time series for the vegetation indicators at EWR Site BM2 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

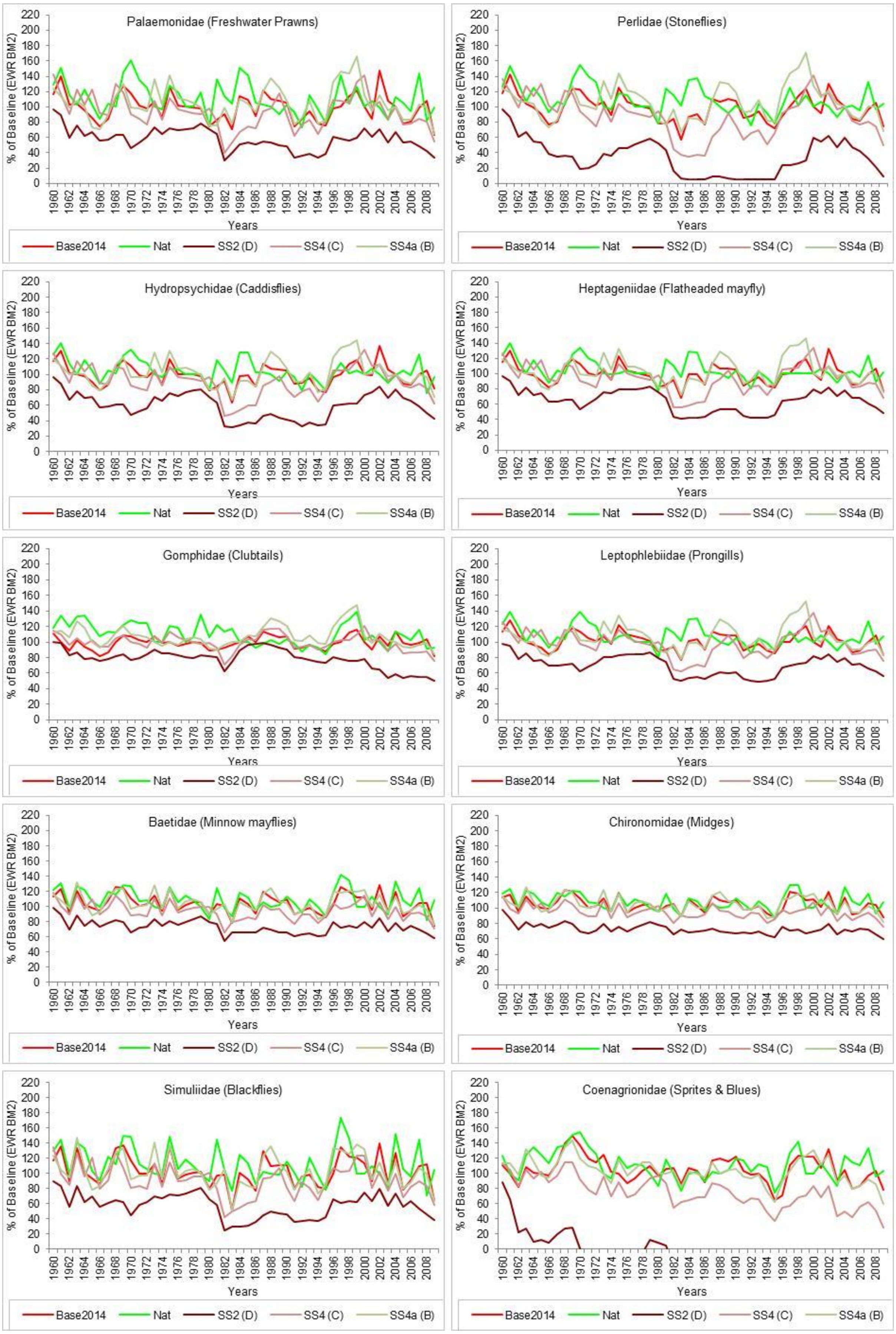


Figure 20-4 Time series for the macroinvertebrate indicators at EWR Site BM2 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

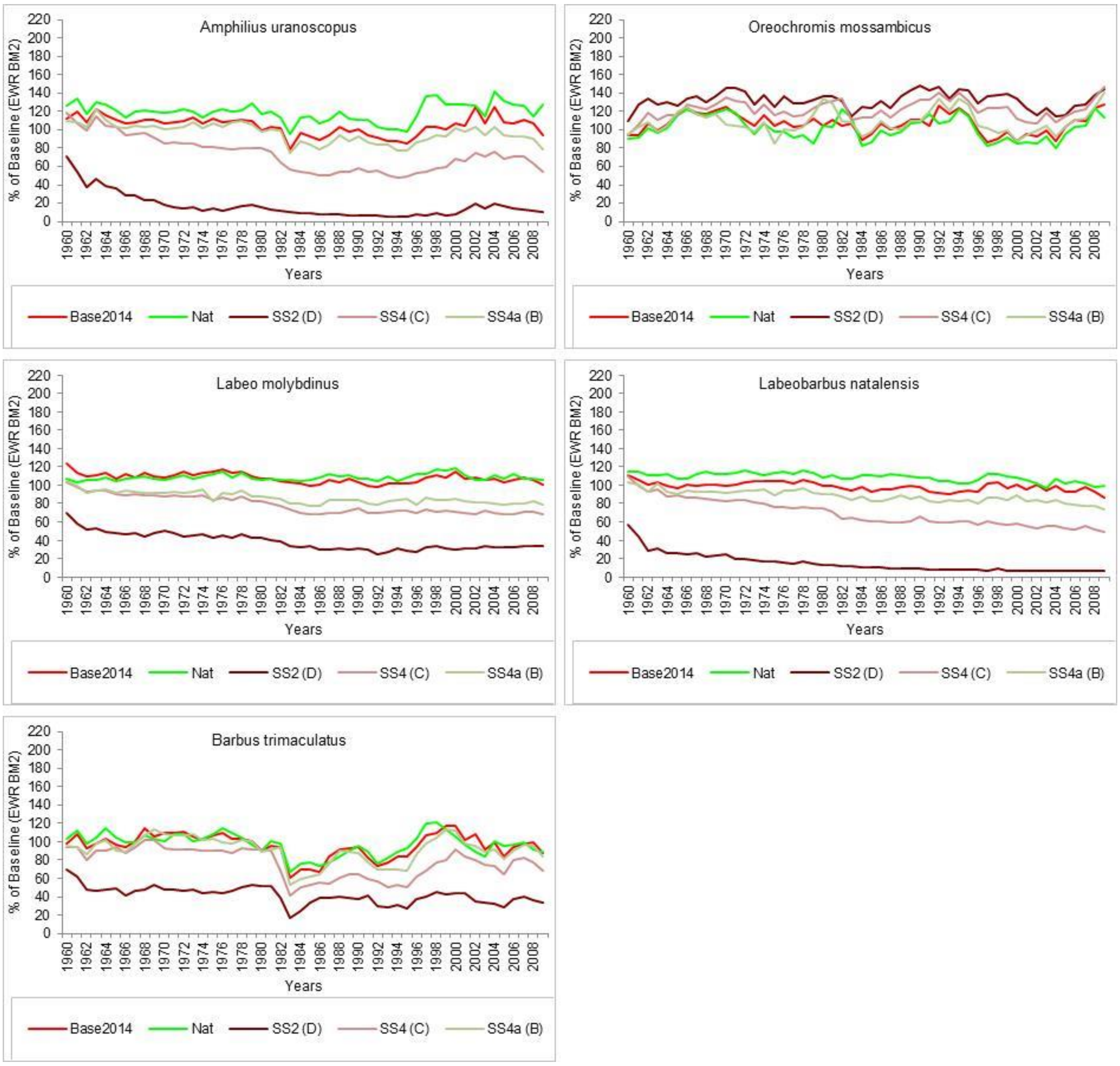


Figure 20-5 Time series for the fish indicators at EWR Site BM2 for Base2014, Nat scenarios, and the EWRs for B-, C- and D-category.

20.3 Hydrological summaries (BM2)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide

a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

20.3.1 Recommended Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C		Discharge (m3/s)	3.50	6.30	12.00	22.10
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	3	3	3	3
			Number	1	2	2	1
Oct	0.248	0.664					
Nov	0.335	0.867					
Dec	0.834	2.235					
Jan	0.872	2.335		1	2	2	1
Feb	0.904	2.188					
Mar	0.760	2.035					
Apr	0.453	1.174					
May	0.095	0.254					
Jun	0.085	0.219					
Jul	0.079	0.212					
Aug	0.074	0.199					
Sep	0.072	0.188					

```
MAR                   96.141          MCM
S.Dev.                3.916
CV                    0.041
Q75                   0.719212963
Ecological Category C
                      MCM             % MAR
Total IFR             28.951          30.113     (excl. >=1:2)
Maint. Lowflow        12.570          13.075
Drought Lowflow       2.231           2.320
Maint. Highflow       16.381          17.039
Monthly Distributions (MCM)
Distribution Type:  ?? KZN
Month                 Natural Flows   Modified Flows (IFR)
                                      Low flows            High Flows   Total Flows
                      Mean            Maint.     Drought   Maint.       Maint.
Oct                   5.942           0.664      0.132     1.481        2.146
Nov                   5.953           0.867      0.151     1.100        1.967
Dec                   13.655          2.235      0.308     3.515        5.750
Jan                   15.780          2.335      0.299     3.381        5.717
Feb                   17.933          2.188      0.280     3.802        5.989
Mar                   7.666           2.035      0.286     1.706        3.740
Apr                   4.308           1.174      0.192     0.330        1.503
May                   2.561           0.254      0.131     0.133        0.387
Jun                   1.391           0.219      0.114     0.000        0.219
Jul                   13.920          0.212      0.114     0.597        0.809
Aug                   2.994           0.199      0.115     0.109        0.308
Sep                   4.038           0.188      0.109     0.228        0.416
```

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	2.288	1.496	0.732	0.503	0.355	0.130	0.075	0.054	0.019	0.001
Nov	1.850	1.311	0.750	0.542	0.493	0.378	0.252	0.194	0.145	0.012
Dec	4.743	3.674	2.897	2.138	1.522	1.110	0.679	0.508	0.167	0.021
Jan	3.842	3.164	2.541	2.219	1.897	1.448	1.217	0.938	0.588	0.030
Feb	4.430	3.996	3.092	2.411	1.946	1.421	0.992	0.677	0.374	0.045
Mar	2.995	1.924	1.567	1.396	0.840	0.424	0.231	0.167	0.076	0.021
Apr	1.082	0.819	0.779	0.695	0.580	0.416	0.220	0.110	0.064	0.016
May	0.126	0.125	0.123	0.122	0.116	0.095	0.080	0.072	0.046	0.005
Jun	0.123	0.123	0.121	0.105	0.085	0.080	0.076	0.058	0.015	0.001
Jul	0.138	0.128	0.113	0.099	0.082	0.077	0.068	0.041	0.002	0.001
Aug	0.138	0.118	0.094	0.080	0.079	0.069	0.058	0.035	0.004	0.001
Sep	0.162	0.139	0.113	0.083	0.069	0.058	0.041	0.030	0.003	0.001

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.523	0.504	0.452	0.335	0.165	0.092	0.068	0.054	0.019	0.001
Nov	0.539	0.514	0.469	0.414	0.332	0.263	0.224	0.165	0.144	0.012
Dec	1.417	1.370	1.189	0.969	0.849	0.760	0.531	0.405	0.138	0.021
Jan	1.433	1.429	1.117	1.014	0.872	0.713	0.604	0.521	0.302	0.030
Feb	1.437	1.416	1.207	1.034	0.926	0.848	0.647	0.479	0.357	0.045
Mar	1.430	1.404	1.350	1.173	0.760	0.340	0.231	0.167	0.077	0.021
Apr	0.812	0.779	0.704	0.594	0.441	0.341	0.202	0.110	0.064	0.016
May	0.126	0.124	0.123	0.122	0.113	0.095	0.080	0.072	0.046	0.005
Jun	0.123	0.123	0.121	0.105	0.085	0.081	0.076	0.058	0.016	0.001
Jul	0.132	0.120	0.109	0.095	0.080	0.077	0.068	0.041	0.002	0.001
Aug	0.138	0.118	0.088	0.080	0.079	0.069	0.058	0.035	0.004	0.001
Sep	0.139	0.121	0.095	0.079	0.067	0.058	0.039	0.030	0.003	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	4.789	3.159	2.276	1.278	0.853	0.528	0.282	0.141	0.078	0.001
Nov	4.173	2.730	2.292	1.925	1.685	1.410	0.962	0.670	0.491	0.084
Dec	12.976	8.072	5.974	4.478	3.042	1.913	1.363	1.048	0.405	0.084
Jan	10.884	8.703	6.654	4.722	3.552	2.894	2.031	1.506	0.996	0.191
Feb	11.814	10.324	7.413	4.590	3.100	2.507	1.920	1.200	0.742	0.069
Mar	6.225	4.854	3.874	2.816	1.239	0.808	0.586	0.355	0.102	0.043
Apr	4.360	2.214	1.695	1.354	1.165	0.834	0.567	0.362	0.079	0.026
May	2.930	1.343	0.939	0.594	0.444	0.261	0.216	0.104	0.077	0.018
Jun	1.472	1.191	0.577	0.367	0.296	0.205	0.150	0.079	0.062	0.001
Jul	10.107	2.933	0.977	0.566	0.315	0.206	0.135	0.079	0.045	0.001
Aug	3.244	1.091	0.497	0.213	0.159	0.107	0.079	0.078	0.026	0.001
Sep	4.158	2.082	1.200	0.597	0.245	0.097	0.079	0.078	0.041	0.001

20.3.2 Alternative Ecological Category B

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: B		Discharge (m3/s)	3.50	6.30	12.00	22.10
	Discharge (m^3/s)	Monthly volume ($10^6 m^3$)	Duration (days)	3	3	3	3
			Number	6	2	2	1
Oct	0.488	1.308					
Nov	0.769	1.994		2			
Dec	1.203	3.222			2	2	1
Jan	1.362	3.647		1			
Feb	1.448	3.503		1			
Mar	1.150	3.079		2			
Apr	0.720	1.866					
May	0.253	0.679					
Jun	0.194	0.504					
Jul	0.169	0.454					
Aug	0.153	0.409					
Sep	0.158	0.410					

AEC1	SS4a				
MAR	96.141	MCM			
S.Dev.	3.916				
CV	0.041				
Q75	0.719212963				
Ecological Category	B				
	MCM	% MAR			
Total IFR	37.475	38.979	(excl. >=1:2)		
Maint. Lowflow	21.075	21.921			
Drought Lowflow	2.231	2.320			
Maint. Highflow	16.400	17.058			
Monthly Distributions (MCM)					
Distribution Type:	?? KZN				
Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	5.942	1.308	0.132	1.420	2.728
Nov	5.953	1.994	0.151	1.031	3.025
Dec	13.655	3.222	0.308	3.625	6.847
Jan	15.780	3.647	0.299	3.447	7.094
Feb	17.933	3.503	0.280	3.637	7.140
Mar	7.666	3.079	0.286	1.833	4.912
Apr	4.308	1.866	0.192	0.305	2.171
May	2.561	0.679	0.131	0.127	0.806
Jun	1.391	0.504	0.114	0.000	0.504
Jul	13.920	0.454	0.114	0.586	1.040
Aug	2.994	0.409	0.115	0.106	0.515
Sep	4.038	0.410	0.109	0.283	0.692

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	2.499	1.909	1.114	0.761	0.429	0.150	0.079	0.054	0.027	0.001
Nov	2.650	1.901	1.585	1.155	0.856	0.591	0.437	0.257	0.152	0.012
Dec	6.295	4.265	3.772	2.527	1.901	1.333	0.698	0.522	0.167	0.021
Jan	4.482	4.039	3.476	3.232	2.591	1.813	1.452	0.993	0.589	0.030
Feb	5.531	4.747	3.424	2.951	2.615	1.708	1.180	0.726	0.374	0.045
Mar	4.229	3.085	2.575	1.870	0.873	0.424	0.231	0.167	0.076	0.021
Apr	1.841	1.546	1.239	0.829	0.706	0.500	0.245	0.111	0.064	0.016
May	0.521	0.491	0.448	0.305	0.222	0.110	0.087	0.072	0.046	0.005
Jun	0.473	0.421	0.314	0.165	0.104	0.081	0.076	0.058	0.015	0.001
Jul	0.495	0.375	0.206	0.151	0.084	0.077	0.068	0.042	0.002	0.001
Aug	0.522	0.268	0.131	0.087	0.079	0.069	0.058	0.035	0.004	0.001
Sep	0.521	0.424	0.210	0.122	0.069	0.058	0.046	0.036	0.003	0.001

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	1.336	0.899	0.716	0.534	0.197	0.118	0.079	0.054	0.027	0.001
Nov	1.726	1.444	0.933	0.780	0.595	0.473	0.428	0.220	0.145	0.012
Dec	2.514	2.132	1.586	1.158	0.813	0.772	0.589	0.412	0.138	0.021
Jan	3.127	2.272	1.648	1.369	1.136	0.847	0.688	0.589	0.296	0.030
Feb	3.035	2.440	1.846	1.451	1.221	0.986	0.753	0.522	0.357	0.045
Mar	2.731	2.339	1.606	1.288	0.789	0.340	0.231	0.167	0.077	0.021
Apr	1.599	1.514	0.920	0.795	0.594	0.379	0.202	0.111	0.064	0.016
May	0.518	0.491	0.448	0.305	0.221	0.110	0.087	0.072	0.046	0.005
Jun	0.473	0.421	0.314	0.165	0.104	0.082	0.076	0.058	0.016	0.001
Jul	0.468	0.332	0.188	0.151	0.084	0.077	0.068	0.042	0.002	0.001
Aug	0.522	0.268	0.131	0.087	0.080	0.069	0.058	0.035	0.004	0.001
Sep	0.511	0.242	0.181	0.096	0.067	0.058	0.046	0.036	0.003	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	4.789	3.159	2.276	1.278	0.853	0.528	0.282	0.141	0.078	0.001
Nov	4.173	2.730	2.292	1.925	1.685	1.410	0.962	0.670	0.491	0.084
Dec	12.976	8.072	5.974	4.478	3.042	1.913	1.363	1.048	0.405	0.084
Jan	10.884	8.703	6.654	4.722	3.552	2.894	2.031	1.506	0.996	0.191
Feb	11.814	10.324	7.413	4.590	3.100	2.507	1.920	1.200	0.742	0.069
Mar	6.225	4.854	3.874	2.816	1.239	0.808	0.586	0.355	0.102	0.043
Apr	4.360	2.214	1.695	1.354	1.165	0.834	0.567	0.362	0.079	0.026
May	2.930	1.343	0.939	0.594	0.444	0.261	0.216	0.104	0.077	0.018
Jun	1.472	1.191	0.577	0.367	0.296	0.205	0.150	0.079	0.062	0.001
Jul	10.107	2.933	0.977	0.566	0.315	0.206	0.135	0.079	0.045	0.001
Aug	3.244	1.091	0.497	0.213	0.159	0.107	0.079	0.078	0.026	0.001
Sep	4.158	2.082	1.200	0.597	0.245	0.097	0.079	0.078	0.041	0.001

20.3.3 Alternative Ecological Category D

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: D		Discharge (m3/s)	3.50	6.30	12.00	22.10
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	3	3	3	3
			Number	1	1	1	1
Oct	0.049	0.132					
Nov	0.058	0.151					
Dec	0.115	0.308					
Jan	0.112	0.299		1	1	1	1
Feb	0.116	0.280					
Mar	0.107	0.286					
Apr	0.074	0.192					
May	0.049	0.131					
Jun	0.044	0.114					
Jul	0.043	0.114					
Aug	0.043	0.115					
Sep	0.042	0.109					

MAR 96.141 MCM
S.Dev. 3.916
CV 0.041
Q75 0.719212963
Ecological Category D

	MCM	% MAR	
Total IFR	17.735	18.447	(excl. >=1:2)
Maint. Lowflow	2.231	2.320	
Drought Lowflow	2.231	2.320	
Maint. Highflow	15.505	16.127	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	5.942	0.132	0.132	1.276	1.408
Nov	5.953	0.151	0.151	0.979	1.130
Dec	13.655	0.308	0.308	3.380	3.688
Jan	15.780	0.299	0.299	3.236	3.536
Feb	17.933	0.280	0.280	3.768	4.048
Mar	7.666	0.286	0.286	1.623	1.909
Apr	4.308	0.192	0.192	0.217	0.408
May	2.561	0.131	0.131	0.103	0.233
Jun	1.391	0.114	0.114	0.000	0.114
Jul	13.920	0.114	0.114	0.600	0.714
Aug	2.994	0.115	0.115	0.110	0.224
Sep	4.038	0.109	0.109	0.213	0.322

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category D
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	0.564	0.249	0.033	0.032	0.032	0.028	0.022	0.012	0.001	0.001
Nov	0.598	0.349	0.102	0.033	0.033	0.032	0.031	0.028	0.018	0.001
Dec	1.048	0.658	0.400	0.315	0.083	0.082	0.081	0.053	0.040	0.013
Jan	0.979	0.630	0.389	0.388	0.263	0.083	0.082	0.081	0.058	0.043
Feb	1.619	1.369	0.703	0.411	0.241	0.082	0.082	0.075	0.055	0.021
Mar	0.570	0.209	0.082	0.082	0.081	0.081	0.072	0.037	0.018	0.003
Apr	0.041	0.032	0.031	0.031	0.031	0.030	0.030	0.028	0.004	0.001
May	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.014	0.008	0.001
Jun	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.013	0.001	0.001
Jul	0.022	0.022	0.021	0.021	0.021	0.020	0.020	0.001	0.001	0.001
Aug	0.023	0.022	0.021	0.020	0.020	0.020	0.011	0.007	0.001	0.001
Sep	0.027	0.022	0.021	0.021	0.020	0.014	0.010	0.002	0.001	0.001

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.065	0.064	0.064	0.063	0.062	0.052	0.043	0.028	0.016	0.001
Nov	0.065	0.064	0.064	0.063	0.063	0.062	0.060	0.058	0.046	0.012
Dec	0.133	0.131	0.130	0.127	0.125	0.119	0.114	0.102	0.091	0.021
Jan	0.124	0.123	0.123	0.123	0.122	0.117	0.111	0.106	0.089	0.026
Feb	0.126	0.124	0.124	0.123	0.123	0.123	0.118	0.112	0.105	0.045
Mar	0.125	0.124	0.123	0.122	0.121	0.115	0.102	0.086	0.077	0.021
Apr	0.082	0.082	0.081	0.081	0.081	0.080	0.079	0.074	0.050	0.013
May	0.058	0.054	0.052	0.051	0.051	0.051	0.050	0.050	0.044	0.005
Jun	0.053	0.052	0.051	0.051	0.051	0.050	0.050	0.044	0.016	0.001
Jul	0.056	0.055	0.052	0.051	0.050	0.050	0.049	0.041	0.002	0.001
Aug	0.059	0.056	0.052	0.051	0.050	0.050	0.046	0.035	0.003	0.001
Sep	0.061	0.058	0.055	0.052	0.050	0.046	0.037	0.025	0.002	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	4.789	3.159	2.276	1.278	0.853	0.528	0.282	0.141	0.078	0.001
Nov	4.173	2.730	2.292	1.925	1.685	1.410	0.962	0.670	0.491	0.084
Dec	12.976	8.072	5.974	4.478	3.042	1.913	1.363	1.048	0.405	0.084
Jan	10.884	8.703	6.654	4.722	3.552	2.894	2.031	1.506	0.996	0.191
Feb	11.814	10.324	7.413	4.590	3.100	2.507	1.920	1.200	0.742	0.069
Mar	6.225	4.854	3.874	2.816	1.239	0.808	0.586	0.355	0.102	0.043
Apr	4.360	2.214	1.695	1.354	1.165	0.834	0.567	0.362	0.079	0.026
May	2.930	1.343	0.939	0.594	0.444	0.261	0.216	0.104	0.077	0.018
Jun	1.472	1.191	0.577	0.367	0.296	0.205	0.150	0.079	0.062	0.001
Jul	10.107	2.933	0.977	0.566	0.315	0.206	0.135	0.079	0.045	0.001
Aug	3.244	1.091	0.497	0.213	0.159	0.107	0.079	0.078	0.026	0.001
Sep	4.158	2.082	1.200	0.597	0.245	0.097	0.079	0.078	0.041	0.001

21 EWR SITE WM1 (WHITE MFOLOZI RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site WM1. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

Please see Appendix B for a discussion on the relationship between the EWRs for BM1 determined using the data prepared for this study (see Report No. RDM/WMA6/CON/COMP/1013) and WR2012 data.

On the basis of the results in Figure 13-1 and Figure 13-2, the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
White Mfolozi	WM1	C	B	D	-
		SS4[13]	SS4a[14]	SS2	

21.1 Mean percentage changes

The mean percentage changes (relative to Baseline) in indicators for the EWRs that were selected as potential Reserves to maintain the REC and AECs at EWR Site WM1 are given in Table 21-1.

[13] Can maintain a B/C provided non flow related impacts are addressed
[14] Should maintain a B provided non-flow related impacts are addressed

Table 21-1 EWR Site WM1: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

Discipline	Indicator	AEC2 SS2 D category	REC SS4 C category	AEC1 SS4a B category
Geomorphology	Channel width	-1.34	1.47	0.61
	Extent of cut banks	-4.42	0.61	1.60
	Secondary channels	-7.66	-2.20	-0.42
	Pool depth	17.03	5.94	5.53
	Bed sediment conditions	-15.00	-5.42	-4.24
Water quality	Summer water temperature	-1.65	-1.36	-1.09
	Nutrients - phosphates	105.31	5.31	7.13
	Nutrients - nitrogen	75.79	0.08	2.44
	Electrical conductivity (salinity)	9.55	-1.25	-0.84
	Sulphates	18.76	-1.41	-0.99
Riparian Vegetation	Algae	34.74	10.83	3.61
	Marginal zone graminoids	-31.54	-0.40	0.71
	Marginal zone trees	-60.50	-4.09	-2.89
	Lower zone graminoids	-70.13	-12.56	-3.82
	Lower zone trees	-72.55	0.89	5.75
	Upper zone trees - riparian	-18.56	-9.41	-5.35
	Upper zone trees - terrestrial	89.63	33.50	13.79
Macro-invertebrates	Palaemonidae (Freshwater Prawns)	-30.93	-10.15	-4.59
	Hydropsychidae (Caddisflies)	-42.44	-13.92	-8.18
	Heptageniidae (Flatheaded mayfly)	-43.71	-14.57	-9.09
	Gomphidae (Clubtails)	-17.98	-3.19	5.62
	Leptophlebiidae (Prongills)	-39.49	-12.27	-4.83
	Baetidae (Minnow mayflies)	-15.25	-3.98	-1.56
	Chironomidae (Midges)	-12.92	-1.89	-0.08
	Simuliidae (Blackflies)	-32.22	-10.29	-7.64
	Coenagrionidae (Sprites & Blues)	-42.16	-7.47	-2.72
Fish	Amphilius uranoscopus	-73.24	-23.36	-15.53
	Oreochromis mossambicus	12.31	4.70	3.17
	Labeo molybdinus	-69.44	-21.97	-17.04
	Labeobarbus natalensis	-62.67	-22.69	-18.94

21.2 Time series

The time series of predicted abundance changes relative to baseline (2014) under baseline, naturalised and the EWRs for maintaining a B-, C- and D-category are provided for the indicators for each discipline (Figure 21-1 to Figure 21-5).

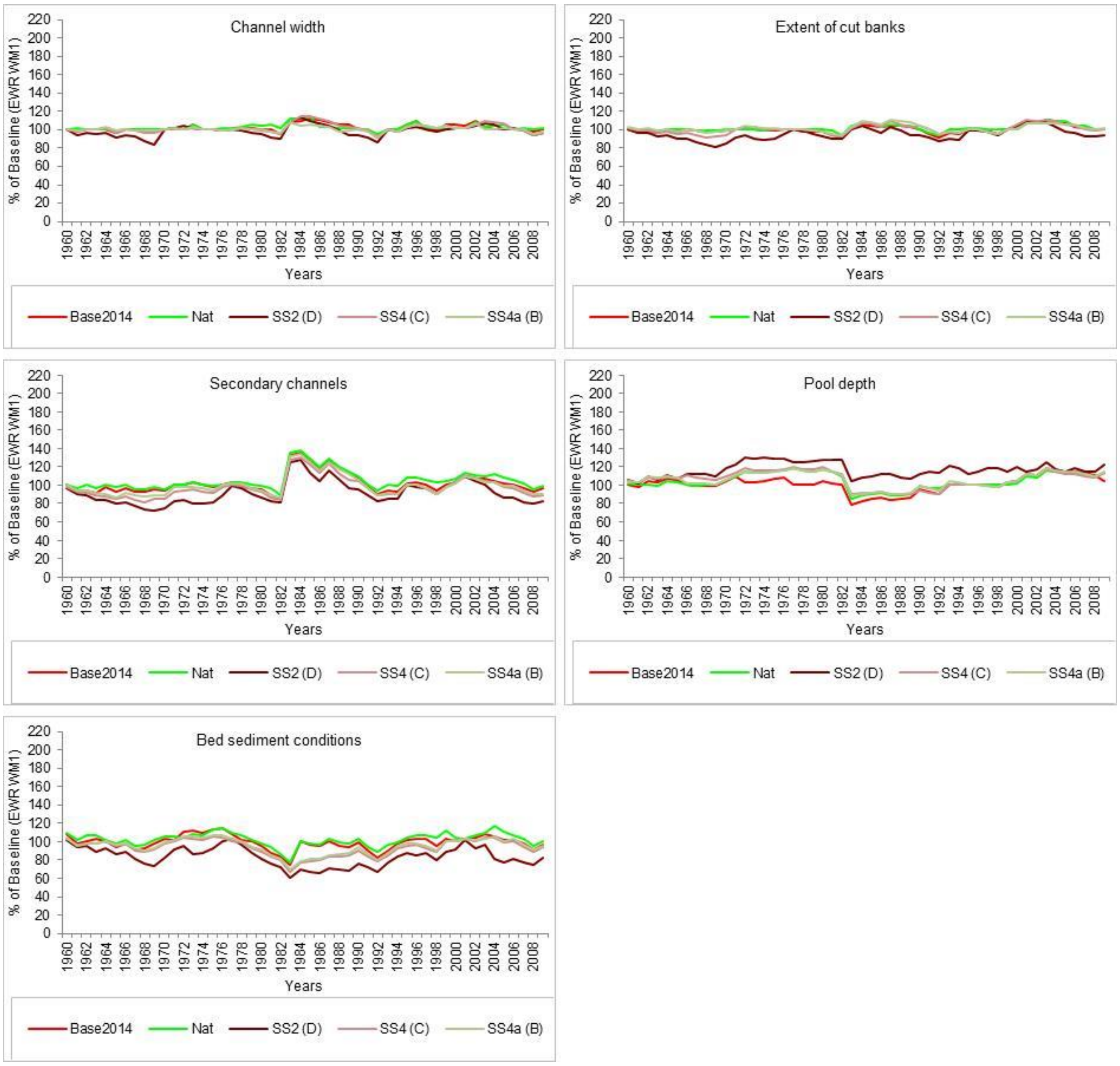


Figure 21-1 Time series for the geomorphological indicators at EWR Site WM1 for Base2014, Nat and the EWRs for B-, C- and D-category.

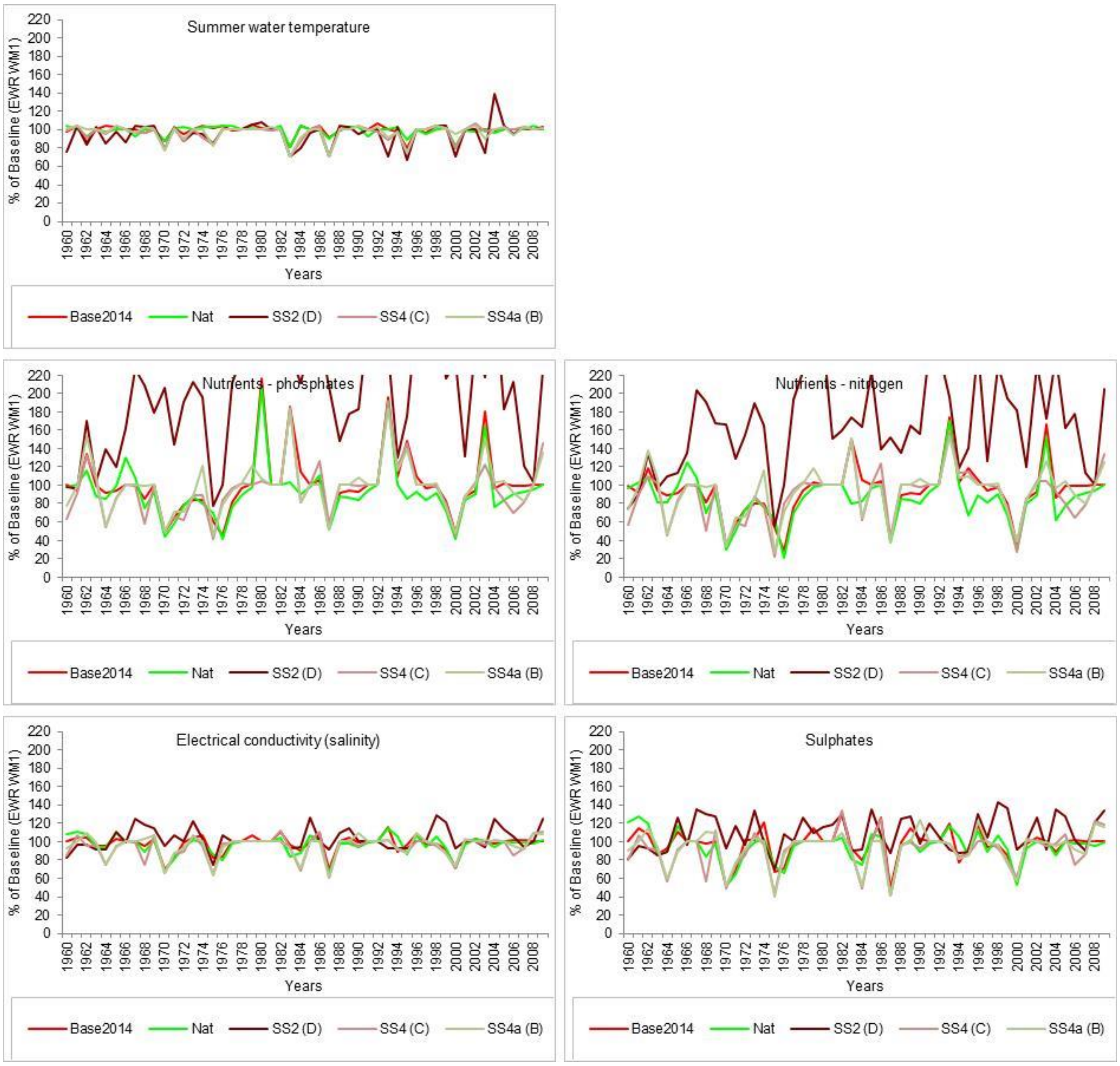


Figure 21-2 Time series for the water quality indicators at EWR Site WM1 for Base2014, Nat and the EWRs for B-, C- and D-category.

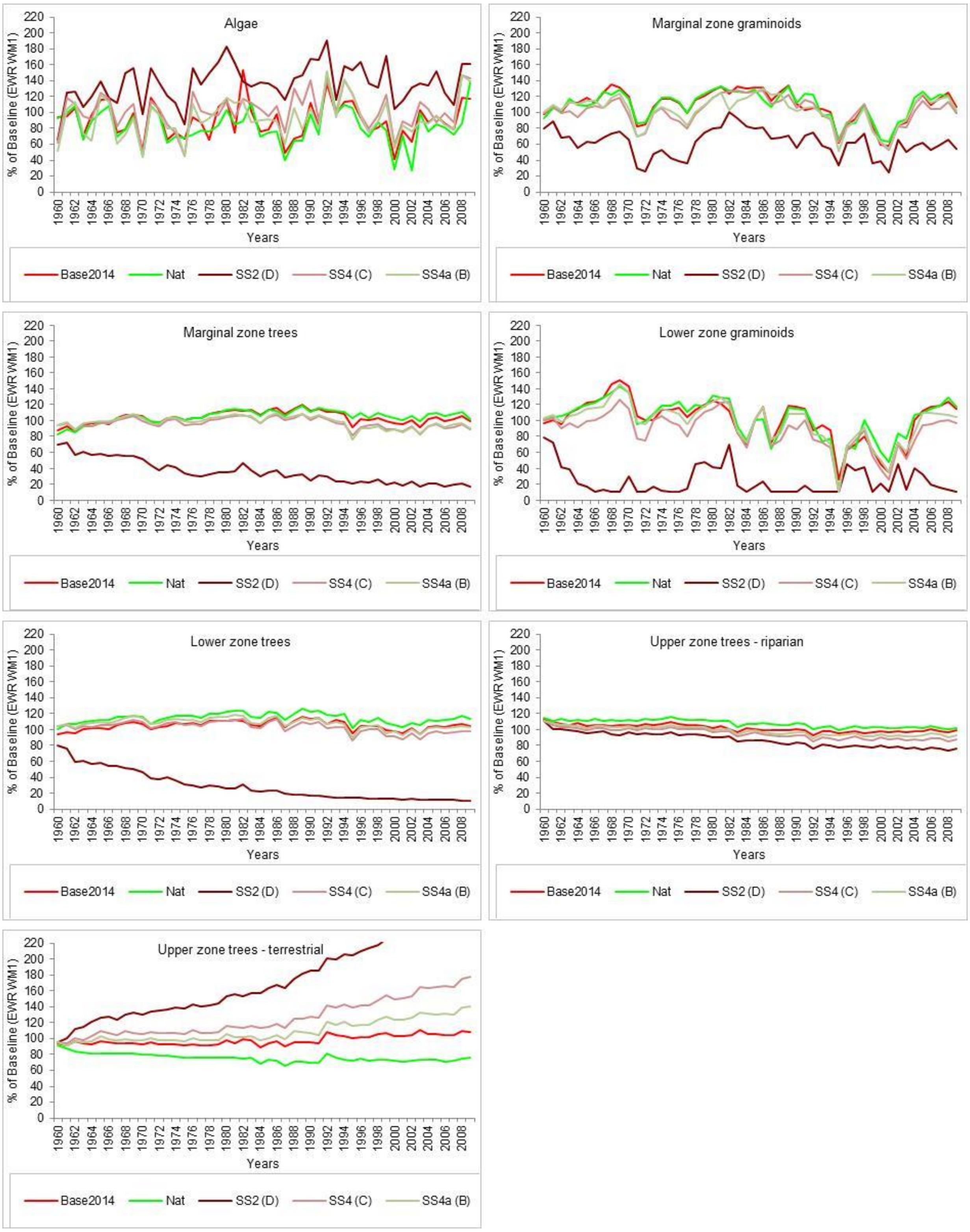


Figure 21-3 Time series for the vegetation indicators at EWR Site WM1 for Base2014, Nat and the EWRs for B-, C- and D-category.

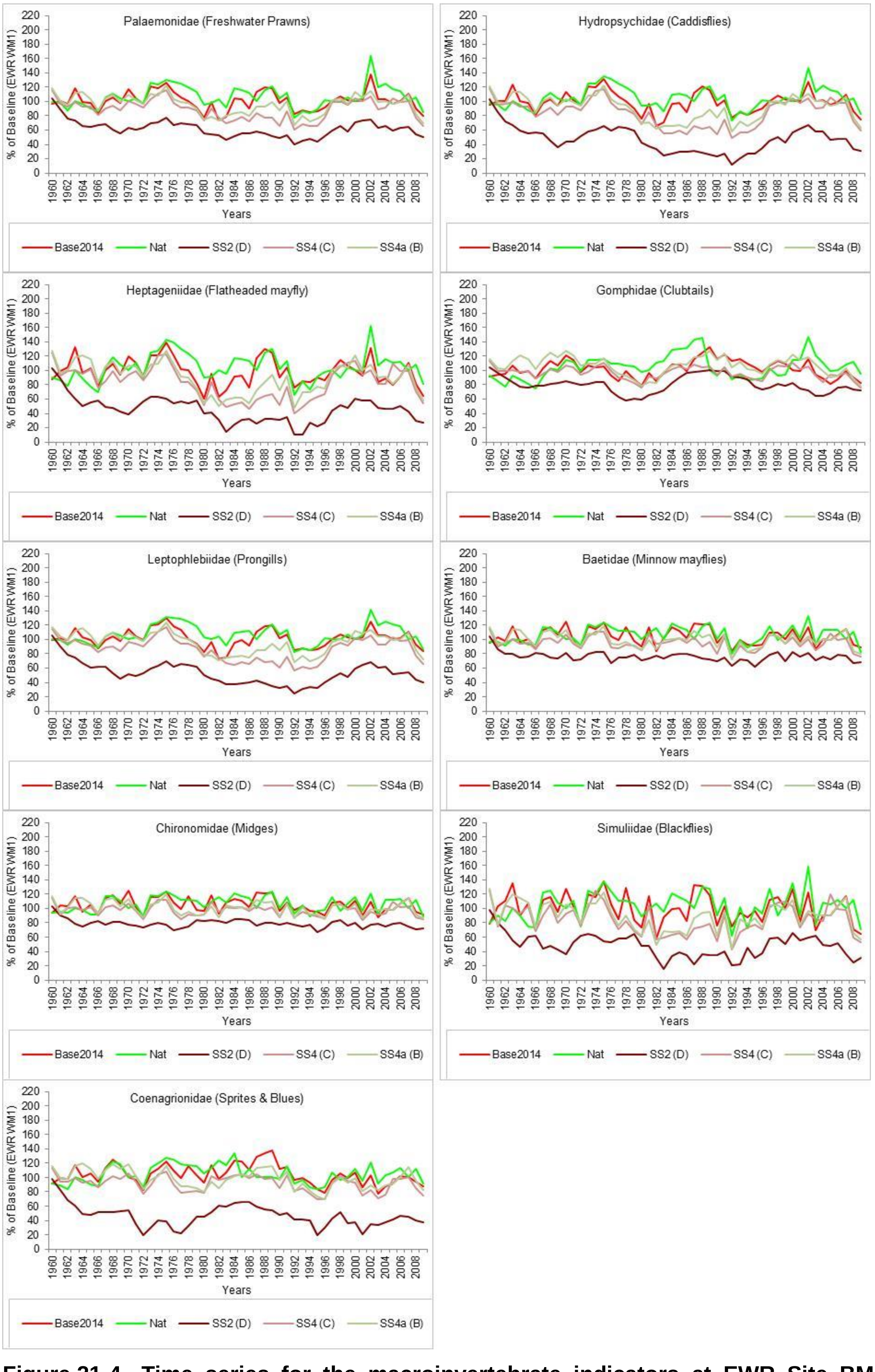


Figure 21-4 Time series for the macroinvertebrate indicators at EWR Site BM1 for Base2014, Nat and the EWRs for B-, C- and D-category.

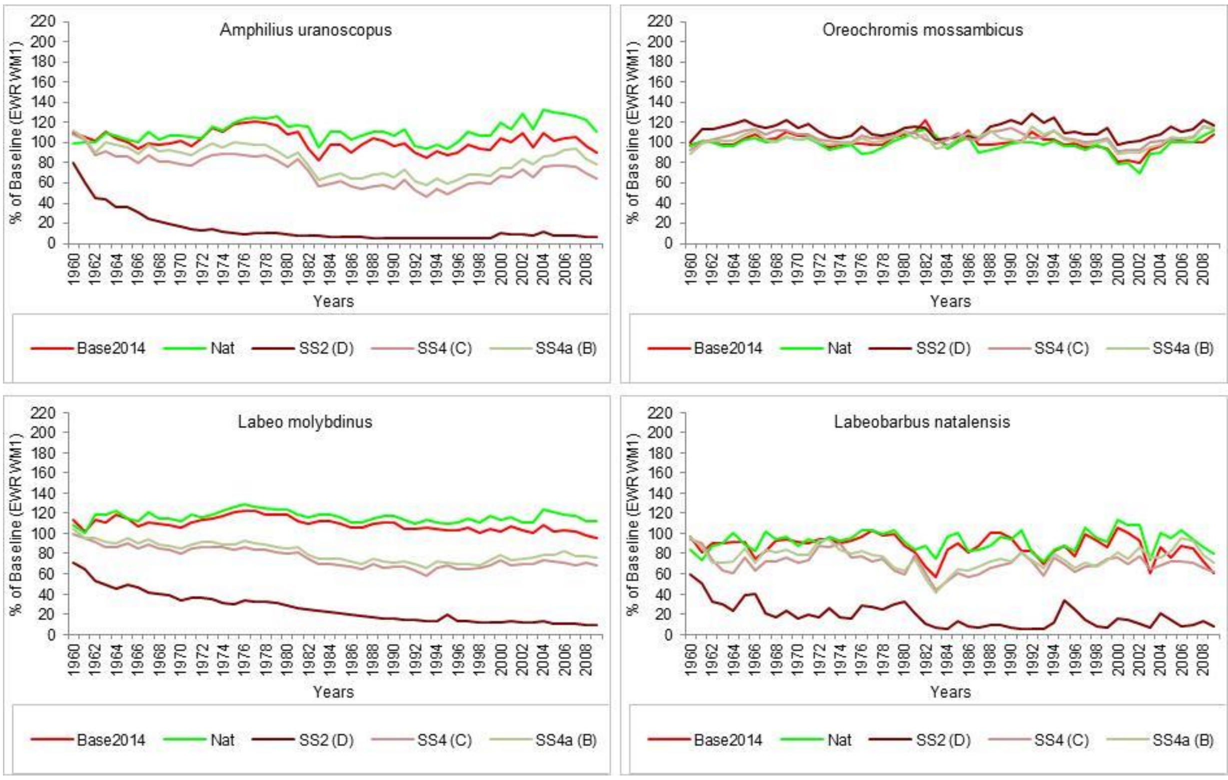


Figure 21-5 Time series for the fish indicators at EWR Site WM1 for for Base2014, Nat and the EWRs for B-, C- and D-category.

21.3 Hydrological summaries (WM1)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

21.3.1 Recommended Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C		Discharge (m3/s)	10.50	20.70	39.80	79.90
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	3	5	7
			Number	2	3	2	1
Oct	1.179	3.158					
Nov	1.766	4.578					
Dec	4.876	13.060			2		
Jan	5.194	13.911		2		2	1
Feb	5.451	13.188			1		
Mar	4.600	12.321					
Apr	2.093	5.425					
May	1.580	4.232					
Jun	0.752	1.948					
Jul	0.642	1.718					
Aug	0.597	1.598					
Sep	0.588	1.525					

MAR	300.210	MCM	
S.Dev.	3.916		
CV	0.013		
Q75	0.719212963		
Ecological Category C			
	MCM	% MAR	
Total IFR	150.918	50.271	(excl. >=1:2)
Maint. Lowflow	76.663	25.536	
Drought Lowflow	25.696	8.559	
Maint. Highflow	74.255	24.734	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	18.698	3.158	0.951	5.545	8.704
Nov	26.166	4.578	1.350	7.199	11.777
Dec	46.329	13.060	4.988	14.685	27.746
Jan	58.821	13.911	3.975	18.348	32.259
Feb	57.710	13.188	4.156	17.350	30.538
Mar	31.064	12.321	4.969	6.733	19.054
Apr	15.737	5.425	0.959	1.150	6.574
May	9.413	4.232	0.967	0.202	4.434
Jun	5.221	1.948	0.833	0.000	1.948
Jul	10.834	1.718	0.854	1.518	3.237
Aug	6.904	1.598	0.862	0.363	1.962
Sep	13.313	1.525	0.832	1.162	2.687

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	7.082	4.492	2.291	1.816	1.204	0.934	0.543	0.360	0.334	0.168
Nov	13.214	6.030	4.242	2.430	2.259	1.729	1.271	0.830	0.614	0.407
Dec	20.040	16.215	12.121	9.768	8.263	6.508	4.942	3.333	1.765	0.694
Jan	20.533	18.021	15.223	12.044	10.681	8.642	8.274	7.298	4.111	2.297
Feb	23.896	19.177	15.099	12.471	10.970	7.490	6.459	5.017	3.347	0.510
Mar	13.245	9.700	7.994	6.261	6.021	4.388	2.943	2.476	1.284	0.419
Apr	3.755	3.037	2.930	2.865	2.669	2.142	1.588	0.868	0.636	0.332
May	2.975	2.906	2.190	1.775	1.688	0.970	0.829	0.553	0.352	0.303
Jun	1.140	1.113	1.090	0.905	0.820	0.647	0.480	0.360	0.325	0.273
Jul	1.188	1.126	1.038	0.722	0.476	0.430	0.360	0.350	0.296	0.243
Aug	1.241	1.130	0.744	0.536	0.360	0.357	0.354	0.340	0.264	0.213
Sep	1.421	1.176	0.813	0.583	0.448	0.358	0.348	0.332	0.282	0.203

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	2.281	2.178	1.652	1.325	1.033	0.781	0.477	0.351	0.326	0.168
Nov	2.447	2.391	2.261	2.091	1.673	1.528	1.246	0.753	0.602	0.407
Dec	7.325	6.901	6.241	5.274	4.537	3.939	3.273	2.572	1.096	0.581
Jan	7.333	7.304	6.608	6.105	5.194	4.688	3.992	3.300	2.544	1.777
Feb	7.358	7.210	7.030	6.408	5.733	4.863	4.009	3.462	2.322	0.510
Mar	7.376	6.838	6.093	5.139	3.948	3.230	2.487	1.516	1.198	0.419
Apr	3.033	2.995	2.883	2.813	2.461	2.003	1.483	0.868	0.636	0.332
May	2.965	2.906	2.190	1.775	1.688	0.970	0.829	0.553	0.352	0.303
Jun	1.140	1.113	1.090	0.905	0.820	0.647	0.480	0.360	0.325	0.273
Jul	1.136	1.081	0.819	0.642	0.476	0.430	0.360	0.350	0.296	0.243
Aug	1.229	1.076	0.690	0.534	0.360	0.357	0.354	0.340	0.264	0.213
Sep	1.170	0.987	0.699	0.559	0.448	0.358	0.348	0.332	0.282	0.203

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	15.139	9.410	6.820	3.351	2.177	1.763	0.952	0.430	0.343	0.202
Nov	24.245	15.161	9.658	7.084	6.340	3.626	2.387	1.862	0.851	0.504
Dec	35.098	28.321	21.318	18.881	13.391	9.926	7.068	4.943	3.117	0.920
Jan	38.212	28.090	25.475	21.353	16.403	12.971	11.955	10.916	7.052	4.407
Feb	49.881	27.713	20.654	17.217	16.390	10.974	8.854	6.190	4.214	0.929
Mar	23.140	17.244	11.955	9.912	8.114	6.480	3.794	3.304	2.172	0.615
Apr	11.027	8.529	6.071	5.019	4.307	3.366	2.244	1.279	0.639	0.345
May	11.325	4.588	3.246	2.639	2.382	1.459	1.261	0.759	0.362	0.336
Jun	6.068	2.714	2.014	1.605	1.460	1.086	0.808	0.398	0.350	0.305
Jul	5.732	3.456	2.031	1.623	0.934	0.852	0.549	0.362	0.320	0.275
Aug	8.219	2.981	1.323	0.964	0.590	0.483	0.365	0.361	0.289	0.244
Sep	9.780	5.079	3.039	1.556	1.182	0.619	0.362	0.361	0.328	0.231

21.3.2 Alternative Ecological Category B

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: B		Discharge (m3/s)	10.90	20.70	39.80	79.60
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	3	5	7
			Number	4	3	2	1
Oct	1.927	5.161					
Nov	2.776	7.194		2			
Dec	5.510	14.757			2	2	
Jan	6.045	16.190					1
Feb	6.252	15.124		2	1		
Mar	5.451	14.599					
Apr	2.779	7.203					
May	1.929	5.167					
Jun	0.879	2.278					
Jul	0.727	1.947					
Aug	0.756	2.025					
Sep	0.688	1.782					

AEC1	SS4a		
MAR	300.210	MCM	
S.Dev.	3.916		
CV	0.013		
Q75	0.719212963		
Ecological Category B			
	MCM	% MAR	
Total IFR	167.937	55.940	(excl. >=1:2
Maint. Lowflow	93.427	31.120	
Drought Lowflow	25.696	8.559	
Maint. Highflow	74.511	24.819	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	18.698	5.161	0.951	5.249	10.409
Nov	26.166	7.194	1.350	6.955	14.149
Dec	46.329	14.757	4.988	15.152	29.909
Jan	58.821	16.190	3.975	18.718	34.908
Feb	57.710	15.124	4.156	17.421	32.545
Mar	31.064	14.599	4.969	6.545	21.143
Apr	15.737	7.203	0.959	1.063	8.266
May	9.413	5.167	0.967	0.182	5.349
Jun	5.221	2.278	0.833	0.000	2.278
Jul	10.834	1.947	0.854	1.510	3.456
Aug	6.904	2.025	0.862	0.361	2.385
Sep	13.313	1.782	0.832	1.356	3.138

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B, B/C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	8.902	6.187	4.143	2.150	1.449	1.052	0.561	0.360	0.334	0.168
Nov	14.886	6.941	5.447	4.791	3.203	1.824	1.362	0.889	0.616	0.407
Dec	22.077	17.700	13.043	11.145	9.127	7.251	5.237	3.333	1.765	0.694
Jan	22.462	18.934	16.499	13.033	11.931	10.431	8.831	8.219	4.137	2.307
Feb	25.133	21.599	16.246	13.844	11.717	8.744	6.719	5.171	3.347	0.510
Mar	15.377	10.950	8.706	6.995	6.226	4.460	2.943	2.476	1.284	0.419
Apr	5.068	4.915	3.962	3.592	3.199	2.245	1.588	0.868	0.636	0.332
May	4.709	3.883	2.254	1.833	1.717	0.970	0.829	0.553	0.352	0.303
Jun	1.511	1.481	1.338	0.931	0.833	0.696	0.480	0.360	0.325	0.273
Jul	1.515	1.253	1.180	0.734	0.476	0.430	0.360	0.350	0.296	0.243
Aug	2.009	1.474	0.810	0.546	0.360	0.357	0.354	0.340	0.264	0.213
Sep	1.795	1.505	0.830	0.669	0.467	0.358	0.348	0.332	0.287	0.203

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	4.844	3.867	2.675	1.801	1.161	0.818	0.480	0.351	0.326	0.168
Nov	5.103	4.805	4.073	3.040	2.401	1.602	1.276	0.876	0.602	0.407
Dec	10.244	7.544	6.762	5.484	4.241	3.672	3.311	2.332	1.096	0.581
Jan	10.457	9.927	7.110	5.955	5.669	4.909	4.021	3.082	2.377	1.580
Feb	10.419	8.792	8.119	7.167	6.252	4.323	3.835	3.365	2.190	0.510
Mar	10.373	7.463	6.267	4.974	4.119	2.947	2.487	1.521	1.198	0.419
Apr	4.915	4.833	3.816	3.425	2.909	2.003	1.588	0.868	0.636	0.332
May	4.360	3.883	2.254	1.833	1.717	0.970	0.829	0.553	0.352	0.303
Jun	1.511	1.481	1.338	0.931	0.833	0.696	0.480	0.360	0.325	0.273
Jul	1.503	1.214	0.946	0.727	0.476	0.430	0.360	0.350	0.296	0.243
Aug	1.975	1.374	0.779	0.546	0.360	0.357	0.354	0.340	0.264	0.213
Sep	1.511	1.295	0.752	0.649	0.467	0.358	0.348	0.332	0.287	0.203

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	15.139	9.410	6.820	3.351	2.177	1.763	0.952	0.430	0.343	0.202
Nov	24.245	15.161	9.658	7.084	6.340	3.626	2.387	1.862	0.851	0.504
Dec	35.098	28.321	21.318	18.881	13.391	9.926	7.068	4.943	3.117	0.920
Jan	38.212	28.090	25.475	21.353	16.403	12.971	11.955	10.916	7.052	4.407
Feb	49.881	27.713	20.654	17.217	16.390	10.974	8.854	6.190	4.214	0.929
Mar	23.140	17.244	11.955	9.912	8.114	6.480	3.794	3.304	2.172	0.615
Apr	11.027	8.529	6.071	5.019	4.307	3.366	2.244	1.279	0.639	0.345
May	11.325	4.588	3.246	2.639	2.382	1.459	1.261	0.759	0.362	0.336
Jun	6.068	2.714	2.014	1.605	1.460	1.086	0.808	0.398	0.350	0.305
Jul	5.732	3.456	2.031	1.623	0.934	0.852	0.549	0.362	0.320	0.275
Aug	8.219	2.981	1.323	0.964	0.590	0.483	0.365	0.361	0.289	0.244
Sep	9.780	5.079	3.039	1.556	1.182	0.619	0.362	0.361	0.328	0.231

21.3.3 Alternative Ecological Category D

<table>
<tr><td rowspan="4"></td><td colspan="2">Baseflows</td><td>High flows (excl. >1:2 yr)</td><td>Class1</td><td>Class2</td><td>Class3</td><td>Class4</td></tr>
<tr><td colspan="2">REC: D</td><td>Discharge (m3/s)</td><td>10.50</td><td>20.70</td><td>39.80</td><td>79.90</td></tr>
<tr><td rowspan="2">Discharge (m^3/s)</td><td rowspan="2">Monthly volume (10^6m^3)</td><td>Duration (days)</td><td>2</td><td>3</td><td>5</td><td>7</td></tr>
<tr><td>Number</td><td>1</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>Oct</td><td>0.355</td><td>0.951</td><td rowspan="12"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Nov</td><td>0.521</td><td>1.350</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Dec</td><td>1.862</td><td>4.988</td><td rowspan="4">1</td><td rowspan="3">1</td><td></td><td></td></tr>
<tr><td>Jan</td><td>1.484</td><td>3.975</td><td rowspan="2">1</td><td></td></tr>
<tr><td>Feb</td><td>1.718</td><td>4.156</td><td></td></tr>
<tr><td>Mar</td><td>1.855</td><td>4.969</td><td></td><td></td><td></td></tr>
<tr><td>Apr</td><td>0.370</td><td>0.959</td><td></td><td></td><td></td><td></td></tr>
<tr><td>May</td><td>0.361</td><td>0.967</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jun</td><td>0.321</td><td>0.833</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jul</td><td>0.319</td><td>0.854</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aug</td><td>0.322</td><td>0.862</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sep</td><td>0.321</td><td>0.832</td><td></td><td></td><td></td><td></td></tr>
</table>

MAR	300.210	MCM	
S.Dev.	3.916		
CV	0.013		
Q75	0.719212963		
Ecological Category D			
	MCM	% MAR	
Total IFR	73.455	24.468	(excl. >=1:2)
Maint. Lowflow	25.696	8.559	
Drought Lowflow	25.696	8.559	
Maint. Highflow	47.759	15.909	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	18.698	0.951	0.951	3.646	4.597
Nov	26.166	1.350	1.350	3.716	5.066
Dec	46.329	4.988	4.988	8.696	13.684
Jan	58.821	3.975	3.975	11.750	15.726
Feb	57.710	4.156	4.156	12.728	16.883
Mar	31.064	4.969	4.969	4.027	8.996
Apr	15.737	0.959	0.959	0.222	1.181
May	9.413	0.967	0.967	0.000	0.967
Jun	5.221	0.833	0.833	0.000	0.833
Jul	10.834	0.854	0.854	1.535	2.389
Aug	6.904	0.862	0.862	0.366	1.228
Sep	13.313	0.832	0.832	1.072	1.905

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category D
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	2.377	1.263	0.390	0.378	0.374	0.367	0.358	0.341	0.322	0.168
Nov	6.152	2.417	0.832	0.423	0.410	0.406	0.390	0.371	0.368	0.358
Dec	9.815	7.285	4.869	2.344	1.807	1.518	1.486	1.476	1.400	0.978
Jan	10.801	8.938	7.939	6.859	4.398	3.355	2.397	1.513	1.468	1.462
Feb	16.980	9.762	7.676	4.996	3.483	2.414	1.540	1.483	1.469	0.989
Mar	4.225	2.996	2.270	1.472	1.446	1.440	1.434	1.358	1.042	0.601
Apr	0.380	0.377	0.375	0.372	0.368	0.366	0.365	0.364	0.360	0.332
May	0.378	0.372	0.367	0.361	0.361	0.360	0.359	0.359	0.351	0.303
Jun	0.335	0.327	0.323	0.321	0.320	0.320	0.320	0.320	0.319	0.273
Jul	0.349	0.330	0.328	0.322	0.320	0.320	0.320	0.319	0.292	0.243
Aug	0.381	0.349	0.331	0.323	0.320	0.320	0.320	0.319	0.263	0.213
Sep	0.398	0.363	0.337	0.331	0.323	0.321	0.320	0.320	0.254	0.203

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.390	0.380	0.375	0.373	0.367	0.362	0.353	0.338	0.318	0.168
Nov	0.430	0.413	0.411	0.408	0.406	0.390	0.378	0.370	0.366	0.358
Dec	1.521	1.500	1.487	1.481	1.476	1.471	1.456	1.403	1.338	0.978
Jan	1.528	1.510	1.497	1.481	1.473	1.469	1.467	1.464	1.439	1.353
Feb	1.533	1.504	1.488	1.478	1.475	1.470	1.469	1.466	1.464	0.935
Mar	1.484	1.464	1.446	1.442	1.439	1.434	1.415	1.347	1.042	0.601
Apr	0.377	0.376	0.373	0.370	0.368	0.366	0.365	0.364	0.360	0.332
May	0.378	0.372	0.367	0.361	0.361	0.360	0.359	0.359	0.351	0.303
Jun	0.335	0.327	0.323	0.321	0.320	0.320	0.320	0.320	0.319	0.273
Jul	0.334	0.328	0.325	0.322	0.320	0.320	0.320	0.319	0.292	0.243
Aug	0.364	0.340	0.329	0.321	0.320	0.320	0.320	0.319	0.263	0.213
Sep	0.366	0.342	0.333	0.330	0.322	0.321	0.320	0.320	0.254	0.203

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	15.139	9.410	6.820	3.351	2.177	1.763	0.952	0.430	0.343	0.202
Nov	24.245	15.161	9.658	7.084	6.340	3.626	2.387	1.862	0.851	0.504
Dec	35.098	28.321	21.318	18.881	13.391	9.926	7.068	4.943	3.117	0.920
Jan	38.212	28.090	25.475	21.353	16.403	12.971	11.955	10.916	7.052	4.407
Feb	49.881	27.713	20.654	17.217	16.390	10.974	8.854	6.190	4.214	0.929
Mar	23.140	17.244	11.955	9.912	8.114	6.480	3.794	3.304	2.172	0.615
Apr	11.027	8.529	6.071	5.019	4.307	3.366	2.244	1.279	0.639	0.345
May	11.325	4.588	3.246	2.639	2.382	1.459	1.261	0.759	0.362	0.336
Jun	6.068	2.714	2.014	1.605	1.460	1.086	0.808	0.398	0.350	0.305
Jul	5.732	3.456	2.031	1.623	0.934	0.852	0.549	0.362	0.320	0.275
Aug	8.219	2.981	1.323	0.964	0.590	0.483	0.365	0.361	0.289	0.244
Sep	9.780	5.079	3.039	1.556	1.182	0.619	0.362	0.361	0.328	0.231

22 EWR SITE NS1 (NSELENI RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site NS1. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

On the basis of the results in Figure 14-1 and Figure 14-2, the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Nseleni	NS1	C	B	D	-
		SS4b	Sc4[15]	SS2	-

22.1 Mean percentage changes

The mean percentage changes (relative to Baseline) for the indicators for the EWRs were selected as potential Reserves to maintain the REC and AECs at EWR Site NS1 are given in Table 22-1.

[15] Should maintain a B provided non-flow related impacts are addressed

Table 22-1 EWR Site NS1: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

		REC SS4b C Category	AEC1 Sc4 B Category	AEC2 SS2 D Category
Geomorphology	Channel width	2.00	4.26	-36.11
	Extent of cut banks	1.20	0.49	21.29
	Secondary channels	2.27	1.12	-20.68
	Pool depth	0.90	-1.22	19.07
	Bed sediment conditions	-4.63	-4.85	-39.34
Water quality	Summer water temperature	0.53	1.02	1.54
	Nutrients - phosphates	2.32	3.33	19.06
	Nutrients - nitrogen	6.50	8.50	31.78
	Electrical conductivity (salinity)	1.30	1.60	2.72
	Sulphates	2.88	3.34	4.10
Riparian Vegetation	Algae	5.90	10.39	41.99
	Marginal zone graminoids	-2.35	-6.47	-38.68
	Marginal zone trees	-16.46	-11.55	-60.72
	Lower zone graminoids	-13.24	-8.98	-67.25
	Lower zone trees	-23.82	-18.17	-77.89
	Upper zone trees - riparian	-23.50	-14.73	-26.63
	Upper zone trees - terrestrial	72.18	30.00	41.79
Macro-invertebrates	Hydropsychidae (Caddisflies)	-19.15	-26.37	-93.59
	Elmidae (Riffle Beetles)	-8.76	-10.88	-62.49
	Leptophlebiidae (Prongills)	-10.66	-16.70	-52.72
	Baetidae (Minnow mayflies)	-3.64	-6.01	-34.68
	Chironomidae (Midges)	-1.65	-2.36	-7.45
	Simuliidae (Blackflies)	-6.39	-9.54	-68.57
	Coenagrionidae (Sprites & Blues)	-4.56	-5.21	-39.45
Fish	Oreochromis mossambicus	4.33	5.35	15.52
	Labeobarbus natalensis	-20.46	-12.43	-81.22
	Barbus paludinosus	0.25	-3.00	-11.08
	Glossogobius callidus	-3.59	-5.44	-28.14
	Anguilla mossambica	-10.45	-8.75	-12.73

22.2 Time series

The time series of predicted abundance changes relative to Base2014 under Base2014, Nat and the EWRs for B-, C- and D-categories are provided for the indicators for each discipline (Figure 22-1 and Figure 22-5). The time-series illustrate the sorts of annual fluctuations that can be expected as a result of climatic variations, and as such may help to guide decisions based on future monitoring. The time-series also illustrate that the responses of different indicators to different flow regimes, i.e., increased flow, such as that associated with a B-Category versus a D-Category river does not necessarily result in a universal improvement in all indicators. This is because changes in flow affect the balance between species. Note, predictions take into account existing issues in the river, such as elevated nutrients.

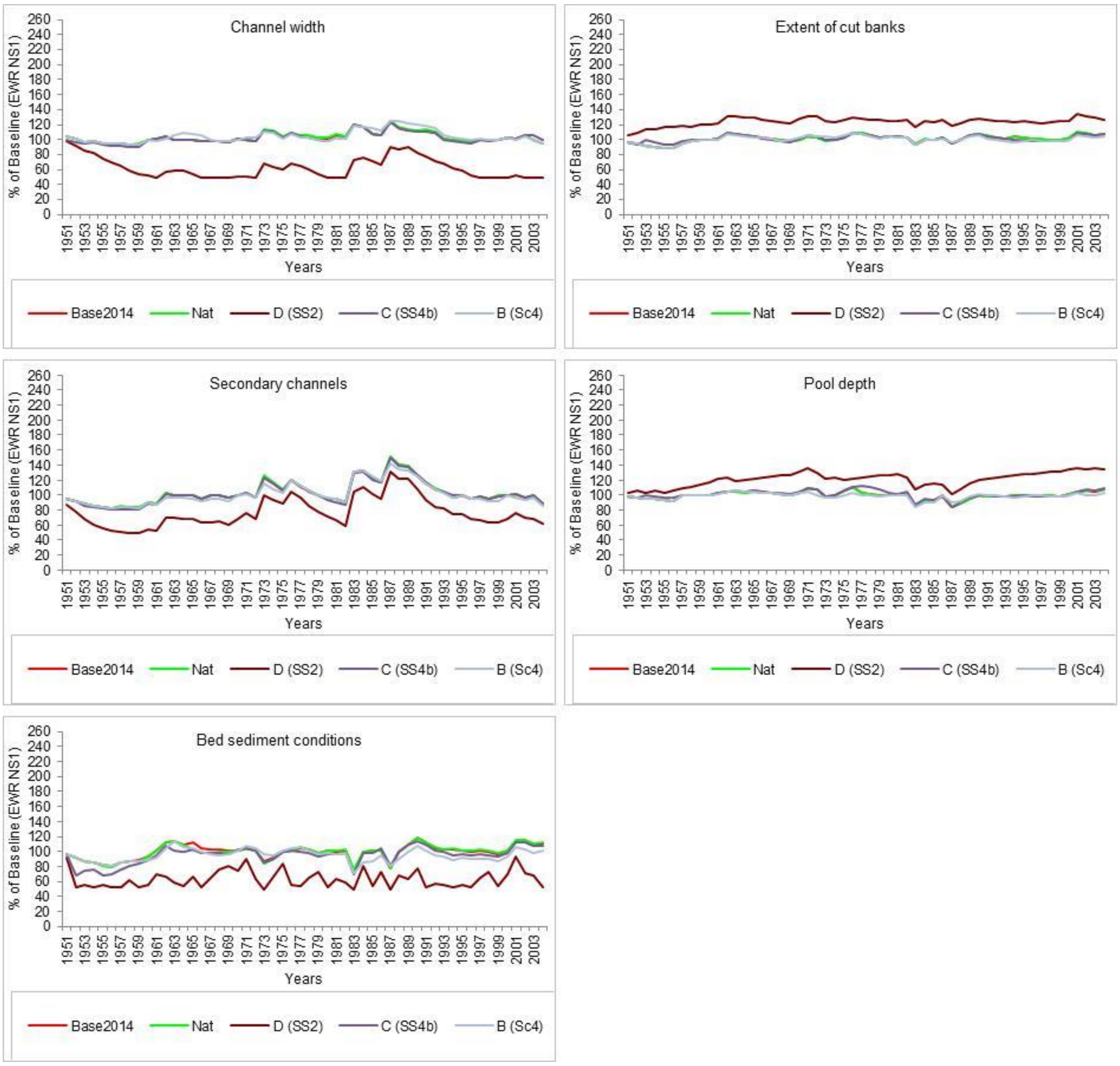


Figure 22-1 Time series for the geomorphological indicators at EWR Site NS1 for Base2014, Nat and the EWRs for B-, C- and D-category.

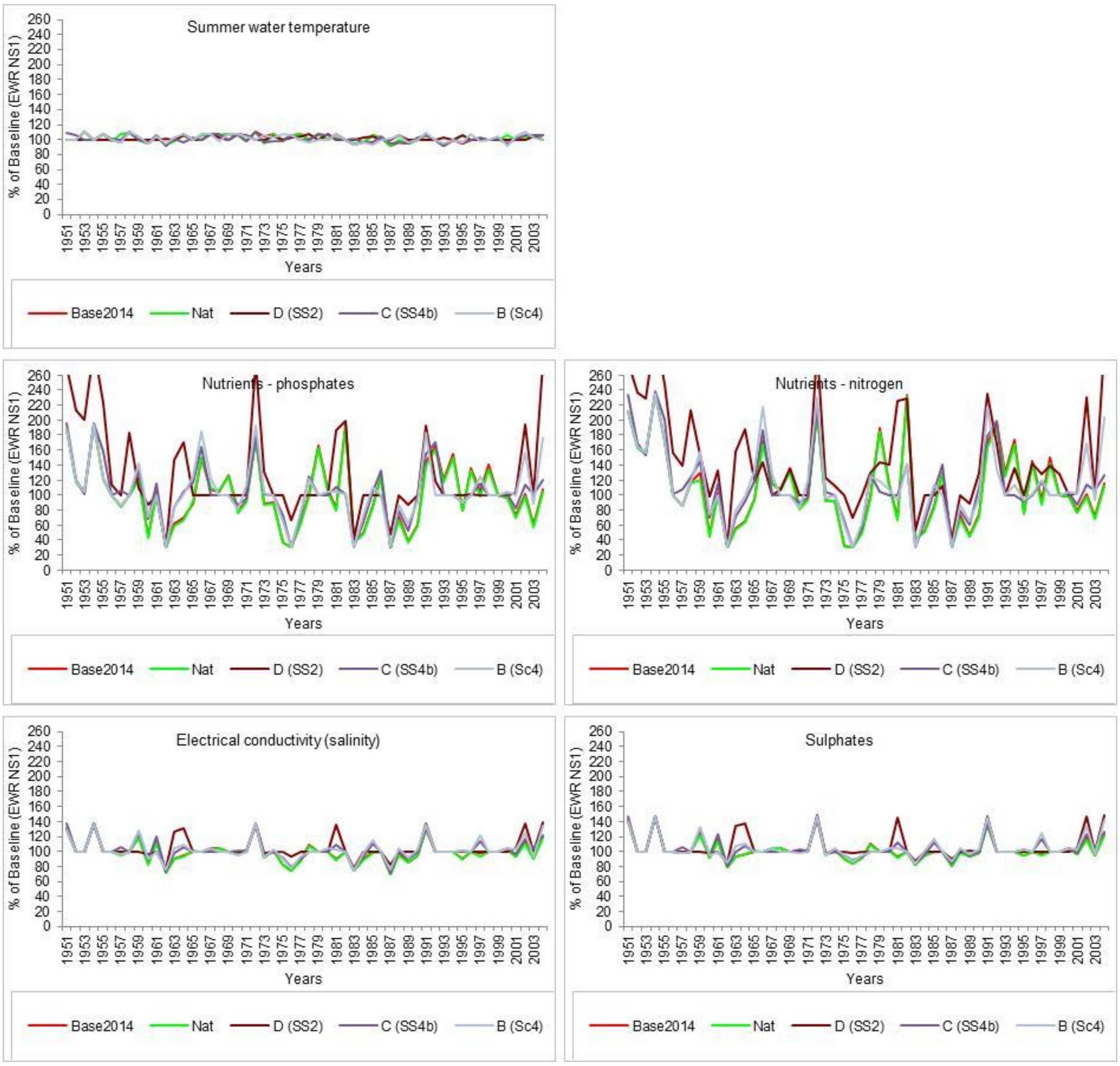


Figure 22-2 Time series for the water quality indicators at EWR Site NS1 for Base2014, Nat and the EWRs for B-, C- and D-category.

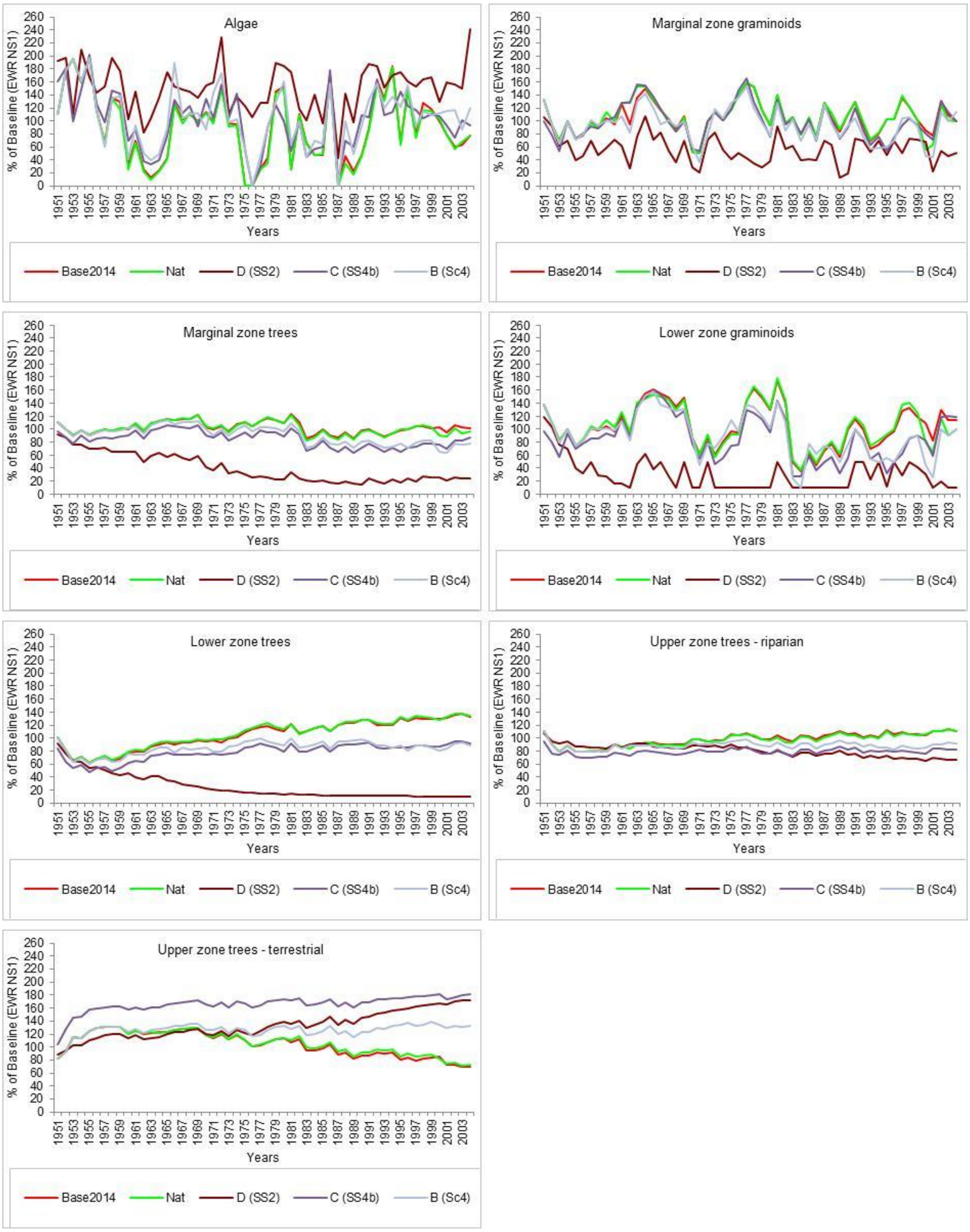


Figure 22-3 Time series for the vegetation indicators at EWR Site NS1 for Base2014, Nat and the EWRs for B-, C- and D-category.

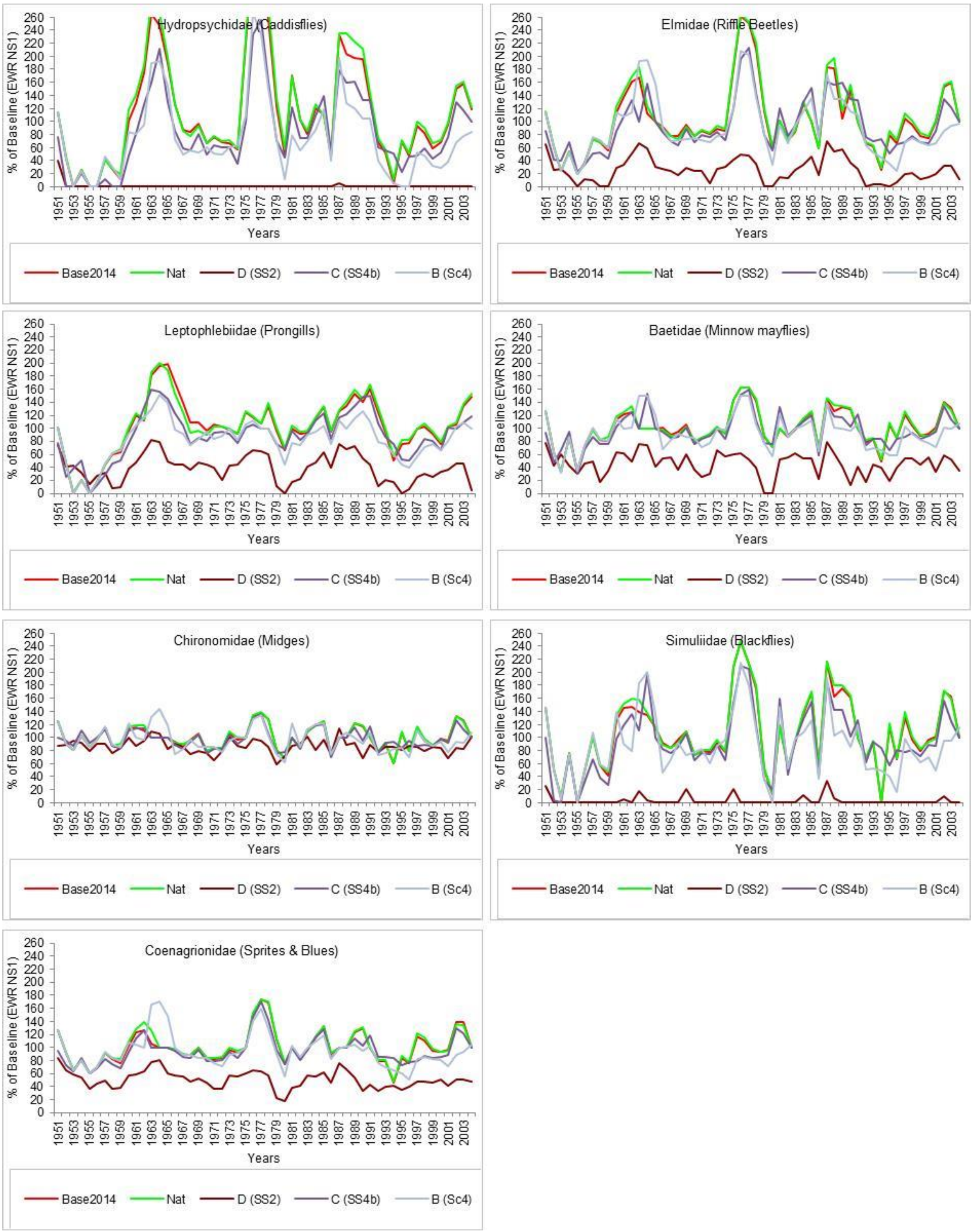


Figure 22-4 Time series for the macroinvertebrate indicators at EWR Site NS1 for Base2014, Nat and the EWRs for B-, C- and D-category.

Figure 22-5 Time series for the fish indicators at EWR Site NS1 for Base2014, Nat and the EWRs for B-, C- and D-category.

22.3 Hydrological summaries (NS1)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide

a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

22.3.1 Recommended Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C	Monthly	Discharge (m3/s)	1.40	2.70	5.20	16.00
	Discharge	volume	Duration (days)	2	2	3	4
	(m^3/s)	($10^6 m^3$)	Number	1	3	1	0
Oct	0.360	0.965			1		
Nov	0.415	1.077		1			
Dec	0.681	1.825			1	1	
Jan	0.614	1.645					
Feb	0.562	1.359			1		
Mar	0.449	1.202					
Apr	0.246	0.637					
May	0.214	0.573					
Jun	0.211	0.546					
Jul	0.200	0.537					
Aug	0.155	0.416					
Sep	0.177	0.460					

```
REC                   SS4b
MAR                   32.111          MCM
S.Dev.                27.109
CV                    0.844
Q75                   8.917
Ecological Category C
                      MCM             % MAR
Total IFR             14.818          46.148     (excl. >=1:2)
Maint. Lowflow        11.242          35.010
Drought Lowflow       0.576           1.793
Maint. Highflow       3.577           11.138
Monthly Distributions (MCM)
Distribution Type:  ?? KZN
Month                 Natural Flows   Modified Flows (IFR)
                                      Low flows             High Flows   Total Flows
                      Mean            Maint.     Drought    Maint.       Maint.
Oct                   2.906           0.965      0.044      0.508        1.474
Nov                   2.500           1.077      0.034      0.269        1.346
Dec                   4.330           1.825      0.099      0.808        2.633
Jan                   4.655           1.645      0.081      0.726        2.371
Feb                   5.146           1.359      0.080      0.586        1.946
Mar                   2.226           1.202      0.077      0.276        1.478
Apr                   1.079           0.637      0.028      0.114        0.751
May                   1.498           0.573      0.031      0.174        0.747
Jun                   1.265           0.546      0.025      0.026        0.572
Jul                   3.530           0.537      0.026      0.065        0.602
Aug                   0.723           0.416      0.026      0.000        0.416
Sep                   2.252           0.460      0.025      0.025        0.484
```

```
Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category     C
Data are given in m^3/s mean monthly flow
Month             % Points
      10     20     30     40     50     60     70     80     90     99
Oct   1.377  1.039  0.501  0.452  0.206  0.074  0.051  0.029  0.011  0.001
Nov   1.169  0.973  0.755  0.462  0.337  0.202  0.142  0.062  0.013  0.001
Dec   2.095  1.539  1.286  0.999  0.744  0.364  0.225  0.149  0.043  0.004
Jan   2.203  1.527  1.193  0.576  0.403  0.219  0.142  0.047  0.026  0.002
Feb   2.234  1.611  0.738  0.604  0.429  0.240  0.159  0.073  0.039  0.014
Mar   1.568  0.934  0.687  0.378  0.305  0.188  0.098  0.041  0.020  0.002
Apr   0.653  0.535  0.424  0.301  0.173  0.082  0.040  0.028  0.017  0.001
May   0.579  0.402  0.301  0.211  0.163  0.104  0.042  0.025  0.014  0.004
Jun   0.571  0.436  0.279  0.188  0.147  0.106  0.033  0.017  0.012  0.001
Jul   0.545  0.481  0.270  0.148  0.104  0.067  0.033  0.019  0.013  0.001
Aug   0.485  0.248  0.178  0.122  0.094  0.064  0.032  0.012  0.009  0.001
Sep   0.559  0.375  0.178  0.128  0.083  0.067  0.034  0.014  0.009  0.001
```

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.995	0.851	0.488	0.331	0.184	0.074	0.051	0.029	0.011	0.001
Nov	0.925	0.827	0.741	0.442	0.316	0.202	0.142	0.062	0.013	0.001
Dec	1.487	1.301	0.941	0.847	0.641	0.282	0.225	0.130	0.043	0.004
Jan	1.501	1.280	0.952	0.521	0.403	0.215	0.142	0.047	0.026	0.002
Feb	1.398	1.267	0.738	0.483	0.390	0.231	0.159	0.073	0.039	0.014
Mar	1.203	0.827	0.594	0.378	0.305	0.188	0.098	0.041	0.020	0.002
Apr	0.560	0.527	0.424	0.301	0.173	0.082	0.040	0.028	0.017	0.001
May	0.562	0.375	0.264	0.211	0.163	0.086	0.042	0.025	0.014	0.004
Jun	0.571	0.436	0.279	0.188	0.147	0.106	0.033	0.017	0.012	0.001
Jul	0.530	0.481	0.270	0.148	0.104	0.067	0.033	0.019	0.013	0.001
Aug	0.485	0.248	0.178	0.122	0.094	0.064	0.032	0.012	0.009	0.001
Sep	0.559	0.375	0.178	0.128	0.083	0.067	0.034	0.014	0.009	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	2.805	1.529	0.945	0.506	0.233	0.092	0.054	0.037	0.013	0.002
Nov	2.486	1.536	0.998	0.618	0.356	0.246	0.149	0.067	0.015	0.002
Dec	4.253	2.745	1.704	1.302	0.933	0.414	0.276	0.151	0.047	0.003
Jan	4.071	2.550	1.425	0.825	0.500	0.288	0.171	0.044	0.027	0.002
Feb	6.153	1.960	1.029	0.771	0.523	0.263	0.162	0.073	0.037	0.012
Mar	2.302	1.130	0.738	0.421	0.318	0.208	0.104	0.043	0.019	0.002
Apr	1.017	0.597	0.517	0.313	0.165	0.089	0.041	0.028	0.017	0.002
May	0.853	0.429	0.317	0.222	0.172	0.105	0.045	0.022	0.016	0.003
Jun	1.870	0.477	0.281	0.199	0.158	0.118	0.036	0.018	0.013	0.002
Jul	0.970	0.634	0.305	0.160	0.111	0.068	0.035	0.020	0.013	0.002
Aug	0.802	0.364	0.223	0.131	0.099	0.069	0.036	0.016	0.010	0.002
Sep	1.882	0.559	0.247	0.160	0.101	0.075	0.036	0.018	0.009	0.002

22.3.2 Alternative Ecological Category B

<table>
<tr><td rowspan="4"></td><td colspan="2">Baseflows</td><td>High flows (excl. >1:2 yr)</td><td>Class1</td><td>Class2</td><td>Class3</td><td>Class4</td></tr>
<tr><td colspan="2">REC: B</td><td>Discharge (m3/s)</td><td>7.00</td><td>13.10</td><td>26.10</td><td>47.00</td></tr>
<tr><td rowspan="2">Discharge (m^3/s)</td><td rowspan="2">Monthly volume ($10^6 m^3$)</td><td>Duration (days)</td><td>3</td><td>4</td><td>6</td><td>6</td></tr>
<tr><td>Number</td><td>3</td><td>5</td><td>5</td><td>2</td></tr>
<tr><td>Oct</td><td>0.390</td><td>1.044</td><td rowspan="12"></td><td rowspan="7">3</td><td></td><td rowspan="2">1</td><td></td></tr>
<tr><td>Nov</td><td>0.371</td><td>0.961</td><td>1</td><td rowspan="4">2</td></tr>
<tr><td>Dec</td><td>0.639</td><td>1.712</td><td rowspan="2">3</td><td rowspan="4">3</td></tr>
<tr><td>Jan</td><td>0.834</td><td>2.233</td></tr>
<tr><td>Feb</td><td>0.666</td><td>1.611</td><td rowspan="2">1</td></tr>
<tr><td>Mar</td><td>0.388</td><td>1.038</td><td></td></tr>
<tr><td>Apr</td><td>0.193</td><td>0.500</td><td></td><td>1</td><td></td></tr>
<tr><td>May</td><td>0.340</td><td>0.911</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jun</td><td>0.166</td><td>0.430</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Jul</td><td>0.128</td><td>0.343</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aug</td><td>0.096</td><td>0.258</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sep</td><td>0.202</td><td>0.524</td><td></td><td></td><td></td><td></td></tr>
</table>

MAR	32.111	MCM	
S.Dev.	27.109		
CV	0.844		
Q75	8.917		
Ecological Category B			
	MCM	% MAR	
Total IFR	16.127	50.223	(excl. >=1:2)
Maint. Lowflow	11.566	36.020	
Drought Lowflow	0.507	1.579	
Maint. Highflow	4.561	14.203	

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	2.906	1.044	0.026	0.466	1.510
Nov	2.500	0.961	0.026	0.476	1.437
Dec	4.330	1.712	0.077	0.901	2.613
Jan	4.655	2.233	0.076	0.666	2.899
Feb	5.146	1.611	0.072	0.708	2.320
Mar	2.226	1.038	0.075	0.481	1.520
Apr	1.079	0.500	0.025	0.176	0.677
May	1.498	0.911	0.027	0.230	1.141
Jun	1.265	0.430	0.025	0.134	0.564
Jul	3.530	0.343	0.026	0.089	0.432
Aug	0.723	0.258	0.026	0.055	0.313
Sep	2.252	0.524	0.025	0.178	0.702

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	1.459	0.802	0.344	0.145	0.061	0.047	0.030	0.022	0.010	0.001
Nov	1.648	1.003	0.730	0.262	0.085	0.056	0.046	0.034	0.016	0.002
Dec	2.694	1.673	0.944	0.591	0.385	0.141	0.066	0.052	0.040	0.004
Jan	2.720	1.885	0.980	0.395	0.101	0.063	0.047	0.038	0.023	0.002
Feb	2.802	1.480	0.630	0.269	0.166	0.088	0.053	0.045	0.037	0.015
Mar	2.451	0.647	0.359	0.270	0.094	0.049	0.043	0.033	0.022	0.002
Apr	0.605	0.312	0.197	0.074	0.054	0.038	0.033	0.023	0.017	0.003
May	0.628	0.153	0.067	0.060	0.049	0.041	0.028	0.020	0.012	0.005
Jun	0.749	0.149	0.073	0.054	0.046	0.042	0.023	0.017	0.012	0.002
Jul	0.422	0.113	0.070	0.053	0.048	0.026	0.019	0.016	0.012	0.002
Aug	0.246	0.085	0.057	0.048	0.045	0.037	0.029	0.015	0.011	0.002
Sep	0.709	0.194	0.069	0.053	0.042	0.035	0.023	0.013	0.010	0.002

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	1.282	0.623	0.205	0.123	0.061	0.047	0.030	0.022	0.010	0.001
Nov	0.929	0.740	0.548	0.242	0.085	0.056	0.046	0.034	0.016	0.002
Dec	1.603	0.927	0.675	0.439	0.317	0.119	0.068	0.052	0.040	0.004
Jan	1.946	1.142	0.625	0.355	0.101	0.063	0.047	0.038	0.023	0.002
Feb	1.517	0.999	0.393	0.245	0.166	0.088	0.053	0.045	0.037	0.015
Mar	1.115	0.600	0.332	0.261	0.094	0.049	0.043	0.033	0.022	0.002
Apr	0.467	0.296	0.177	0.074	0.054	0.038	0.033	0.023	0.017	0.003
May	0.540	0.142	0.067	0.060	0.049	0.041	0.028	0.020	0.012	0.005
Jun	0.654	0.149	0.073	0.054	0.046	0.042	0.023	0.017	0.012	0.002
Jul	0.303	0.113	0.070	0.053	0.048	0.026	0.019	0.016	0.012	0.002
Aug	0.191	0.085	0.057	0.048	0.045	0.037	0.029	0.015	0.011	0.002
Sep	0.651	0.105	0.066	0.053	0.042	0.035	0.023	0.013	0.010	0.002

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	2.805	1.529	0.945	0.506	0.233	0.092	0.054	0.037	0.013	0.002
Nov	2.486	1.536	0.998	0.618	0.356	0.246	0.149	0.067	0.015	0.002
Dec	4.253	2.745	1.704	1.302	0.933	0.414	0.276	0.151	0.047	0.003
Jan	4.071	2.550	1.425	0.825	0.500	0.288	0.171	0.044	0.027	0.002
Feb	6.153	1.960	1.029	0.771	0.523	0.263	0.162	0.073	0.037	0.012
Mar	2.302	1.130	0.738	0.421	0.318	0.208	0.104	0.043	0.019	0.002
Apr	1.017	0.597	0.517	0.313	0.165	0.089	0.041	0.028	0.017	0.002
May	0.853	0.429	0.317	0.222	0.172	0.105	0.045	0.022	0.016	0.003
Jun	1.870	0.477	0.281	0.199	0.158	0.118	0.036	0.018	0.013	0.002
Jul	0.970	0.634	0.305	0.160	0.111	0.068	0.035	0.020	0.013	0.002
Aug	0.802	0.364	0.223	0.131	0.099	0.069	0.036	0.016	0.010	0.002
Sep	1.882	0.559	0.247	0.160	0.101	0.075	0.036	0.018	0.009	0.002

22.3.3 Alternative Ecological Category D

Month	Baseflows REC: D Discharge (m^3/s)	Monthly volume ($10^6 m^3$)	High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
			Discharge (m3/s)	1.40	2.70	5.20	16.00
			Duration (days)	2	2	3	4
			Number	1	1	1	0
Oct	0.016	0.044					
Nov	0.013	0.034					
Dec	0.037	0.099		1	1		
Jan	0.030	0.081				1	
Feb	0.033	0.080					
Mar	0.029	0.077					
Apr	0.011	0.028					
May	0.011	0.031					
Jun	0.010	0.025					
Jul	0.010	0.026					
Aug	0.010	0.026					
Sep	0.010	0.025					

```
AEC2                SS2
MAR                 32.111          m3/s
S.Dev.              27.109
CV                  0.844
Q75                 8.917
Ecological Category D
                    m3/s            % MAR
Total IFR           4.146           12.912     (excl. >=1:2)
Maint. Lowflow      0.576           1.793
Drought Lowflow     0.576           1.793
Maint. Highflow     3.570           11.119
Monthly Distributions (m3/s)
Distribution Type:  ?? KZN
Month               Natural Flows   Modified Flows (IFR)
                                    Low flows             High Flows  Total Flows
                    Mean            Maint.     Drought    Maint.      Maint.
Oct                 2.906           0.044      0.044      0.450       0.494
Nov                 2.500           0.034      0.034      0.229       0.263
Dec                 4.330           0.099      0.099      0.841       0.939
Jan                 4.655           0.081      0.081      0.804       0.885
Feb                 5.146           0.080      0.080      0.662       0.742
Mar                 2.226           0.077      0.077      0.271       0.348
Apr                 1.079           0.028      0.028      0.074       0.101
May                 1.498           0.031      0.031      0.117       0.148
Jun                 1.265           0.025      0.025      0.028       0.053
Jul                 3.530           0.026      0.026      0.069       0.095
Aug                 0.723           0.026      0.026      0.000       0.026
Sep                 2.252           0.025      0.025      0.026       0.052
```

```
Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category     D
Data are given in m^3/s mean monthly flow
Month               % Points
       10     20     30     40     50     60     70     80     90     99
Oct    0.631  0.122  0.011  0.011  0.011  0.011  0.010  0.010  0.009  0.001
Nov    0.309  0.013  0.011  0.011  0.011  0.010  0.010  0.010  0.010  0.001
Dec    0.839  0.349  0.214  0.141  0.033  0.032  0.031  0.031  0.024  0.004
Jan    0.803  0.346  0.034  0.032  0.032  0.031  0.031  0.029  0.016  0.002
Feb    0.968  0.335  0.106  0.032  0.032  0.031  0.031  0.031  0.025  0.010
Mar    0.285  0.036  0.032  0.032  0.031  0.031  0.031  0.028  0.017  0.002
Apr    0.012  0.011  0.011  0.011  0.011  0.010  0.010  0.010  0.006  0.001
May    0.012  0.011  0.011  0.010  0.010  0.010  0.010  0.010  0.009  0.004
Jun    0.011  0.011  0.011  0.010  0.010  0.010  0.010  0.010  0.007  0.001
Jul    0.011  0.011  0.011  0.010  0.010  0.010  0.010  0.010  0.009  0.001
Aug    0.011  0.011  0.011  0.010  0.010  0.010  0.010  0.010  0.008  0.001
Sep    0.011  0.011  0.011  0.011  0.010  0.010  0.010  0.010  0.008  0.001
```

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.048	0.011	0.011	0.011	0.011	0.010	0.010	0.010	0.009	0.001
Nov	0.013	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.010	0.001
Dec	0.073	0.033	0.032	0.031	0.031	0.031	0.031	0.030	0.024	0.004
Jan	0.033	0.032	0.032	0.031	0.031	0.031	0.031	0.029	0.016	0.002
Feb	0.034	0.032	0.032	0.032	0.031	0.031	0.031	0.031	0.025	0.010
Mar	0.033	0.032	0.031	0.031	0.031	0.031	0.031	0.028	0.017	0.002
Apr	0.011	0.011	0.011	0.011	0.011	0.010	0.010	0.010	0.006	0.001
May	0.012	0.011	0.011	0.010	0.010	0.010	0.010	0.010	0.009	0.004
Jun	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.010	0.007	0.001
Jul	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.010	0.009	0.001
Aug	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.010	0.008	0.001
Sep	0.011	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.008	0.001

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	2.805	1.529	0.945	0.506	0.233	0.092	0.054	0.037	0.013	0.002
Nov	2.486	1.536	0.998	0.618	0.356	0.246	0.149	0.067	0.015	0.002
Dec	4.253	2.745	1.704	1.302	0.933	0.414	0.276	0.151	0.047	0.003
Jan	4.071	2.550	1.425	0.825	0.500	0.288	0.171	0.044	0.027	0.002
Feb	6.153	1.960	1.029	0.771	0.523	0.263	0.162	0.073	0.037	0.012
Mar	2.302	1.130	0.738	0.421	0.318	0.208	0.104	0.043	0.019	0.002
Apr	1.017	0.597	0.517	0.313	0.165	0.089	0.041	0.028	0.017	0.002
May	0.853	0.429	0.317	0.222	0.172	0.105	0.045	0.022	0.016	0.003
Jun	1.870	0.477	0.281	0.199	0.158	0.118	0.036	0.018	0.013	0.002
Jul	0.970	0.634	0.305	0.160	0.111	0.068	0.035	0.020	0.013	0.002
Aug	0.802	0.364	0.223	0.131	0.099	0.069	0.036	0.016	0.010	0.002
Sep	1.882	0.559	0.247	0.160	0.101	0.075	0.036	0.018	0.009	0.002

23 EWR SITE MA1 (MATIGULU RIVER) RECOMMENDED RESERVES

This Section provides the detailed outputs for the EWRs that were selected to maintain REC and the AECs for at EWR Site MA1. These include:

- Predicted change in percentage of 2014 abundance for each indicator;
- Time-series plots showing expected variations in each indicator with climatic variations;
- EWR data in Reserve Template format, including rule curves.

These data can be used to construct the ecospecifications for the Reserve, and to compile the RDM Reserve Templates for water quantity. In this project, the ecospecifications for the Reserve to maintain REC will be provided in the Intermediate River EWR Ecospecs Report (Volume 4). The RDM Reserve templates for the REC will also be constructed.

Note: The EWRs provided are relative to the modelled baseline hydrology. If the baseline hydrology changes then the EWRs MUST change accordingly.

On the basis of the results in Figure 15-1 and Figure 15-2, the following EWRs were selected as potential Reserves to maintain the REC and AECs:

River	Site	REC	AEC1	AEC2	AEC3
Matigulu	MA1	B/C	B	C	D
		SS4	Sc3	SS3a	SS1

23.1 Mean percentage changes

The mean percentage changes (relative to Baseline) for the indicators for the EWRs were selected as potential Reserves to maintain the REC and AECs at EWR Site MA1 are given in Table 23-1.

Table 23-1 EWR Site MA1: The mean percentage changes in abundance (relative to 2014) for the indicators for the EWRs for maintaining a B, B/C,, C and D category. Blue and green are major changes towards natural: green = 40-70%; blue = >70%. Orange and red are major changes away from natural: orange = 40-70%; red = >70%. Baseline, by definition, equals 100%.

Discipline	Indicator	REC SS4 B/C-Category	AEC1 SS3a B-Category	AEC2 Sc3 C-Category	AEC3 SS1 D-Category
Geomorphology	Channel width	2.13	2.48	1.84	0.17
	Extent of cut banks	-6.12	-8.27	0.64	-10.92
	Secondary channels	6.31	7.16	2.69	4.66
	Pool depth	-5.03	-5.48	-0.76	0.90
	Bed sediment conditions	-0.24	-1.32	2.52	-4.13
Water quality	Summer water temperature	3.60	7.43	3.24	11.41
	Nutrients - phosphates	7.22	13.08	4.17	35.48
	Nutrients - nitrogen	6.31	10.85	1.88	14.62
	Electrical conductivity (salinity)	1.84	3.76	1.28	18.86
	Sulphates	4.32	7.82	4.08	27.15
Riparian Vegetation	Algae	5.64	10.43	-0.55	22.70
	Marginal zone graminoids	-31.13	-45.08	1.98	-57.91
	Marginal zone trees	-50.61	-63.49	-0.97	-77.77
	Lower zone graminoids	-49.80	-61.67	-4.43	-77.59
	Lower zone trees	-39.25	-60.74	-1.37	-73.56
	Upper zone trees - riparian	-4.57	-16.18	-9.14	-36.85
	Upper zone trees - terrestrial	-35.60	22.65	43.80	141.81
Macroinvertebrates	Palaemonidae (Freshwater Prawns)	-1.07	-15.90	-2.52	-44.85
	Perlidae (Stoneflies)	-25.96	-46.78	-18.00	-89.25
	Hydropsychidae (Caddisflies)	-9.66	-23.75	-8.46	-61.24
	Elmidae (Riffle Beetles)	0.74	-20.35	-1.87	-56.07
	Gomphidae (Clubtails)	11.95	-4.86	0.81	-27.50
	Leptophlebiidae (Prongills)	-4.65	-14.03	-3.40	-42.32
	Baetidae (Minnow mayflies)	-5.64	-14.15	-0.03	-26.39
	Chironomidae (Midges)	-6.96	-14.72	0.78	-25.97
	Simuliidae (Blackflies)	-9.63	-23.60	-0.33	-44.30
	Coenagrionidae (Sprites & Blues)	-30.54	-55.74	2.06	-76.47
Fish	Oreochromis mossambicus	2.57	2.76	3.56	6.24
	Labeobarbus natalensis	-38.53	-60.52	-10.03	-81.51
	Barbus paludinosus	-24.04	-39.32	-3.56	-54.83
	Glossogobius callidus	-6.32	-13.22	1.56	-24.59
	Anguilla mossambica	-23.33	-45.83	-6.58	-68.36

23.2 Time series

The time series of predicted abundance changes relative to baseline (2014) under baseline, naturalised and the EWRs for maintaining a B-, B/C-, C- and D-category are provided for the indicators for each discipline (Figure 23-1 to Figure 23-5).

Figure 23-1 Time series for the geomorphological indicators at EWR Site MA1 for the Baseline and Naturalised scenarios, and for the EWRs for B-, B/C-, C- and D-category.

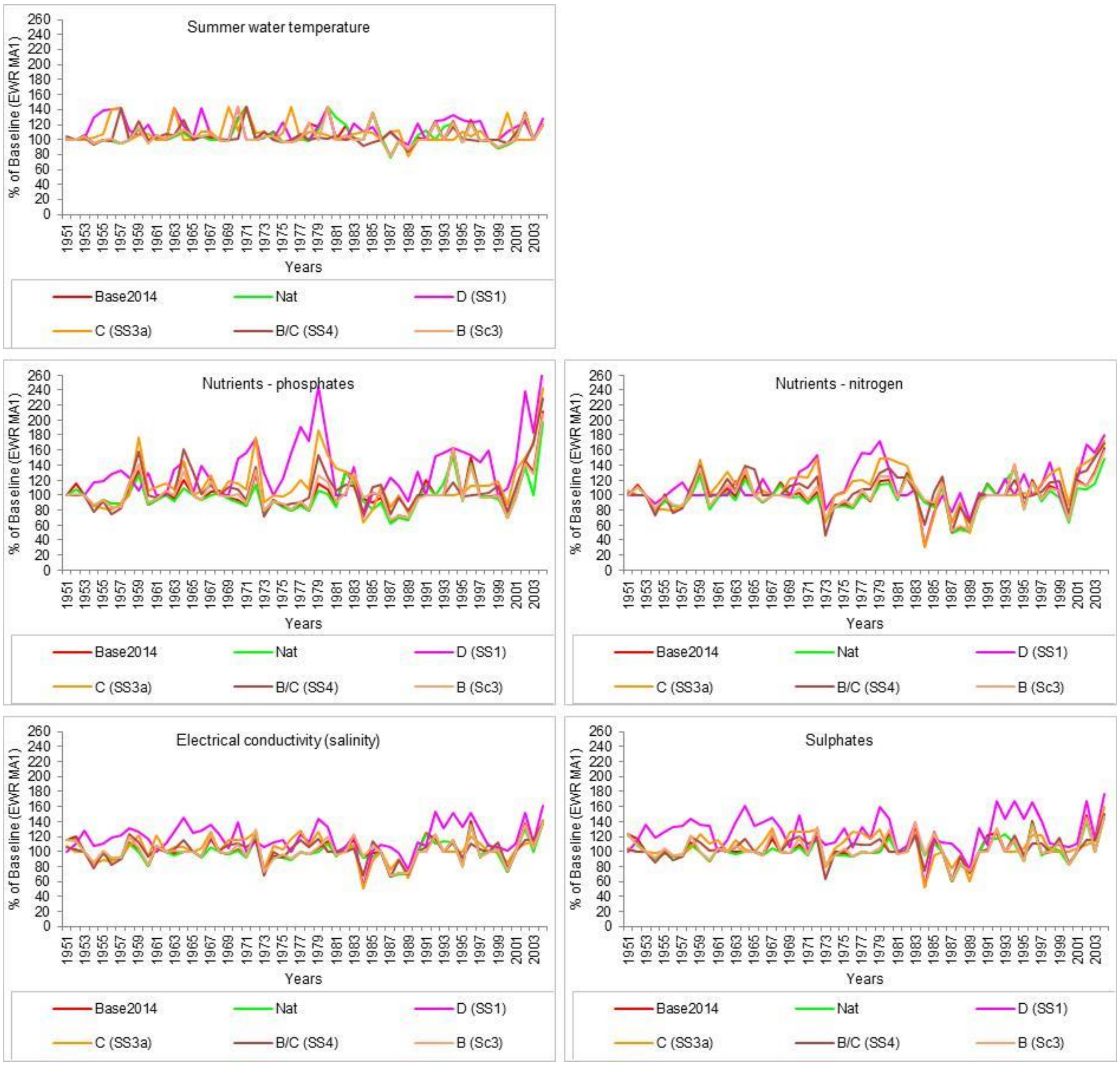


Figure 23-2 Time series for the water quality indicators at EWR Site MA 1 for the Baseline and Naturalised scenarios, and for the EWRs for B-, B/C-, C- and D-category.

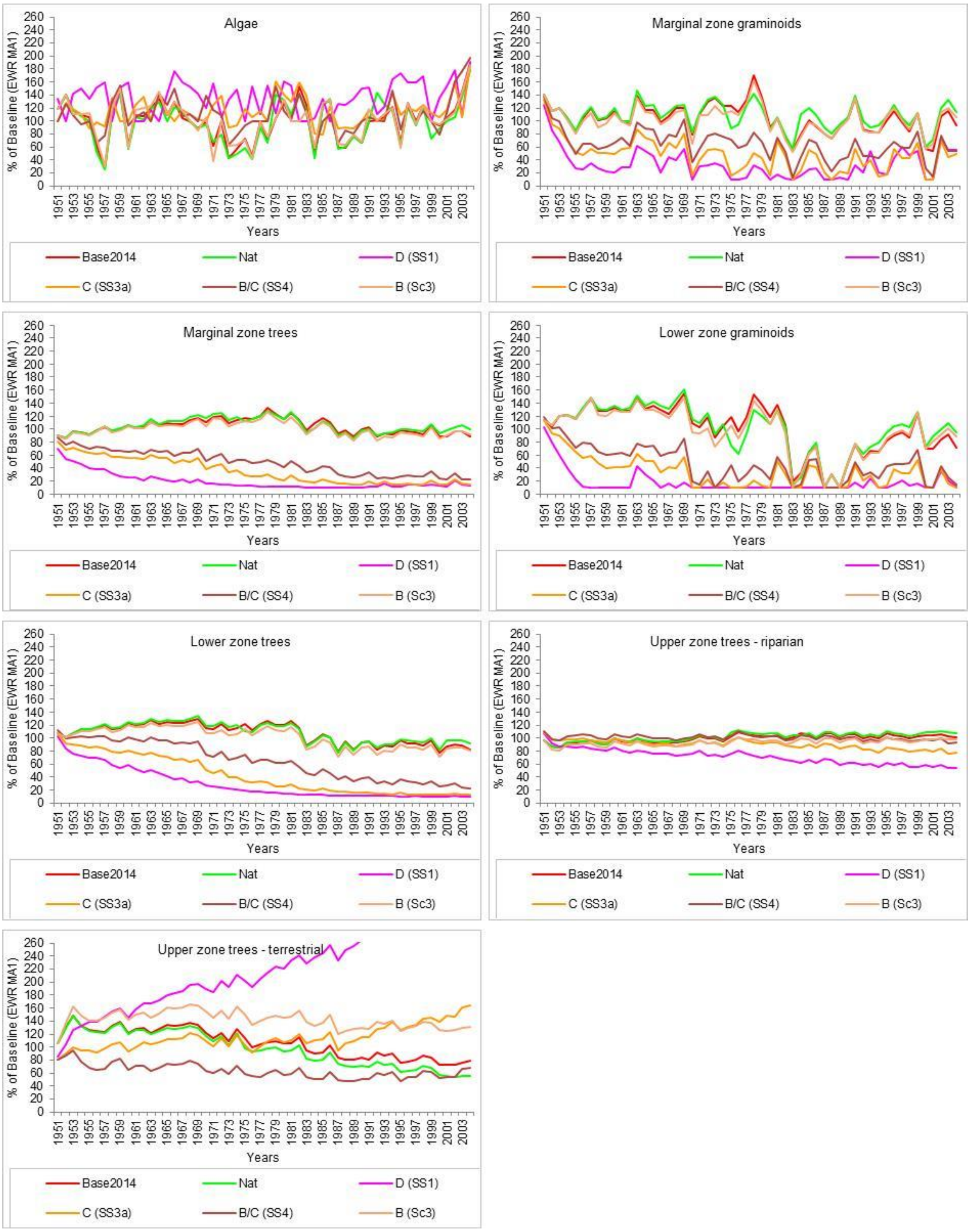


Figure 23-3 Time series for the vegetation indicators at EWR Site MA 1 for the Baseline and Naturalised scenarios, and for the EWRs for B-, B/C-, C- and D-category.

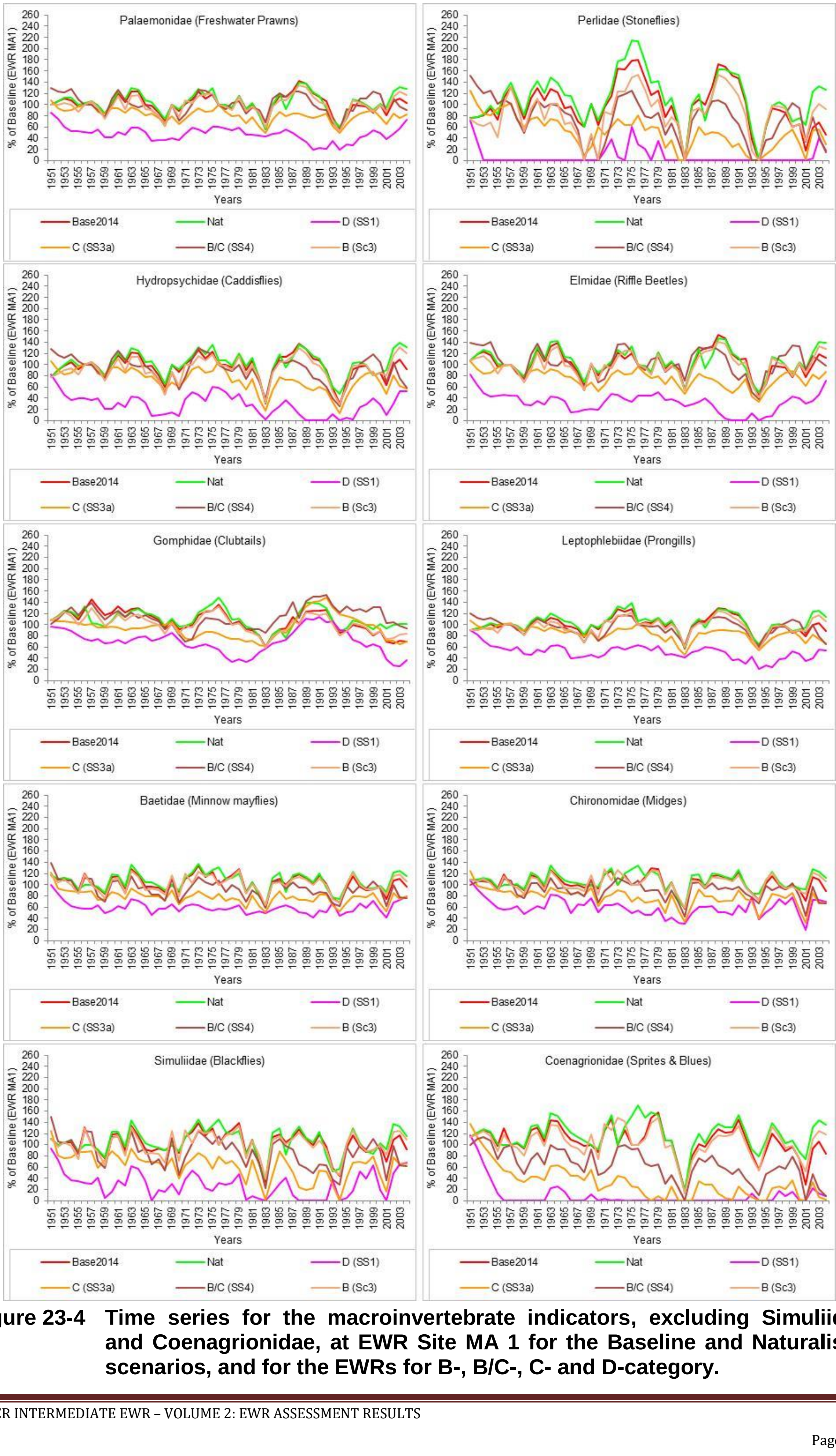


Figure 23-4 Time series for the macroinvertebrate indicators, excluding Simuliidae and Coenagrionidae, at EWR Site MA 1 for the Baseline and Naturalised scenarios, and for the EWRs for B-, B/C-, C- and D-category.

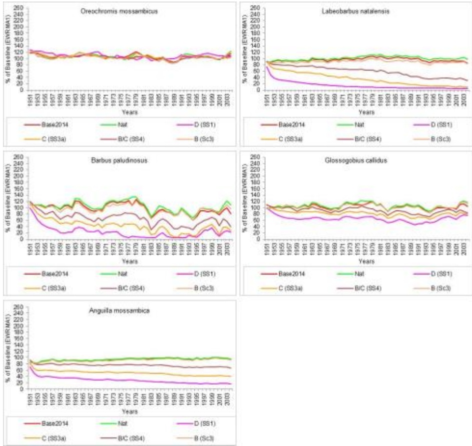


Figure 23-5 Time series for the fish indicators at EWR Site MA 1 for the Baseline and Naturalised scenarios, and for the EWRs for B-, B/C-, C- and D-category.

23.3 Hydrological summaries (MA1)

Please note:

1. As per RDM convention, the volumes provided here EXCLUDE flows with a return period of ≥ 1:2 years.
2. The information in the ".tab" files provides the volumes of maintenance low- and high-flows required to maintain the specified ecological category. The "long term average", as determined by the Desktop Model (the .mrv file), frequently does not match this required volume. This is because, in the Desktop Model, if sufficient flow is unavailable to provide a flood in a particular month, as requested, the flood will be skipped, but is not provided in the next month, even if sufficient flow is available.

23.3.1 Recommended Ecological Category B/C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: B/C		Discharge (m3/s)	3.30	6.10	12.10	22.10
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	3	3	2
			Number	3	3	2	1
Oct	0.958	2.565		2	2	1	1
Nov	1.040	2.697					
Dec	0.880	2.358		1	1		
Jan	0.840	2.251				1	
Feb	0.847	2.049					
Mar	0.832	2.227					
Apr	0.556	1.442					
May	0.525	1.406					
Jun	0.453	1.173					
Jul	0.444	1.190					
Aug	0.432	1.157					
Sep	0.587	1.522					

MAR	85.236	MCM		
S.Dev.	27.109			
CV	0.318			
Q75	8.917			
Ecological Category	B/C			
	MCM	% MAR		
Total IFR	36.805	43.180	(excl. >=1:2)	
Maint. Lowflow	22.037	25.854		
Drought Lowflow	6.762	7.933		
Maint. Highflow	14.767	17.325		

Monthly Distributions (MCM)
Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	10.687	2.565	0.793	2.559	5.124
Nov	10.425	2.697	0.776	1.670	4.367
Dec	7.699	2.358	0.802	2.022	4.380
Jan	7.990	2.251	0.777	1.100	3.350
Feb	12.419	2.049	0.698	2.414	4.463
Mar	10.137	2.227	0.753	2.490	4.717
Apr	5.489	1.442	0.235	0.964	2.406
May	4.597	1.406	0.241	0.862	2.268
Jun	2.851	1.173	0.380	0.271	1.444
Jul	2.939	1.190	0.399	0.306	1.497
Aug	2.574	1.157	0.393	0.000	1.157
Sep	7.426	1.522	0.516	0.110	1.631

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B/C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	4.648	2.965	1.987	1.436	1.194	1.025	0.882	0.685	0.590	0.288
Nov	3.308	2.217	1.794	1.522	1.316	1.168	1.046	0.942	0.792	0.498
Dec	2.599	1.682	1.249	1.132	1.054	0.874	0.773	0.679	0.588	0.363
Jan	2.747	1.680	1.373	1.142	0.940	0.770	0.678	0.554	0.428	0.153
Feb	4.554	2.731	1.784	1.266	1.088	0.921	0.676	0.497	0.326	0.077
Mar	4.647	3.151	1.274	1.147	1.083	0.915	0.616	0.366	0.298	0.069
Apr	1.918	1.009	0.724	0.712	0.675	0.625	0.460	0.392	0.216	0.106
May	0.819	0.720	0.711	0.682	0.609	0.547	0.461	0.333	0.169	0.056
Jun	0.587	0.573	0.563	0.556	0.542	0.474	0.378	0.333	0.191	0.055
Jul	0.578	0.566	0.559	0.532	0.508	0.453	0.382	0.292	0.210	0.082
Aug	0.573	0.568	0.559	0.543	0.470	0.393	0.331	0.302	0.250	0.089
Sep	0.749	0.740	0.735	0.712	0.680	0.596	0.475	0.384	0.331	0.247

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	1.252	1.227	1.207	1.134	1.039	0.974	0.822	0.665	0.503	0.267
Nov	1.222	1.217	1.212	1.187	1.144	1.076	0.969	0.878	0.713	0.441
Dec	1.245	1.219	1.120	1.014	0.837	0.712	0.652	0.596	0.554	0.328
Jan	1.241	1.212	1.151	1.022	0.789	0.709	0.628	0.527	0.373	0.153
Feb	1.248	1.227	1.170	1.067	0.913	0.811	0.620	0.472	0.311	0.077
Mar	1.253	1.245	1.236	1.032	0.926	0.791	0.593	0.366	0.298	0.069
Apr	0.726	0.719	0.712	0.687	0.657	0.596	0.455	0.392	0.216	0.068
May	0.721	0.717	0.708	0.633	0.600	0.534	0.419	0.333	0.169	0.056
Jun	0.587	0.573	0.563	0.556	0.542	0.474	0.378	0.333	0.191	0.055
Jul	0.570	0.565	0.555	0.532	0.508	0.453	0.382	0.292	0.210	0.082
Aug	0.573	0.568	0.559	0.543	0.470	0.393	0.331	0.302	0.250	0.089
Sep	0.745	0.739	0.734	0.708	0.674	0.596	0.475	0.384	0.331	0.247

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	9.510	6.603	3.810	2.528	1.508	1.273	1.062	0.845	0.685	0.329
Nov	7.784	5.633	3.710	3.031	2.137	1.883	1.521	1.092	0.990	0.724
Dec	6.755	3.223	2.240	1.580	1.299	1.033	0.890	0.830	0.771	0.595
Jan	7.715	4.502	2.292	1.707	1.254	0.921	0.792	0.707	0.535	0.350
Feb	18.609	7.374	2.637	1.774	1.309	1.143	0.823	0.618	0.487	0.230
Mar	11.320	7.140	3.114	1.594	1.352	1.219	0.753	0.548	0.358	0.206
Apr	4.895	3.233	1.958	1.485	0.980	0.882	0.644	0.508	0.312	0.196
May	2.740	1.847	1.275	0.930	0.728	0.641	0.602	0.452	0.275	0.206
Jun	2.184	1.150	0.840	0.760	0.687	0.583	0.485	0.419	0.307	0.190
Jul	1.635	1.243	0.770	0.692	0.597	0.501	0.420	0.385	0.275	0.204
Aug	1.803	1.118	0.939	0.794	0.670	0.538	0.466	0.384	0.347	0.216
Sep	4.889	1.662	1.320	1.064	0.911	0.830	0.704	0.508	0.418	0.336

23.3.2 Alternative Ecological Category B

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: B		Discharge (m3/s)	3.30	6.10	12.40	24.50
	Discharge (m^3/s)	Monthly volume ($10^6 m^3$)	Duration (days)	2	3	4	6
			Number	3	3	2	1
Oct	2.407	6.446		2	2	1	1
Nov	2.155	5.586					
Dec	1.747	4.679		1	1		
Jan	1.642	4.399				1	
Feb	1.992	4.819					
Mar	2.380	6.375					
Apr	1.480	3.837					
May	1.161	3.110					
Jun	0.890	2.307					
Jul	0.756	2.025					
Aug	0.664	1.778					
Sep	0.965	2.502					

MAR	85.236	MCM	
S.Dev.	27.109		
CV	0.318		
Q75	8.917		
Ecological Category B			
	MCM	% MAR	
Total IFR	62.859	73.748	(excl. >=1:2)
Maint. Lowflow	47.862	56.153	
Drought Lowflow	6.762	7.933	
Maint. Highflow	14.997	17.595	

Monthly Distributions (MCM)

Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	10.687	6.446	0.793	2.396	8.841
Nov	10.425	5.586	0.776	2.141	7.727
Dec	7.699	4.679	0.802	1.807	6.485
Jan	7.990	4.399	0.777	1.568	5.967
Feb	12.419	4.819	0.698	2.483	7.302
Mar	10.137	6.375	0.753	1.723	8.098
Apr	5.489	3.837	0.235	0.946	4.782
May	4.597	3.110	0.241	0.403	3.513
Jun	2.851	2.307	0.380	0.154	2.461
Jul	2.939	2.025	0.399	0.255	2.280
Aug	2.574	1.778	0.393	0.374	2.152
Sep	7.426	2.502	0.516	0.749	3.250

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category B
Data are given in m^3/s mean monthly flow

Month	10	20	30	40	50	60	70	80	90	99
	% Points									
Oct	9.042	5.300	3.315	2.201	1.344	1.079	0.948	0.700	0.570	0.188
Nov	6.078	5.305	3.599	2.809	2.041	1.604	1.294	0.924	0.772	0.589
Dec	5.182	2.991	1.999	1.408	1.112	0.911	0.759	0.612	0.551	0.365
Jan	5.710	4.133	2.272	1.523	1.101	0.750	0.625	0.545	0.297	0.163
Feb	8.806	6.039	2.612	1.717	1.197	0.982	0.620	0.406	0.273	0.111
Mar	9.431	5.737	2.758	1.382	1.206	1.011	0.547	0.358	0.191	0.101
Apr	4.522	3.177	1.743	1.292	0.802	0.683	0.458	0.343	0.184	0.099
May	2.593	1.626	1.040	0.697	0.590	0.491	0.444	0.297	0.132	0.101
Jun	1.890	0.974	0.702	0.591	0.532	0.424	0.356	0.299	0.172	0.101
Jul	1.411	1.044	0.643	0.565	0.433	0.364	0.308	0.252	0.158	0.101
Aug	1.668	0.912	0.780	0.646	0.567	0.429	0.327	0.243	0.200	0.101
Sep	2.401	1.350	1.130	0.839	0.747	0.664	0.578	0.357	0.275	0.216

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	5.788	3.015	1.989	1.653	1.277	1.006	0.832	0.644	0.500	0.188
Nov	4.395	3.639	2.664	1.948	1.560	1.266	1.091	0.917	0.691	0.419
Dec	3.354	2.420	1.546	1.199	0.954	0.780	0.614	0.546	0.488	0.281
Jan	3.975	3.119	1.653	1.249	0.887	0.701	0.586	0.454	0.296	0.163
Feb	5.541	2.990	1.996	1.281	1.058	0.793	0.515	0.384	0.273	0.111
Mar	7.044	3.587	2.758	1.224	0.987	0.886	0.505	0.348	0.191	0.101
Apr	3.266	2.200	1.371	1.008	0.770	0.683	0.458	0.343	0.184	0.099
May	2.270	1.457	0.923	0.691	0.553	0.476	0.398	0.297	0.132	0.101
Jun	1.488	0.861	0.660	0.586	0.532	0.424	0.356	0.299	0.164	0.077
Jul	1.291	0.934	0.643	0.565	0.433	0.364	0.308	0.252	0.158	0.101
Aug	1.311	0.818	0.652	0.600	0.455	0.389	0.314	0.243	0.200	0.101
Sep	1.815	1.174	0.964	0.716	0.695	0.584	0.519	0.354	0.275	0.216

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	9.510	6.603	3.810	2.528	1.508	1.273	1.062	0.845	0.685	0.329
Nov	7.784	5.633	3.710	3.031	2.137	1.883	1.521	1.092	0.990	0.724
Dec	6.755	3.223	2.240	1.580	1.299	1.033	0.890	0.830	0.771	0.595
Jan	7.715	4.502	2.292	1.707	1.254	0.921	0.792	0.707	0.535	0.350
Feb	18.609	7.374	2.637	1.774	1.309	1.143	0.823	0.618	0.487	0.230
Mar	11.320	7.140	3.114	1.594	1.352	1.219	0.753	0.548	0.358	0.206
Apr	4.895	3.233	1.958	1.485	0.980	0.882	0.644	0.508	0.312	0.196
May	2.740	1.847	1.275	0.930	0.728	0.641	0.602	0.452	0.275	0.206
Jun	2.184	1.150	0.840	0.760	0.687	0.583	0.485	0.419	0.307	0.190
Jul	1.635	1.243	0.770	0.692	0.597	0.501	0.420	0.385	0.275	0.204
Aug	1.803	1.118	0.939	0.794	0.670	0.538	0.466	0.384	0.347	0.216
Sep	4.889	1.662	1.320	1.064	0.911	0.830	0.704	0.508	0.418	0.336

23.3.3 Alternative Ecological Category C

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: C		Discharge (m3/s)	3.30	6.10	12.30	26.40
	Discharge (m^3/s)	Monthly volume (10^6m^3)	Duration (days)	2	3	3	3
			Number	2	2	1	1
Oct	2.407	6.446		1	1	1	1
Nov	2.155	5.586					
Dec	1.747	4.679		1	1		
Jan	1.642	4.399					
Feb	1.992	4.819					
Mar	2.380	6.375					
Apr	1.480	3.837					
May	1.161	3.110					
Jun	0.890	2.307					
Jul	0.756	2.025					
Aug	0.664	1.778					
Sep	0.965	2.502					

MAR	85.236	MCM			
S.Dev.	27.109				
CV	0.318				
Q75	8.917				
Ecological Category	C				
	MCM	% MAR			
Total IFR	27.461	32.218	(excl. >=1:2)		
Maint. Lowflow	14.123	16.569			
Drought Lowflow	6.762	7.933			
Maint. Highflow	13.339	15.649			
Monthly Distributions (MCM)					
Distribution Type:	?? KZN				
Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	10.687	1.501	0.793	2.347	3.849
Nov	10.425	1.509	0.776	1.429	2.937
Dec	7.699	1.483	0.802	1.869	3.352
Jan	7.990	1.404	0.777	0.929	2.333
Feb	12.419	1.249	0.698	2.179	3.429
Mar	10.137	1.336	0.753	2.269	3.606
Apr	5.489	0.996	0.235	0.800	1.796
May	4.597	0.989	0.241	0.816	1.805
Jun	2.851	0.841	0.380	0.277	1.118
Jul	2.939	0.873	0.399	0.311	1.184
Aug	2.574	0.855	0.393	0.000	0.855
Sep	7.426	1.086	0.516	0.112	1.198

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category C
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	3.451	2.340	1.355	0.873	0.740	0.606	0.598	0.564	0.432	0.262
Nov	2.446	1.472	0.973	0.873	0.814	0.648	0.606	0.604	0.571	0.393
Dec	1.792	1.115	0.697	0.622	0.609	0.602	0.582	0.524	0.491	0.334
Jan	1.721	1.062	0.795	0.611	0.601	0.582	0.528	0.481	0.392	0.144
Feb	3.509	1.815	1.166	0.873	0.616	0.604	0.537	0.431	0.319	0.077
Mar	3.554	2.250	0.822	0.635	0.614	0.596	0.481	0.356	0.297	0.069
Apr	1.566	0.679	0.446	0.438	0.437	0.433	0.410	0.352	0.212	0.105
May	0.544	0.443	0.439	0.436	0.433	0.431	0.397	0.307	0.162	0.056
Jun	0.377	0.368	0.363	0.362	0.362	0.359	0.345	0.301	0.191	0.046
Jul	0.372	0.365	0.363	0.362	0.361	0.359	0.336	0.273	0.197	0.077
Aug	0.369	0.365	0.364	0.362	0.358	0.341	0.316	0.243	0.234	0.089
Sep	0.473	0.469	0.465	0.464	0.462	0.455	0.405	0.350	0.321	0.224

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.628	0.614	0.608	0.606	0.605	0.603	0.575	0.554	0.381	0.222
Nov	0.611	0.608	0.607	0.606	0.605	0.604	0.597	0.572	0.538	0.373
Dec	0.626	0.616	0.609	0.603	0.580	0.545	0.521	0.496	0.470	0.273
Jan	0.621	0.613	0.610	0.602	0.584	0.530	0.488	0.430	0.349	0.144
Feb	0.626	0.618	0.613	0.607	0.595	0.555	0.501	0.420	0.304	0.077
Mar	0.627	0.624	0.619	0.609	0.593	0.549	0.454	0.353	0.297	0.069
Apr	0.446	0.441	0.438	0.437	0.436	0.432	0.397	0.344	0.212	0.066
May	0.443	0.440	0.436	0.435	0.431	0.414	0.367	0.289	0.162	0.056
Jun	0.377	0.368	0.363	0.362	0.362	0.359	0.345	0.301	0.191	0.046
Jul	0.372	0.365	0.363	0.362	0.361	0.359	0.336	0.273	0.197	0.077
Aug	0.369	0.365	0.364	0.362	0.358	0.341	0.316	0.243	0.234	0.089
Sep	0.472	0.468	0.465	0.463	0.462	0.453	0.405	0.350	0.321	0.224

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	9.510	6.603	3.810	2.528	1.508	1.273	1.062	0.845	0.685	0.329
Nov	7.784	5.633	3.710	3.031	2.137	1.883	1.521	1.092	0.990	0.724
Dec	6.755	3.223	2.240	1.580	1.299	1.033	0.890	0.830	0.771	0.595
Jan	7.715	4.502	2.292	1.707	1.254	0.921	0.792	0.707	0.535	0.350
Feb	18.609	7.374	2.637	1.774	1.309	1.143	0.823	0.618	0.487	0.230
Mar	11.320	7.140	3.114	1.594	1.352	1.219	0.753	0.548	0.358	0.206
Apr	4.895	3.233	1.958	1.485	0.980	0.882	0.644	0.508	0.312	0.196
May	2.740	1.847	1.275	0.930	0.728	0.641	0.602	0.452	0.275	0.206
Jun	2.184	1.150	0.840	0.760	0.687	0.583	0.485	0.419	0.307	0.190
Jul	1.635	1.243	0.770	0.692	0.597	0.501	0.420	0.385	0.275	0.204
Aug	1.803	1.118	0.939	0.794	0.670	0.538	0.466	0.384	0.347	0.216
Sep	4.889	1.662	1.320	1.064	0.911	0.830	0.704	0.508	0.418	0.336

23.3.4 Alternative Ecological Category D

	Baseflows		High flows (excl. >1:2 yr)	Class1	Class2	Class3	Class4
	REC: D			Class1	Class2	Class3	Class4
	Discharge (m^3/s)	Monthly volume ($10^6 m^3$)	Discharge (m3/s)	3	6	12	22
			Number	1	1	0	0
Oct	0.560	1.501		1			
Nov	0.582	1.509			1		
Dec	0.554	1.483					
Jan	0.524	1.404					
Feb	0.516	1.249					
Mar	0.499	1.336					
Apr	0.384	0.996					
May	0.369	0.989					
Jun	0.324	0.841					
Jul	0.326	0.873					
Aug	0.319	0.855					
Sep	0.419	1.086					

MAR	85.236	MCM	
S.Dev.	27.109		
CV	0.318		
Q75	8.917		
Ecological Category D			
	MCM	% MAR	
Total IFR	15.159	17.785	(excl. >=1:2)
Maint. Lowflow	6.762	7.933	
Drought Lowflow	6.762	7.933	
Maint. Highflow	8.398	9.852	

Monthly Distributions (MCM)

Distribution Type: ?? KZN

Month	Natural Flows	Modified Flows (IFR)			
		Low flows		High Flows	Total Flows
	Mean	Maint.	Drought	Maint.	Maint.
Oct	10.687	0.793	0.793	1.242	2.035
Nov	10.425	0.776	0.776	0.686	1.462
Dec	7.699	0.802	0.802	1.320	2.121
Jan	7.990	0.777	0.777	0.330	1.107
Feb	12.419	0.698	0.698	1.626	2.324
Mar	10.137	0.753	0.753	1.428	2.180
Apr	5.489	0.235	0.235	0.375	0.610
May	4.597	0.241	0.241	0.677	0.918
Jun	2.851	0.380	0.380	0.283	0.663
Jul	2.939	0.399	0.399	0.317	0.716
Aug	2.574	0.393	0.393	0.000	0.393
Sep	7.426	0.516	0.516	0.114	0.629

Summary of IFR rule curves (without >=1:2 year floods)
Ecological Category D
Data are given in m^3/s mean monthly flow

Month	% Points									
	10	20	30	40	50	60	70	80	90	99
Oct	1.161	0.760	0.589	0.441	0.307	0.305	0.303	0.302	0.290	0.186
Nov	0.943	0.841	0.528	0.305	0.304	0.304	0.303	0.303	0.302	0.248
Dec	0.892	0.454	0.308	0.305	0.304	0.303	0.302	0.299	0.291	0.189
Jan	0.580	0.311	0.305	0.305	0.304	0.303	0.300	0.294	0.264	0.108
Feb	2.590	0.835	0.547	0.311	0.307	0.306	0.304	0.293	0.273	0.073
Mar	1.720	1.033	0.316	0.310	0.308	0.307	0.303	0.266	0.228	0.065
Apr	0.413	0.095	0.093	0.093	0.092	0.092	0.091	0.091	0.091	0.054
May	0.288	0.094	0.093	0.092	0.092	0.091	0.091	0.091	0.090	0.047
Jun	0.158	0.155	0.154	0.152	0.152	0.151	0.151	0.151	0.134	0.033
Jul	0.155	0.153	0.152	0.151	0.151	0.151	0.151	0.151	0.149	0.065
Aug	0.154	0.152	0.152	0.152	0.151	0.151	0.151	0.150	0.132	0.069
Sep	0.206	0.204	0.203	0.202	0.202	0.202	0.201	0.201	0.199	0.144

Reserve Flows without High Flows

	10	20	30	40	50	60	70	80	90	99
Oct	0.314	0.308	0.306	0.305	0.304	0.303	0.303	0.301	0.257	0.186
Nov	0.305	0.305	0.304	0.304	0.303	0.303	0.303	0.302	0.287	0.243
Dec	0.313	0.308	0.305	0.304	0.303	0.303	0.301	0.297	0.290	0.189
Jan	0.310	0.307	0.305	0.304	0.303	0.303	0.300	0.291	0.264	0.108
Feb	0.313	0.310	0.307	0.307	0.306	0.305	0.301	0.290	0.248	0.073
Mar	0.313	0.312	0.310	0.308	0.308	0.307	0.295	0.266	0.228	0.065
Apr	0.095	0.094	0.093	0.092	0.092	0.092	0.091	0.091	0.091	0.054
May	0.094	0.093	0.092	0.092	0.091	0.091	0.091	0.091	0.086	0.047
Jun	0.158	0.155	0.154	0.152	0.152	0.151	0.151	0.151	0.134	0.033
Jul	0.155	0.153	0.152	0.151	0.151	0.151	0.151	0.151	0.149	0.065
Aug	0.154	0.152	0.152	0.152	0.151	0.151	0.151	0.150	0.132	0.069
Sep	0.205	0.204	0.203	0.202	0.202	0.202	0.201	0.201	0.199	0.144

Natural Duration curves

	10	20	30	40	50	60	70	80	90	99
Oct	9.510	6.603	3.810	2.528	1.508	1.273	1.062	0.845	0.685	0.329
Nov	7.784	5.633	3.710	3.031	2.137	1.883	1.521	1.092	0.990	0.724
Dec	6.755	3.223	2.240	1.580	1.299	1.033	0.890	0.830	0.771	0.595
Jan	7.715	4.502	2.292	1.707	1.254	0.921	0.792	0.707	0.535	0.350
Feb	18.609	7.374	2.637	1.774	1.309	1.143	0.823	0.618	0.487	0.230
Mar	11.320	7.140	3.114	1.594	1.352	1.219	0.753	0.548	0.358	0.206
Apr	4.895	3.233	1.958	1.485	0.980	0.882	0.644	0.508	0.312	0.196
May	2.740	1.847	1.275	0.930	0.728	0.641	0.602	0.452	0.275	0.206
Jun	2.184	1.150	0.840	0.760	0.687	0.583	0.485	0.419	0.307	0.190
Jul	1.635	1.243	0.770	0.692	0.597	0.501	0.420	0.385	0.275	0.204
Aug	1.803	1.118	0.939	0.794	0.670	0.538	0.466	0.384	0.347	0.216
Sep	4.889	1.662	1.320	1.064	0.911	0.830	0.704	0.508	0.418	0.336

24 NEXT STEPS IN THE PROCESS

The next steps in the river Reserve process lead into Classification. These include:

- extrapolation of the information generated to nodes throughout the Usuthu-Mthlatuze WMA;
- generation of the catchment configuration scenarios;
- evaluation of these by stakeholders;
- final decision on the Management Class and ecological Reserves .

In the interim:

- the ecospecifications for the Reserve to maintain the REC will be provided for the EWR sites (Intermediate River EWR: Ecospecs and Monitoring Programme Report - Volume 4);
- the RDM Reserve templates for the REC will be constructed;

25 REFERENCES

Brown, C.A., Joubert, A.R., Beuster, J. Greyling, A. and King, J.M. 2013. DRIFT: DSS software development for Integrated Flow Assessments. FINAL REPORT to the South African Water Research Commission. February 2013.

King, J.M. and Brown, C.A. 2010. Integrated Flow Assessments: concepts and method development in Africa and South-east Asia. *Freshwater Biology* 55 (1): 127-146

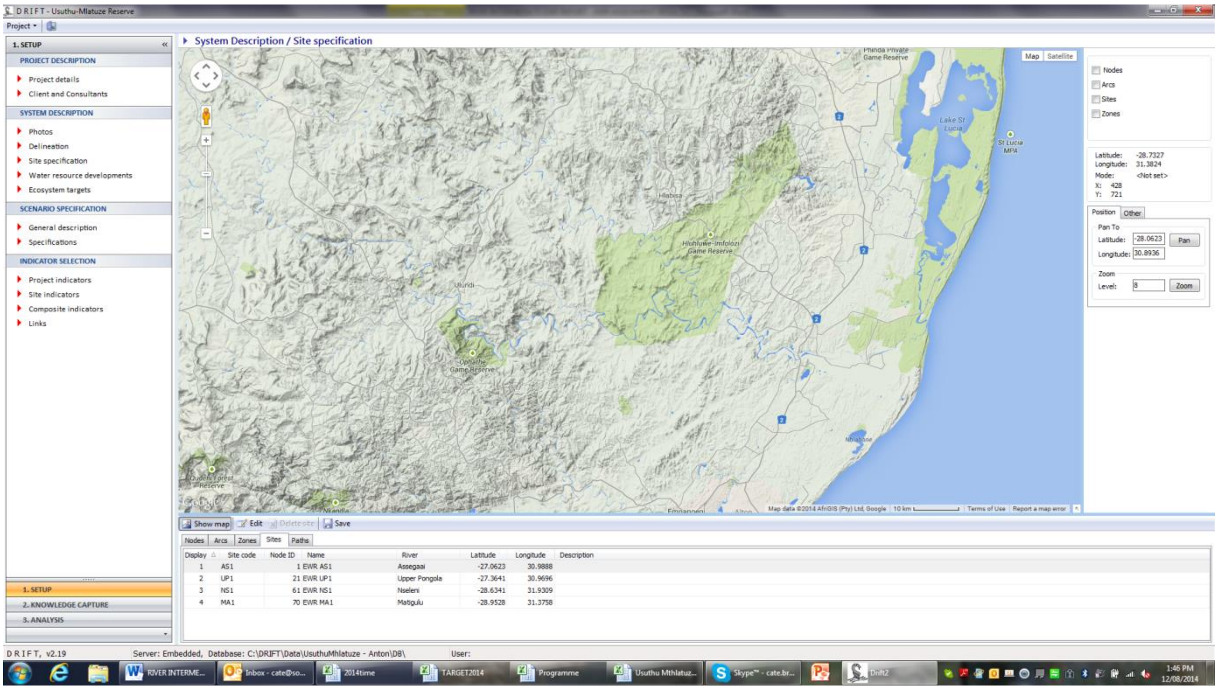
TPTC, 2011. PRIMA IAAP 10: System Operating Rules for the Incomati and Maputo Watercourses. Report by Aurecon South Africa to the Tripartite Permanent Technical Committee.

Appendix A. OVERVIEW OF DRIFT

A.1 DRIFT-DSS

The DRIFT-DSS is programmed using Delphi XE and uses a NexusDB v3 database. The software is designed for use in all computers running Windows XP and upwards, and the DSS supports both single-user and multi-user modes.

The DSS makes use of Google Earth (standard version) (Appendix Figure 1), for which a licence is required if Google Earth images are used in reports.

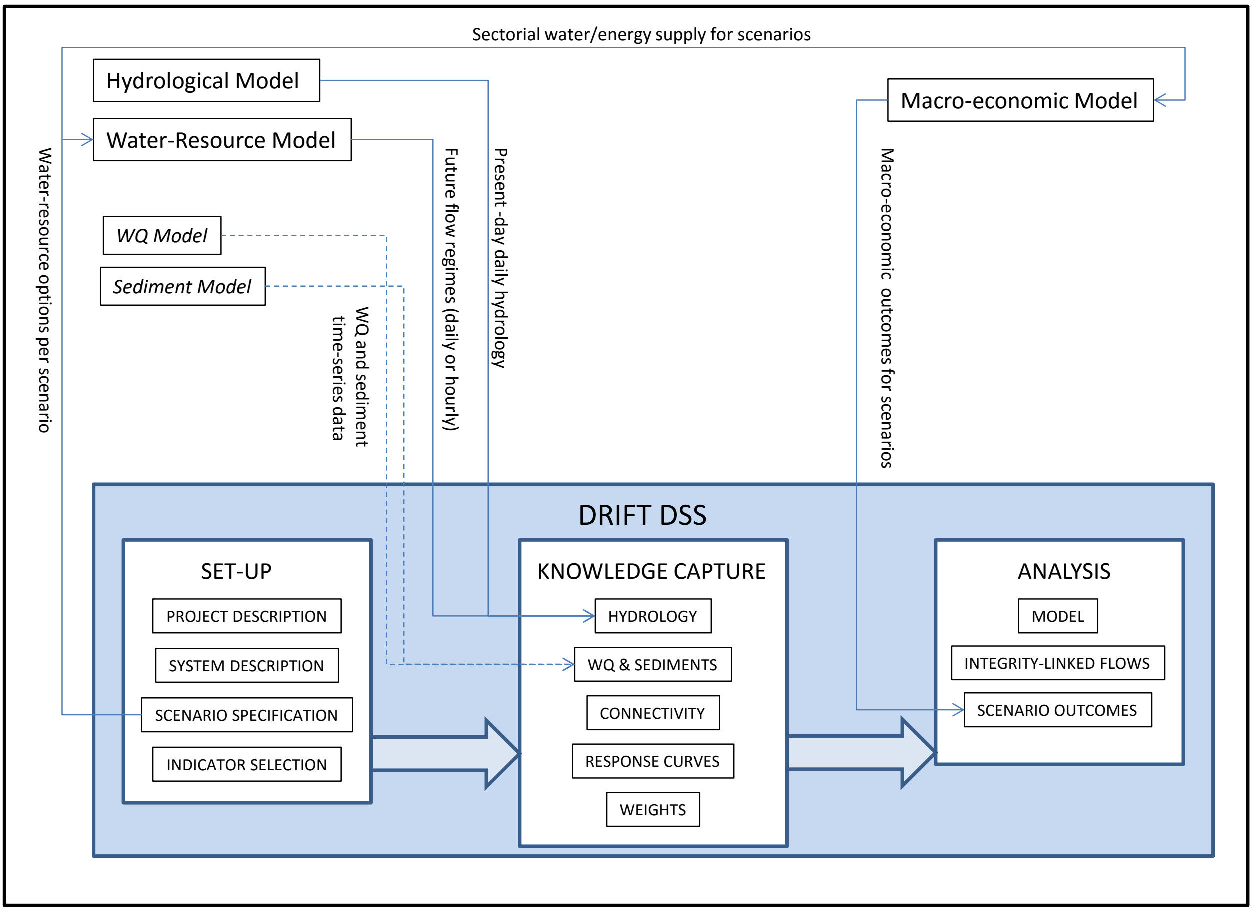


Appendix Figure 1 Screen shot of DRIFT map page showing a portion of the study area.

The DRIFT DSS is divided into three sections, each dealing with a different stage in the EWR determination process. These are (Brown *et al*. 2013; Appendix Figure 2):

- Set-up
- Knowledge Capture
- Analysis.

The first two sections deal with the population of the DSS and the calibration of the relationships that will be used to predict the ecosystem response to changes in flows. The third section is used to generate results once the first two sections have been populated, and to produce the reports and graphics detailing the predictions for the scenarios under consideration.



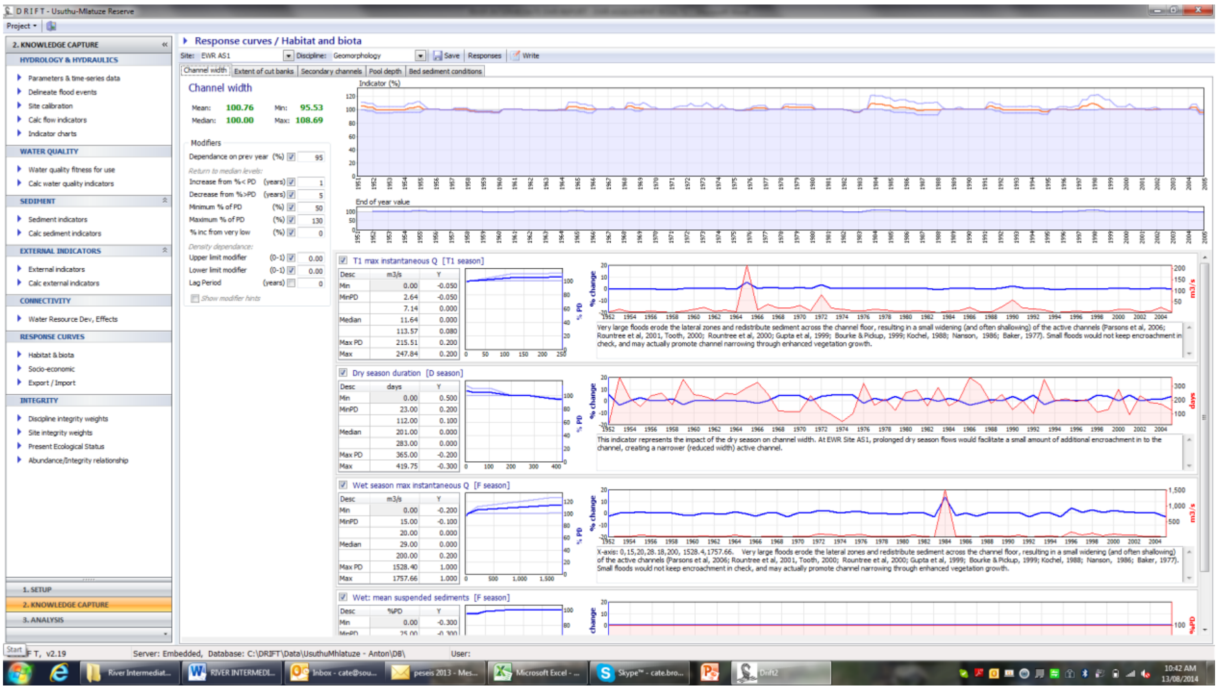
Appendix Figure 2 Arrangement of modules in the DRIFT-DSS and inputs required from external models.

All hydrological modelling is done outside of the DSS. The DSS is dependent on the outputs of two external models, namely:

1. an Hydrological Model used to provide baseline basin hydrology; and
2. a Water Resource Model used to predict the changes in the flow regime associated with the existing and proposed water-resource developments under the various scenarios.

These aspects are covered in the Hydrology and Scenario Reports, respectively.

The module groups in the DRIFT DSS and external models are shown in Appendix Figure 2, and an example of the DRIFT-DSS Response Curves entry datasheet for geomorphology, showing Assegaai (EWR Site AS1) data is shown in Appendix Figure 3. Additional detail on the DSS, including a User Manual, is available in Brown *et al.* (2013).



Appendix Figure 3 Example of the DRIFT-DSS Response Curves entry datasheet for fish, showing Assegaai (EWR Site AS1) data.

A.2 Summary of DRIFT Process

DRIFT (Downstream Response to Imposed Flow Transformations; King *et al.* 2003) was used to evaluate different water management scenarios for the reaches represented by the EWR sites in the study area, *inter alia*, the following reasons:

1. It is a holistic interactive method, which provides the biophysical consequences for the downstream river for various scenarios of flow change. These scenarios can then be used to determine the impact of proposed operating rules for the dam, and possible mitigation thereof.
2. It is a published method (King *et al*. 2003), with a detailed User Manual (Brown *et al., 2*008), and as such is has been peer reviewed.
3. It has been widely applied in the Southern African Development Community, such as Lesotho (King *et al*. 2003), Mozambique (Beilfuss and Brown, 2010; Southern Waters 2011), Namibia (Southern Waters 2010), Peru (Norconsult and Southern Waters 2011), South Africa (e.g. Brown *et al*., 2006), Tanzania (PBWO/IUCN 2008), Zimbabwe (Brown 2007) and Sudan (Southern Waters 2009). It was used as the basis of a basin-wide EF assessment in the Okavango River Basin (Angola, Namibia and Botswana; King and Brown 2009), and has been used in Pakistan on the Neelum-Jhellum River (Southern Waters and Hagler-Bailly Pakistan 2013).
4. It is based on Response Curves constructed from any relevant knowledge including expert opinion and local wisdom and as such is suitable for use in regions where there are few biophysical data available for the flow-related aspects of the rivers, as was the case for the rivers in the study are.

5. It aims to provide an objective and transparent assessment of the effects of changes in flow on the downstream environment based solely on structured consideration of the biophysical aspects thereof.

DRIFT is 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 discipline-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.

In DRIFT, the long-term daily-flow time-series is partitioned into parts of the flow regime that are thought to play different roles in sculpting and maintaining the river ecosystem, such as the onset of important flow seasons, which may affect breeding cycles, or the magnitude of the annual flood, which may inundate a floodplain. This makes it easier for ecologists to predict how changes in the flow regime could affect the ecosystem. The 'parts' of the flow regime used in DRIFT are called flow indicators. In this project, these included (see Volume 2 for actual indicators used by individual specialists):

- Seasonal/daily variations
- Dry season onset
- Dry season minimum 5-day discharge
- Dry season duration
- Dry season average daily volume
- Wet season onset
- Wet season minimum 5-day discharge
- Wet season duration
- Wet season flood volume
- Wet season instantaneous discharge
- Number of Class 1 – 8 floods.

The variability of the flow regime in timing and magnitude, both in its natural state and in any future scenario, was captured automatically through instructions within the hydrological module of the DSS that identify the flow indicators year-by-year. Thus, for the study rivers, the time-series are made up of annual time-series of each flow indicator for the c. 50 years of flow record. This means the specialists can consider a response to a condition for a particular time-step rather than thinking of an averaged response over several years. They can also use data from a particular year or season to calibrate time-series responses.

The study process was structured as follows:

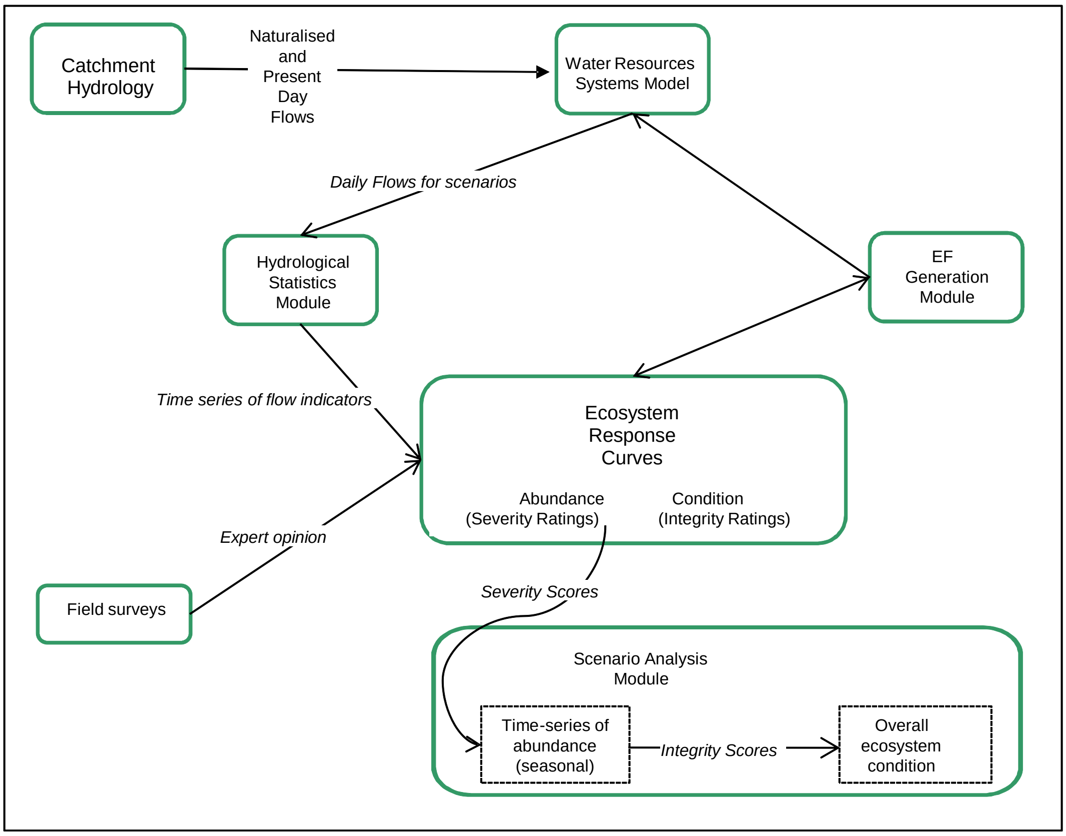
1. The study focused on eight EWR sites within the study area (Section 3.2).
2. The flow changes that were evaluated encompass a mixture of:
    i. Changes in magnitude.
    ii. Changes in duration.

   iii. Changes in timing (e.g., delayed onset of wet season or range of hourly discharge fluctuations).

3. Specialists provided opinion on the consequences of these changes in the form of Response Curves. The disciplines represented were:
   i. Hydraulics
   ii. Geomorphology
   iii. Water quality
   iv. Riparian vegetation and algae
   v. Invertebrates
   vi. Fish.
4. The database was used to evaluate
   i. changes in individual aspects of the ecosystem (e.g. fish, vegetation), for each site and scenario;
   ii. changes in the overall condition of the river, for each site and scenario.
5. The outputs of the DRIFT database are written up in Sections 8 to 23.

The basic sequence of activities in the DRIFT DSS can be summarised as follows (Appendix Figure 4):

1. Collect data for the study at the river.
2. Augment with expert knowledge for similar river systems and a global understanding of river functioning.
3. Construct relationships for the expected response of individual ecosystem indicators to changes in aspects of the flow regime (Response Curves).
4. Use Response Curves to predict time-series of abundance changes.
5. Adjust the severity ratings to integrity ratings by assigning a negative sign for a move away from the natural ecosystem condition and a positive for a move towards natural.
6. Model future changes in catchment hydrology.
7. Calculate annual flow indicator time-series.
8. Use Response curves to calculate severity scores and develop time-series of change in abundance for ecosystem indicators.
9. Calculate average severity score for each indicator for entire hydrological time-series.
10. Convert severity scores to Integrity Scores to predict overall ecological condition.



Appendix Figure 4 Flow chart of DRIFT process

A.1. RESPONSE CURVES[16]

Response Curves depict the relationship between a biophysical or socio-economic indicator and a driving variable (e.g., flow). In this EWR assessment, Response Curves linked an indicator to any other indicator deemed to be driving change. The aim is not to ensure that every conceivable link is captured but rather to restrict the linkages to those that are most meaningful and can be used to predict the bulk of the likely responses to a change in the flow or sediment regimes of the river.

Response curves are constructed using severity ratings (Section A.2).

The full set of Response Curves for this study are provided in Volume 2.

The number of Response Curves constructed for an EWR assessment depends on the level of detail at which a flow assessment is done. In this assessment, the specialists collectively completed c. 250 Response Curves for EWR Site AS1. These were used to evaluate scenarios by taking the value of the flow indicator for any one scenario and reading off the resultant value for the biophysical indicators from their respective Response Curves. Once

[16] The bulk of this section is taken from Joubert *et al*., 2009.

this had been done the database combined these values to predict the overall change in each biophysical indicator and in the overall ecosystem under each scenario.

A.1.1. CONSTRUCTION OF THE RESPONSE CURVES

The Response Curves used in this project were constructed at two specialist workshops held in Pretoria. Additional calibration was also done by individual specialists after the workshop.

The final curves and explanations for their shape are contained in the DRIFT DSS, and addressed in Volume 2.

A.1.2. RESPONSE CURVES AND CUMULATIVE CHANGE

The time-series approach means that the Response Curves are used to predict the likely seasonal change in an ecosystem indicator in response to the flow/sediment conditions experienced in that, or possibly preceding, seasons. For instance, the kind of question typically asked to facilitate setting the dry season discharge Response Curve for *Amphilius uranoscopus* are:

- "If the dry season discharge declines from baseline values, what will be the consequences for the abundance of *Amphilius uranoscopus*?":
- Do *Amphilius uranoscopus* use the main river in the dry season?
- Do *Amphilius uranoscopus* abundances change noticeably over the climatic range covered in the baseline, i.e., are they noticeably more abundant in wet years than in dry years, or vice versa?
- What kinds of habitat do adult *Amphilius uranoscopus* use in the main river?
- Do *Amphilius uranoscopus* breed in the dry or wet season?
- Do they breed in the main river or in the tributaries?
- Where do *Amphilius uranoscopus* lay their eggs?
- What sorts of habitat do fry, fingerlings and juvenile trout use in the main river?
- At what discharge(s) does the favoured habitat(s) disappear?
- What is the consequence of these habitats not being available for one season?
- If discharge reaches zero for one season, are there pools that the trout will be able to survive in?
- Can the *Amphilius uranoscopus* survive for a dry season in pools?
- Is water temperature a concern, i.e., would summer temperature be an issue for *Amphilius uranoscopus* if discharge dropped?
- What do *Amphilius uranoscopus* adults/juveniles/fingerlings/fry eat?
- How will the food base be affected by changes in dry season lowflows?
- Etc.

Often, a species (such as *Amphilius uranoscopus* will be expected to survive even an extremely-dry dry season, with possibly only minor changes (20-30%) in overall abundance if dry season flows drop to zero. If, however, the flows drop to this level in the dry season year after year, then the cumulative effect on trout populations is likely to be far greater. The time-series enable the DSS to capture this cumulative effect.

A.2. SCORING SYSTEM USED

Into the foreseeable future, predictions of river change will be based on limited knowledge. Most river scientists, particularly when using sparse data, are thus reluctant to quantify predictions: it is relatively easy to predict the nature and direction of ecosystem change, but more difficult to predict its timing and intensity. To calculate the implications of loss of resources to subsistence and other users in order to facilitate discussion and trade-offs, it is nevertheless necessary to quantify these predictions as accurately as possible.

Two types of information are generated for each biophysical indicator, *viz*.:

- Severity ratings, which describe increase/decreases for an indicator in response to changes in the flow indicators, and;
- Integrity ratings, which indicate whether the predicted change is a move towards or away from natural, i.e., how the change influences overall ecosystem condition.

The severity ratings are used to construct the Response Curves. The Integrity ratings are used to describe overall ecosystem condition/health.

A.2.1. SEVERITY RATINGS

The severity ratings comprise 11-point scale of -5 (large reduction) to +5 (very large change; Brown *et al*., 2008; Appendix Table 1), where the + or – denotes a increase or decrease in abundance or extent. These ratings are converted to percentages using the relationships provided in Appendix Table 1. The scale accommodates uncertainty, as each rating encompasses a range of percentages; however, greater uncertainty can also be expressed through providing a range of severity ratings (i.e. a range of ranges) for any one predicted change (after King *et al.*, 2003).

Note that the percentages applied to severity ratings associated with gains in abundance are strongly non-linear[17] and that negative and positive percentage changes are not symmetrical (Appendix Figure 5; King *et al*. 2003).

Appendix Table 1 DRIFT severity ratings and their associated abundances and losses – a negative score means a loss in abundance relative to baseline, a positive means a gain

Severity rating	Severity	% abundance change
5	Critically severe	501% gain to ∞ up to pest proportions
4	Severe	251-500% gain
3	Moderate	68-250% gain

[17] The non-linearity is necessary because the scores have to be able to show that a critically-severe loss equates to local extinction whilst a critically severe gain equates to proliferation to pest proportions.

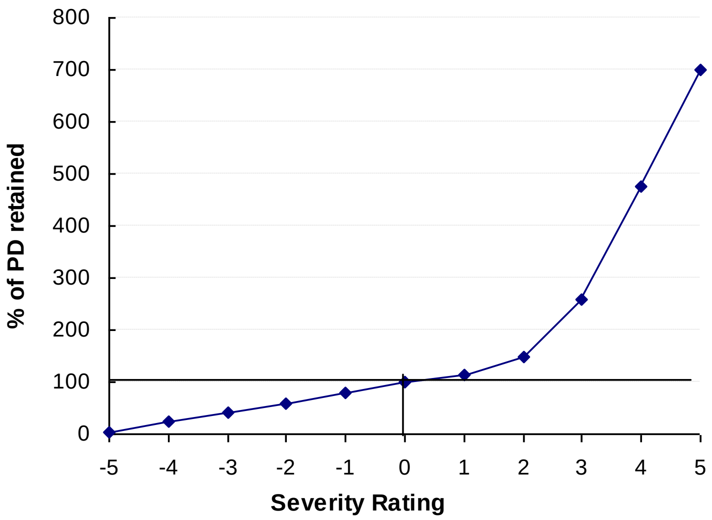
2	Low	26-67% gain
1	Negligible	1-25% gain
0	None	no change
-1	Negligible	80-100% retained
-2	Low	60-79% retained
-3	Moderate	40-59% retained
-4	Severe	20-39% retained
-5	Critically severe	0-19% retained includes local extinction

For each year of hydrological record, and for each ecosystem indicator, the severity rating corresponding to the value of a flow indicator is read off its Response Curve. The severity ratings for each flow indicator are then combined to produce a severity score, which provides an indication of how abundance, area or concentration of an indicator is expected to change under the given flow conditions in each year, relative to the changes that would have been expected under baseline conditions in the catchment.

A.2.2. INTEGRITY RATINGS

Integrity ratings use the absolute value of between 0 and 5 provided for the severity scores but include a negative or positive sign, depending on whether the change in abundance predicted by the severity score represents a shift to/away from naturalness, *viz*. (Brown and Joubert 2003):

- *toward natural* ecosystem condition is represented by a positive integrity rating; and
- *away from natural* ecosystem condition is represented by a negative integrity rating.



Appendix Figure 5 The relationship between severity ratings (and severity scores) and percentage abundance lost or retained as used in DRIFT and adopted for the DSS. (PD=present day AND = 100%)

The integrity ratings are calculated using the average severity score for each ecosystem indicator over the entire hydrological time-series. The integrity ratings for each indicator are then combined to provide an Overall Integrity Score, which is used to place a flow scenario within a classification of overall river condition, using the South African eco-classification categories A to F (Appendix Table 2; Kleynhans 1996; Kleynhans 1999; Brown and Joubert 2003). The ecological condition of a river is defined as its ability to support and maintain a balanced, integrated composition of physico-chemical and habitat characteristics, as well as biotic components on a temporal and spatial scale that are comparable to the natural

characteristics of ecosystems of the region. For instance, if the present ecological status (PES) of a river is a B-category, a scenario that yields a negative Integrity Score would represent movement in the direction of a category C-F, whilst one with a positive score would indicate movement toward a category A, as follows:

If the Overall Integrity Score is positive, this denotes a move toward natural, i.e. restoration initiatives:

- ≤1 or ≥-1, the ecological condition will remain within the same category as present day/baseline;
- >1 and ≤2, the ecological condition will move one category closer to natural;
- >2 and ≤3, the ecological condition will move two categories closer to natural;
- Etc.

Appendix Table 2 Definitions of the Present Ecological State (PES) categories (after Kleynhans 1996).

Ecological category	Description of the habitat
A	Unmodified. Still in a natural condition.
B	Slightly modified. A small change in natural habitats and biota has taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. Loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically / Extremely modified. The system has been critically modified with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible.

If the Overall Integrity Score is negative, this denotes a move away from natural:

- ≥-1, the ecological condition will remain within the same category as present day;
- <1 and ≥ 2, the ecological condition will move one category further away from natural;
- <2 and ≥ 3, the ecological condition will move two categories further away from natural;
- Etc.

Note: In South Africa, the D-category is considered to represent the lower limit of degradation allowable under sustainable development (e.g., Dollar et al. 2006; Dollar *et al*. 2010).

Overall Integrity Scores are calculated for the ecosystem as a whole, i.e., the combined effect of changes in the indicators. The results can be plotted as Overall Integrity Score (y-axis) vs. percentage or volume of MAR (x-axis) or, where there are relatively few points as in this project, simply as a plot of Overall Integrity Scores per site, which allows for easy comparison between sites. The categories actually represent points along a continuum, thus the 'divisions' between the categories are only guides as to the general position at which the ecological condition might be expected to shift from one category to the next. They provide an indication of the relative categories associated with each scenario and should not be misconstrued as an absolute prediction of future condition.

A.3. IDENTIFICATION OF ECOLOGICALLY-RELEVANT ELEMENTS OF THE FLOW REGIME

One of the main assumptions underlying the DRIFT process is that it is possible to identify ecologically-relevant elements of the flow regime and isolate them within the historical hydrological record. Thus, one of the first steps in the DRIFT process is to identify the ecologically-important flow indicators, which are calculated per season for each year. The rules and thresholds for defining the seasons in the study area are given in Section 4, and the list of flow indicators provide to specialists for their use are provided in Table 6-1.

A.4. MAJOR ASSUMPTIONS AND LIMITATIONS OF DRIFT

Predicting the effect of flow changes on rivers is difficult because the actual trajectory and magnitude of the change is additionally dependent on so many other variables, such as climate, sediment supply and human use of the system. Thus, several assumptions underlie the predictions. Should any of these assumptions prove to be invalid, the actual changes may not match the predicted changes. This does not necessarily make the predictions themselves incorrect or invalid, but simply means that the surrounding set of circumstances that support the predictions has changed.

The following important major assumptions apply:

- The baseline hydrology closely approximates the actual flow conditions in the river over the period of record.
- Different parts of the flow regime sustain the river ecosystem in different ways. Changing one part of the flow regime will change the river in a different way than will changing another part.
- It is possible to identify ecologically-relevant elements of the flow regime and isolate them within the historical hydrological record (see Section A.3)
- Present day flows (c. 1954 – 2004/10) were used as the baseline flow for predicting change, and change was expressed as a percentage move towards or away from the baseline.
- Changes include flow and non-flow related changes.
- Predicted changes in ecological status are relative to the baseline ecological state (2014).
- Predictions are based on a *c*. 50-year horizon.

The main limitation is the paucity of data. This is a universal problem, as ecosystems are complex and we will probably never have complete certainty of their present and possible future characteristics. Instead it is essential to push ahead cautiously and aid decision-making, using best available information. The alternative is that water resource development decisions are made without consideration of the consequences for the supporting ecosystems, eventually probably making management of sustainability impossible. Data paucity is addressed in the DRIFT process by accessing every kind of knowledge available - general scientific understanding, international scientific literature, local wisdom and specific data from the river under consideration or from similar ones – and capturing these in a structured process that is transparent, with the DSS inputs and outputs checked and approved at every step. The Response Curves used (and the reasoning used to construct them) are available for scrutiny within the DSS and they, as well as the DRIFT DSS, can be updated as new information becomes available.

A second aspect of the paucity of data is that it is neither known what the river was like in its pristine condition nor exactly how abundant each ecosystem aspect (sand bars, fish, etc.) was then or is now. To address this, all DRIFT predictions are made relative to the baseline situation (there will be a little more, or a lot less, than today, and so on), as explained further below.

These inherent uncertainties also mean that the trends and relative position of the scenarios are more reliable predictors of the impacts of the scenarios than are their absolute values. Also, DRIFT is designed to predict overall condition, and focusing on one indicator to the exclusion of others is not recommended.

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Appendix B. ACRU/WR2012 HYDROLOGICAL DATA

The hydrological simulations for influent catchments for the St Lucia estuarine system were prepared using the ACRU model (Smithers and Schulze 2004; as per the Inception Report RDM/WMA6/CON/COMP/0113). This was done to ensure compatability between the river hydrology and that required for the St Lucia Estuarine EWR, and was mainly related to need to deliver daily sediment load sequences for the various catchment scenarios required for the the hydrodynamic modelling of the Lake St Lucia System (Hydrology Report_Report No. RDM/WMA6/CON/COMP/1013).

Thus the EWRs for Mfolozi (BM1, BM2, WM1) and Mkuze (MK1) were determind using ACRU-generated hydrological sequences.

Queries related to the use of ACRU, and its relationship to WR2012 hydrological data for those catchments were raised at the PSC meeting in August 2015, and resulted in discussion between the study team and the Client on the best way to address these. The main two outcomes of this process were:

1. A letter from Tlou Consulting and the relevant sub-consultants explaining the reasoning behind the use of ACRU.
2. A comparison between the EWRs for ACRU generated data and WR2012 data, which had two motives:
    a. to document the actual differences between the EWRs generated using these two sets of data, and;
    b. to provide WR2012-corrected EWRs in the event that these were required in later studies.

Both of these outcomes are presented in this appendix.

B.1. LETTER FROM TLOU CONSULTING AND THE RELEVANT SUB-CONSULTANTS EXPLAINING THE REASONING BEHIND THE USE OF ACRU

21 October 2015
Our ref. P12273/4.1

Mr Y Atwaru
Director: Aquatic Ecosystems
Chief Directorate: Resource Directed Measures
Private Bag X313, Pretoria, 0001

Dear Mr Atwaru

RESERVE DETERMINATION STUDIES OF SELECTED WATER RESOURCES IN USUTU TO MHLATUZE WMA: HYDROLOGICAL MODEL USED IN THE MFOLOZI AND MKUZE RIVER CATCHMENTS

Queries related to the hydrological model used in the EWR assessments for the rivers and planned use in the St Lucia assessment were raised at the PSC meeting in August 2015. In response to the queries, we felt it necessary to document the approach and reasoning for the use of ACRU in the study, in order to obtain guidance from the Client on the way forward.

The use of ACRU for the Mfolozi and Mkuze was discussed with DWS and is outlined in the Inception Report for the study, which was accepted by DWS. Thus, it is our understanding that this request is not an issue of liability, but rather an attempt to find a way to best integrate the results of the Reserve studies with those of ongoing and upcoming development studies.

To this end, we have provided a short comment on the approach adopted for generating the hydrological data used and the reasons therefor. We have then commented on the potential for aligning DRIFT with a different set of hydrology. We have not (as yet) commented on using different hydrological data, partly because the initial reason for using ACRU was to provide the sediment data needed for the St Lucia portion of the study. Thus, changing from this approach has wider implications for the overall study than can be dealt with in this letter.

APPROACH ADOPTED BY AURECON

Aurecon, in liaison with Tlou Consulting and Southern Waters, initially considered disaggregation of WR2005/12 monthly flows to dailies for the Lake St Lucia's inflowing rivers, but realised that the disaggregation approach could not deliver the daily sediment load sequences for the various catchment scenarios that the hydrodynamic modelling of the Lake St Lucia System required. Hence, we decided to calibrate ACRU against flow records for the Mfolozi and the Mkuze for gauging stations that are nearest to the EWR sites, despite general concerns about the quality of observed daily flow records in the region.

The GEF Study had shown that ACRU was generating too much runoff (mainly during flood periods) for these catchments. Therefore, our calibration primarily focused on iteratively reducing the mean annual rainfall (MAP) for the various modelling sub-catchments until a pragmatic balance was achieved between matching the simulated and observed individual flood hydrograph recession limbs, freshets, baseflows, number of near-zero and zero flows (all important for EWR determination) and mean annual runoff (MAR).

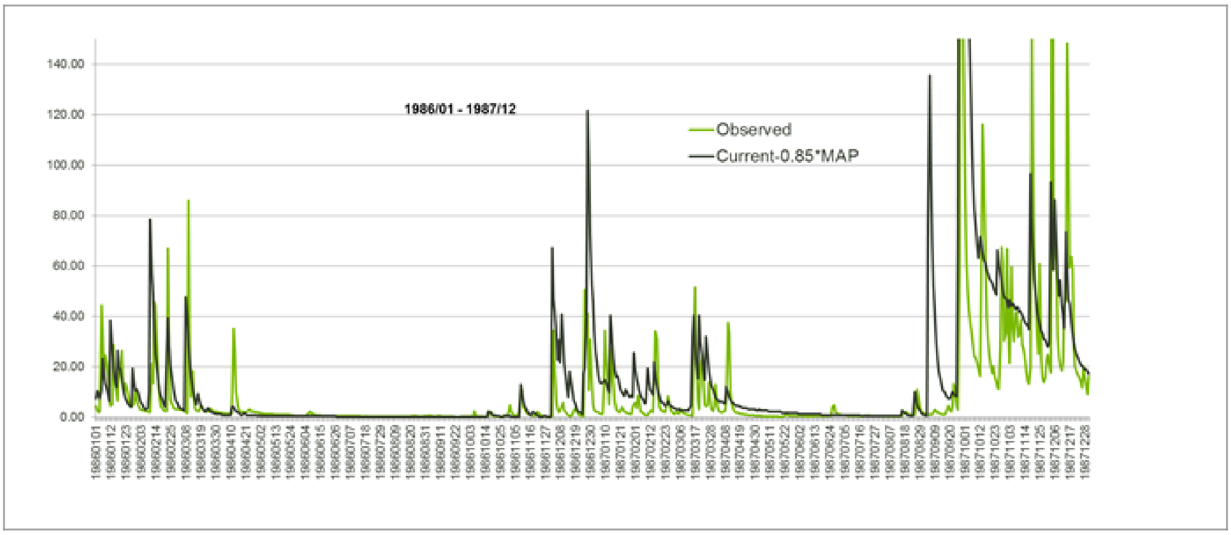
MFOLOZI RIVER

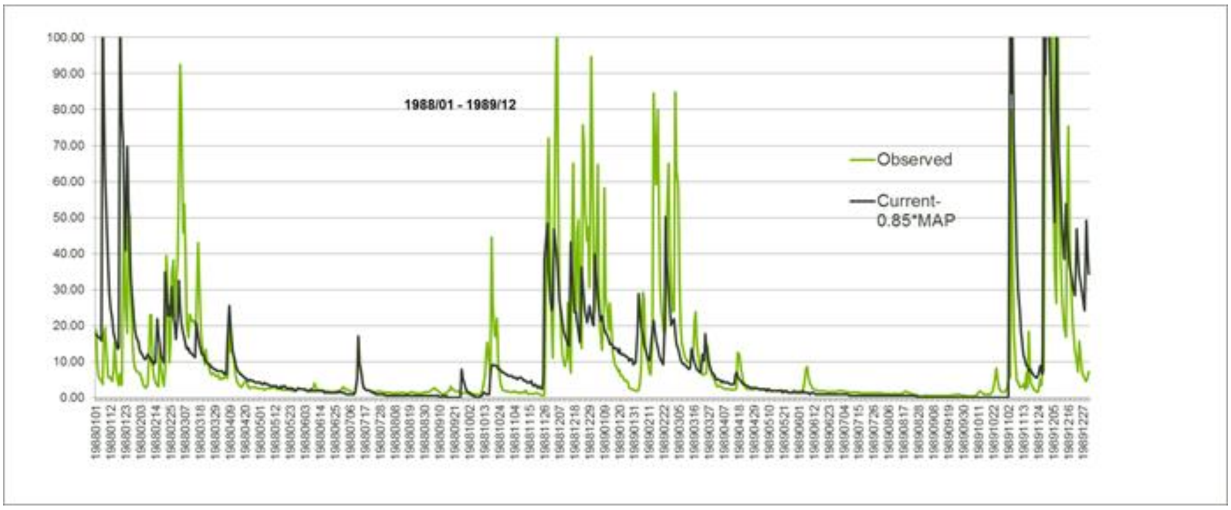
For the calculation of the MAR a sizeable number of days with missing values were removed from both the simulated and observed sequences, but a number of days with rating curve exceedences remained in the sequences. The best balance of matching the above hydrograph characteristics was achieved with the sub-catchment MAPs reduced by a factor of 0.85, resulting in the following MARs:

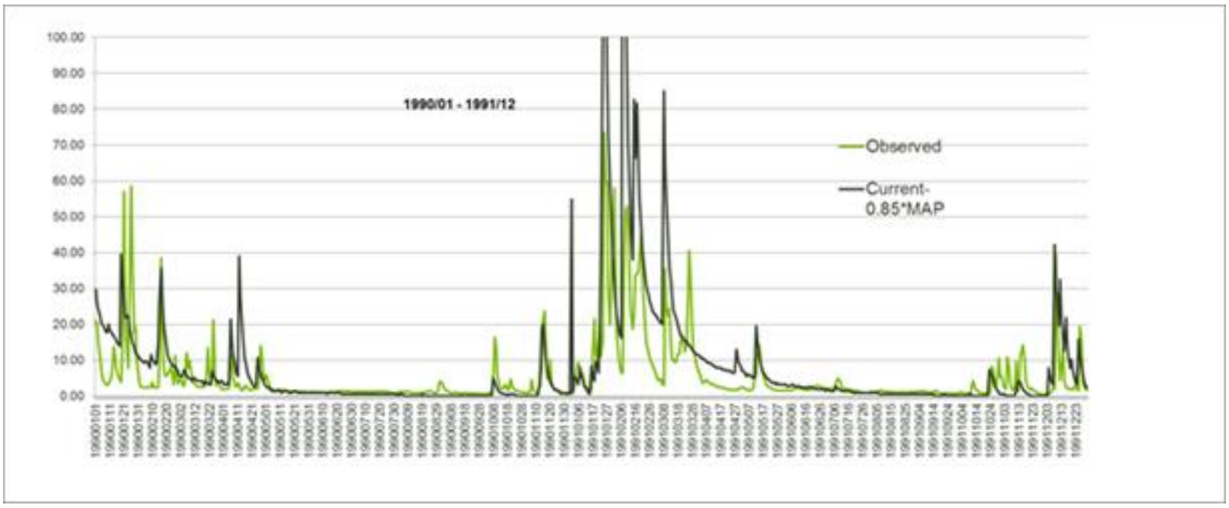
Gauge (1986 – 2010)	Observed (million m^3/a)	Simulated (million m^3/a)
W2H006 (Black)	182	213
W2H005 (White)	255	315

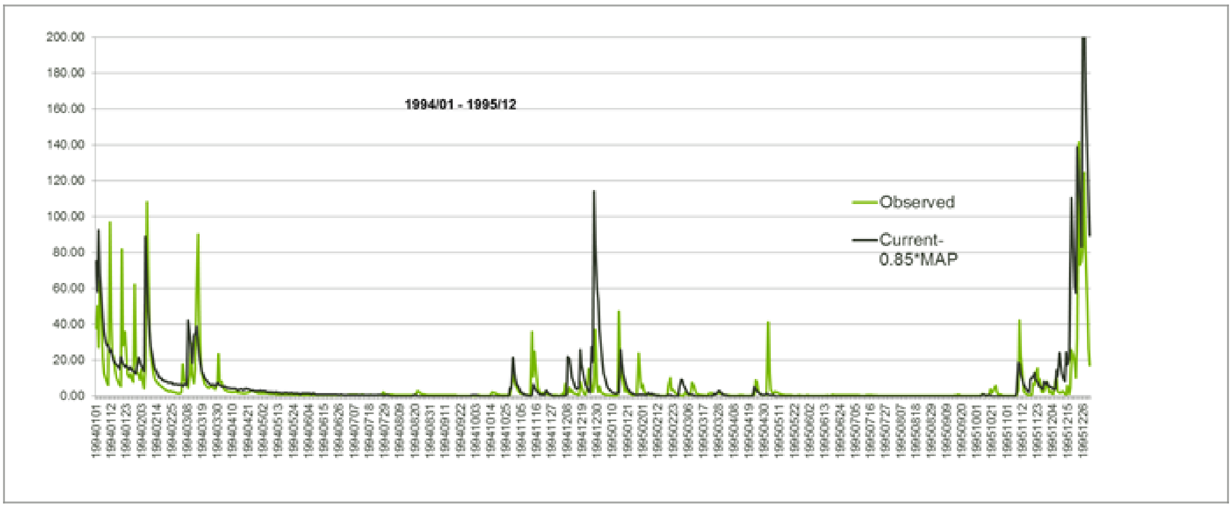
We accepted the over-simulation of the MARs as a pragmatic compromise because this was mainly due to over-simulation during flood periods and because any further reductions in MAPs caused excessive numbers of near-zero and zero simulated flows and generally under-simulated baseflows and freshets. Additionally, it also accounted for the observed flows not fully recorded because of rating curve exceedences. Below follow some graphical comparisons of observed and simulated daily flows (indicated as “current” in the graphs) at the two gauging stations:

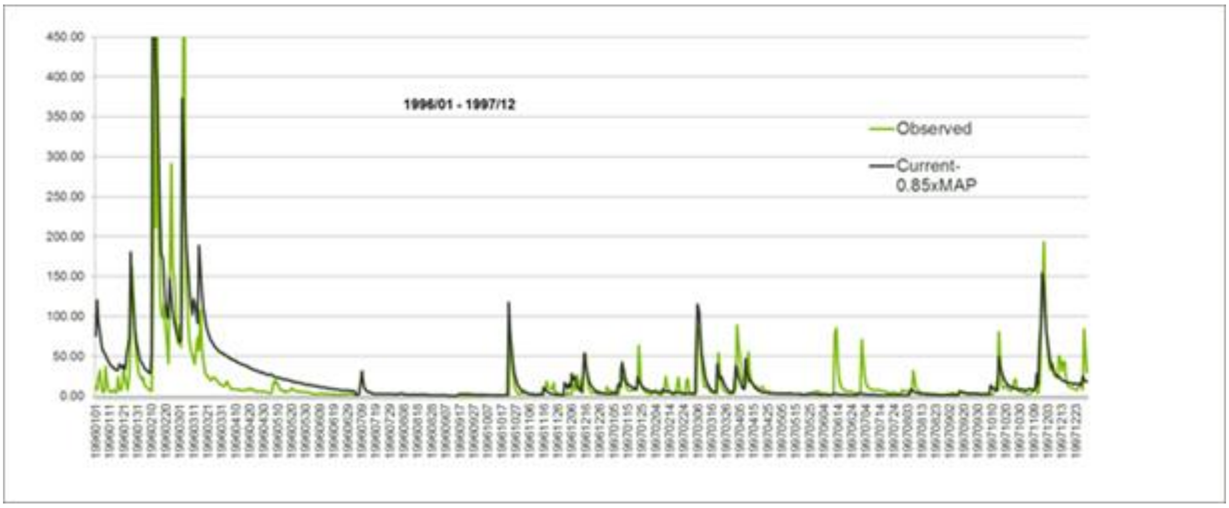
W2H005 (White Mfolozi)



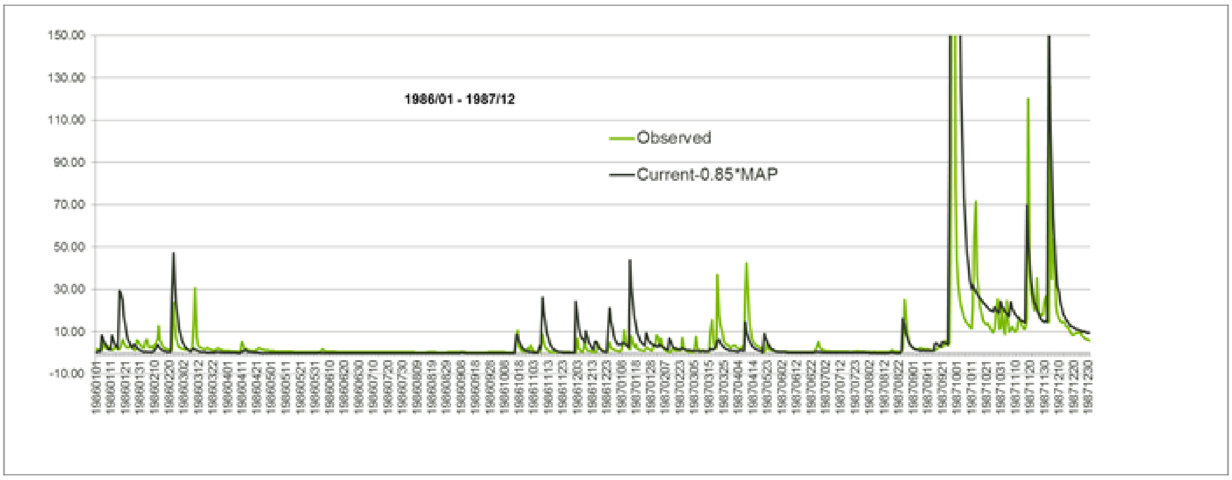

1988/01 - 1989/12
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Observed
Current-
0.85*MAP

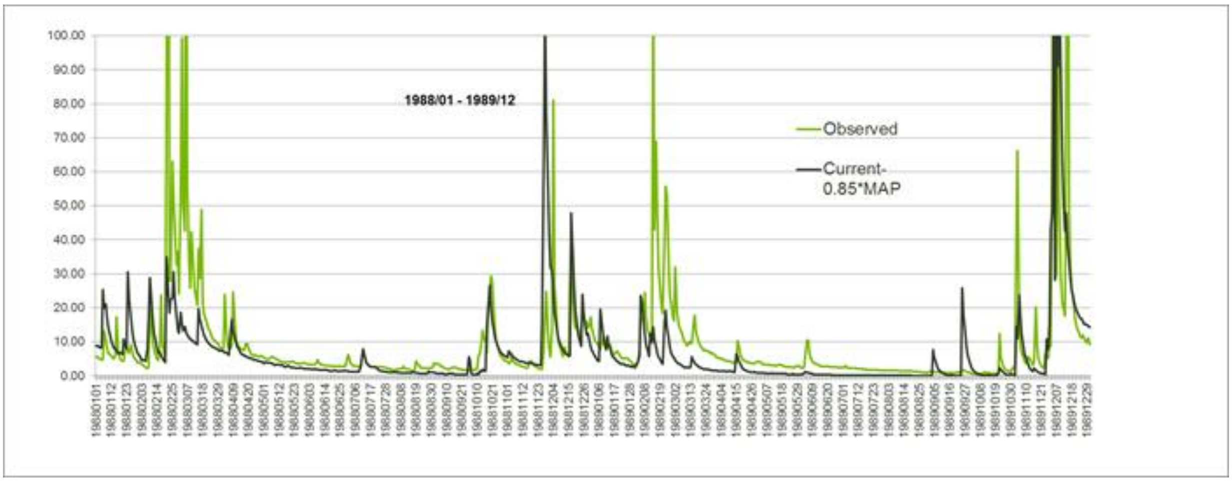

1990/01 - 1991/12
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Observed
Current-
0.85*MAP

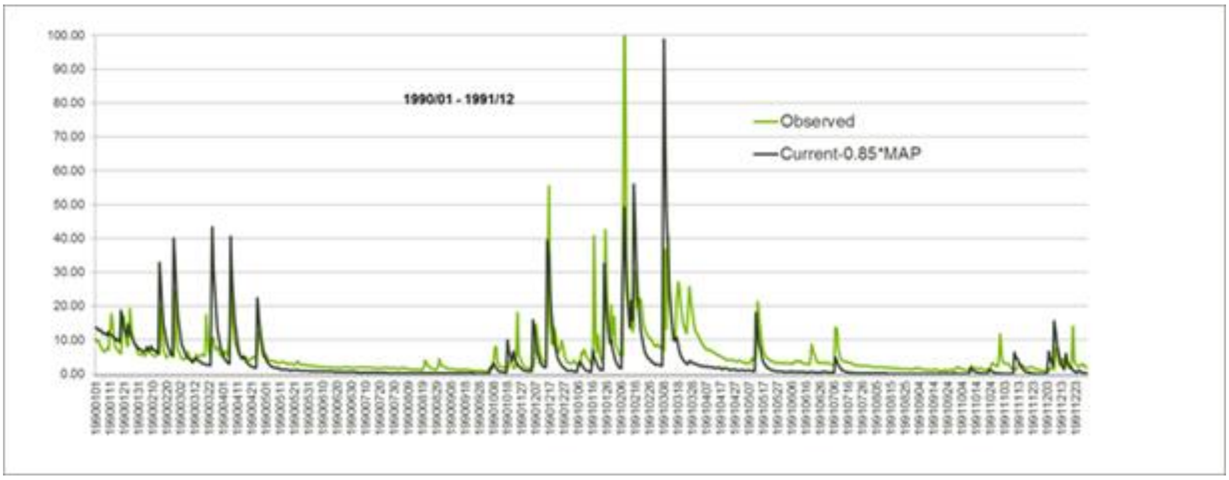

1994/01 - 1995/12
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Observed
Current-
0.85*MAP

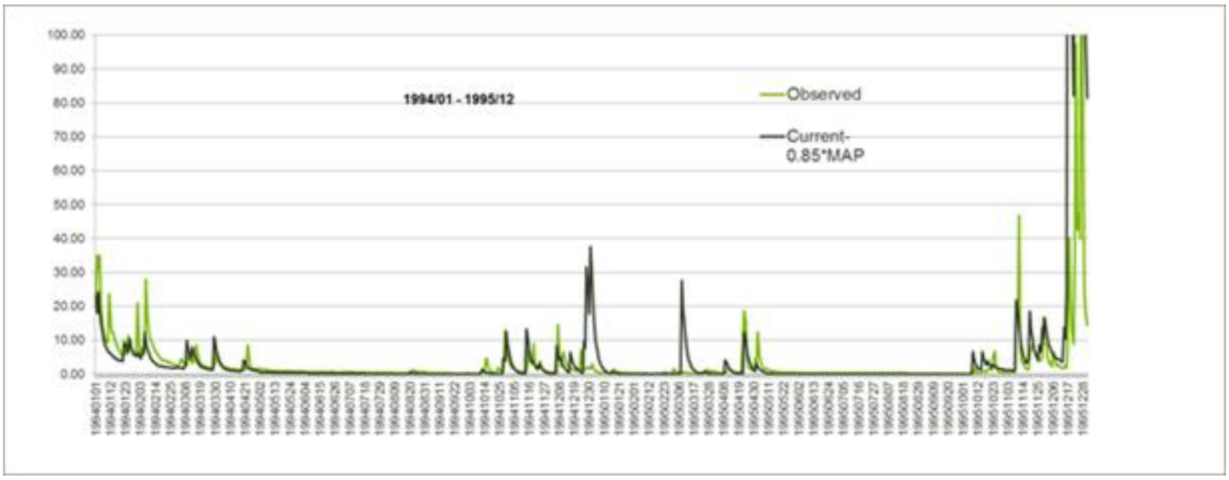


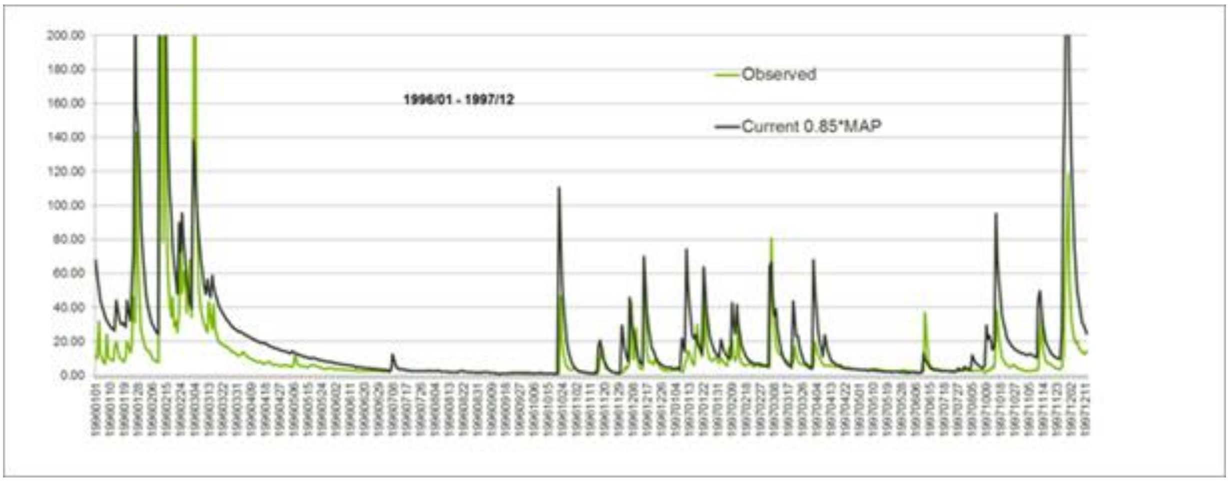
W2H004 (Black Mfolozi)









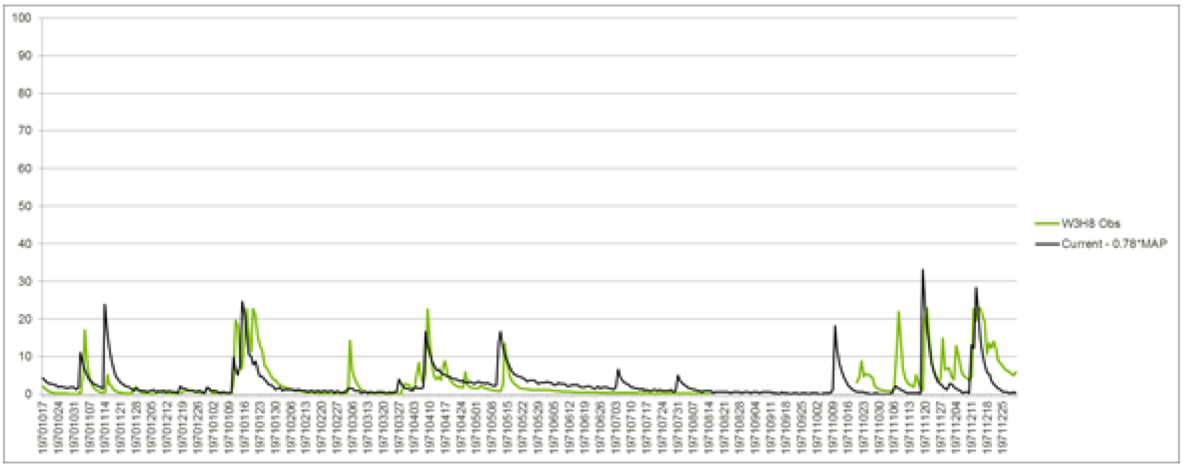


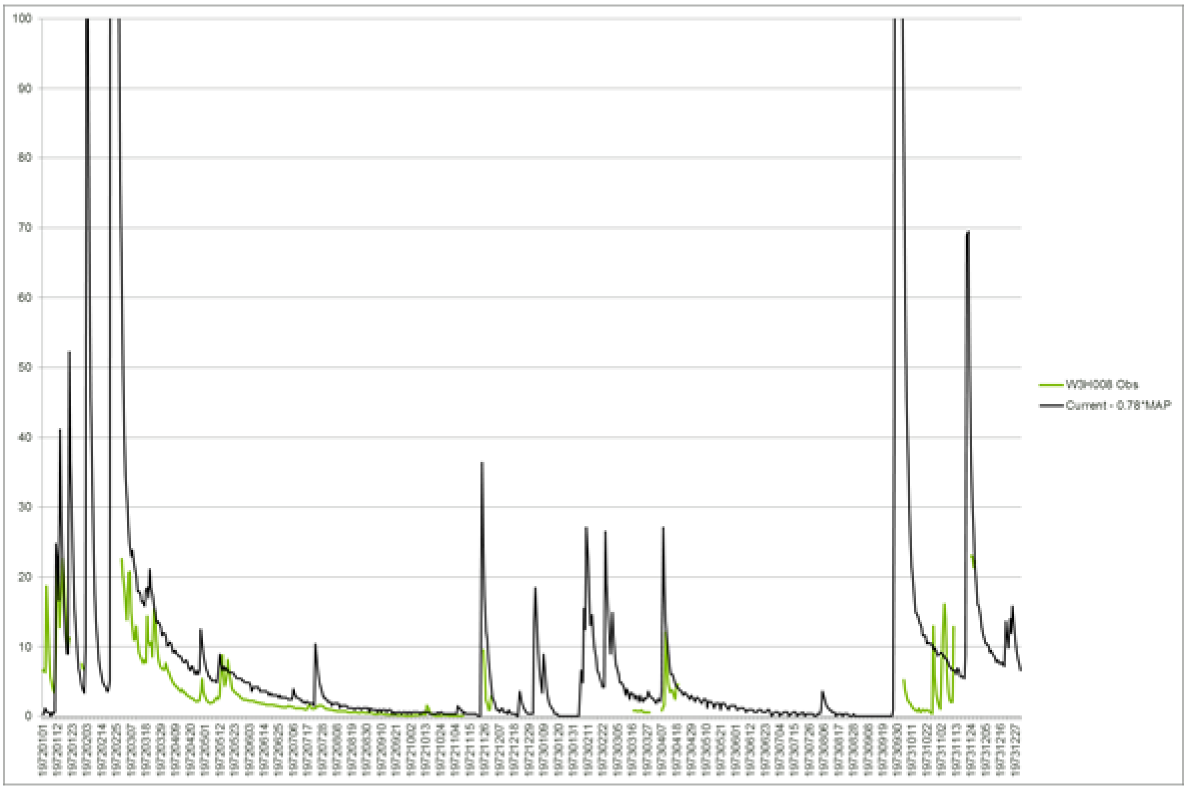
The calibrated ACRU configurations were subsequently used to generate daily flows at the three river EWR sites, and at the Mfolozi mouth. The graphs show that for both gauges the simulated flow periodically dropped to zero. Because the frequency of near-zero and zero simulated flows was unrealistically high, these values were empirically patched before the EWR site flows were passed on to the aquatic ecology team. A few simulated July floods were also reduced because the DWS records did not reflect any high flows in those particular Julys.

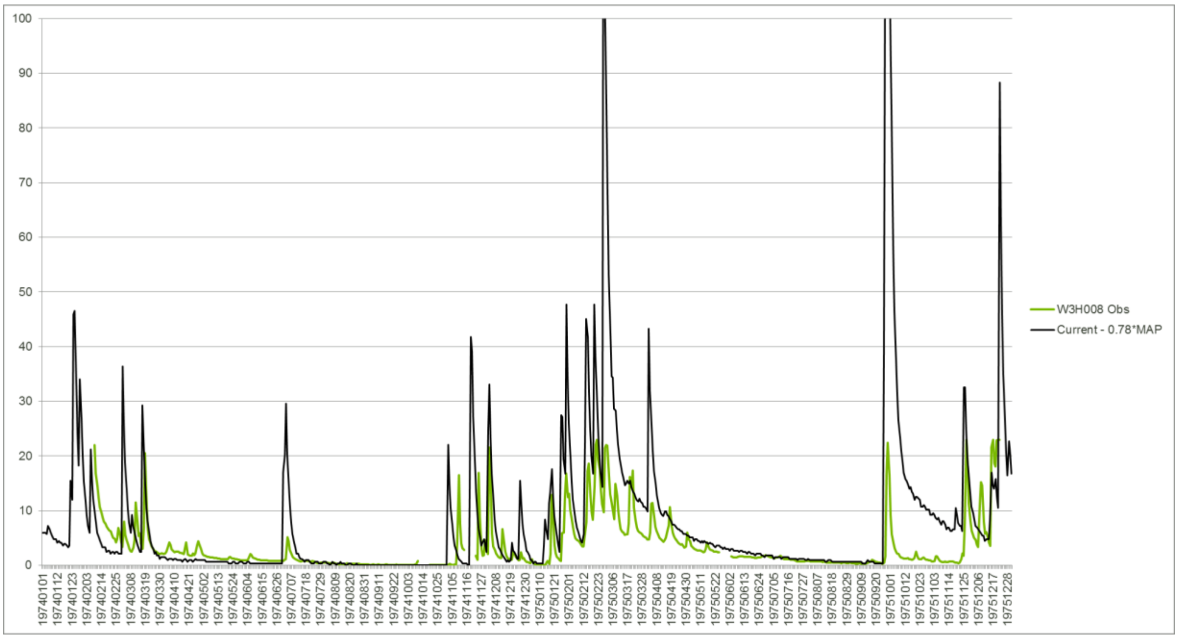
MKUZE RIVER

A broadly similar calibration approach was used for the Mkuze for which the flow record at W3H008 (1965 – 2010, with 26% missing days) was used. The “observed” MAR was a challenge, because the rating equation for this gauge had a low limit of only 23 m^3/s; thus, the number of exceedences was quite significant (718 days in 12433 days). Hence, we estimated the under-recorded part of the MAR as follows: We calculated the mean stage of all exceeded days’ stage values and then calculated the ratio of this mean relative to the rating stage limit as a %. This % was then powered by 1.5 which is a standard power value for a weir discharge equation for a broad-crested weir such as W3H008. The resulting value of 268% represented the extent to which the recorded <u>total</u> flow of the 718 rating exceedence days needed to be increased to account for the under-measurement of flow on rating exceedence days. This result was added to the “recorded” MAR of 91.6 million m^3/a, resulting in an “observed” MAR of 178.6 million m^3/a (missing days removed from both sequences).

We then cross-checked our estimated MAR against the WR2012 MAR of 159.6 million m^3/a for the same period at a site somewhat upstream of this gauge and were comfortable to aim the ACRU calibration at our value of 178.6 million m^3/a. In this calibration process, apart from the MAR, we also focused on the recessions, freshets and baseflows below the rating limit of 23 m^3/s. This calibration process achieved a pragmatic balance between the above hydrograph criteria with the MAPs of the various modelling sub-catchments reduced by the factor of 0.78. The final simulated MAR was 183.6 million m^3/a for the above period. Graphical comparisons of observed and simulated daily flows at W3H008 for the first few years of record are presented below:




100
90
80
70
60
50
40
30
20
10
0
W3H008 Obs
Current - 0.78*MAP


100
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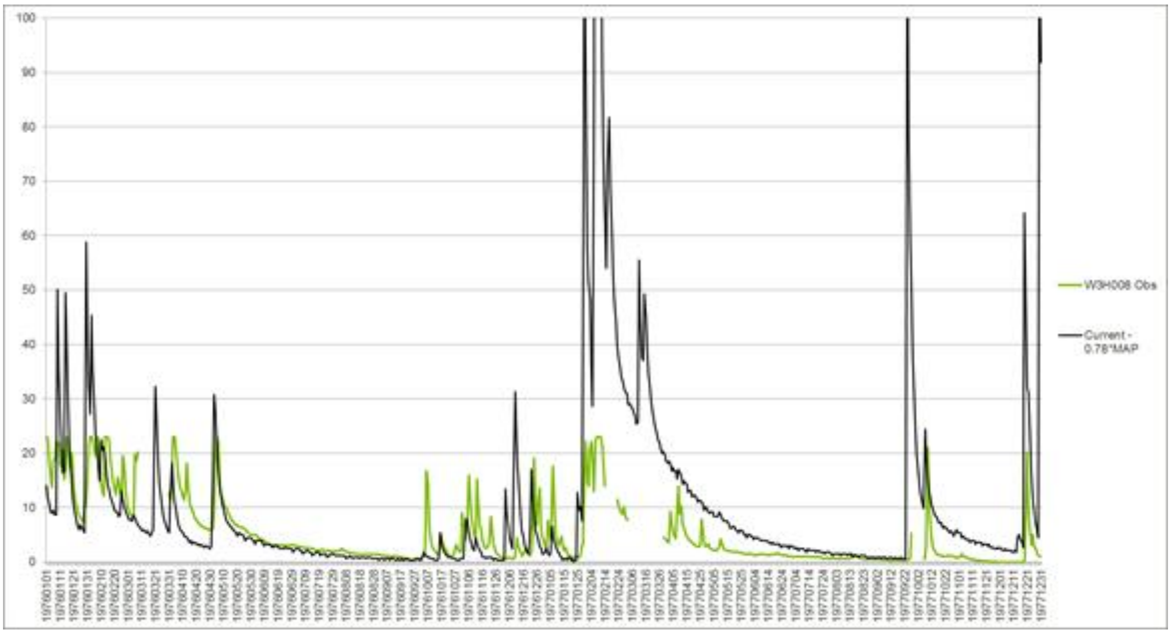
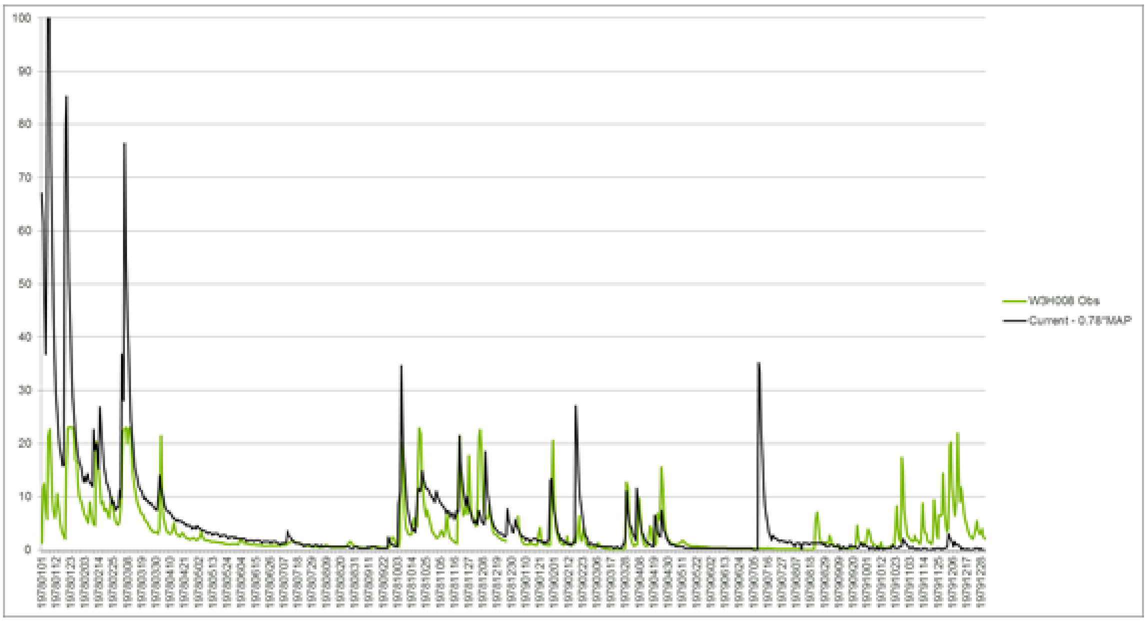
20
10
0
W3H008 Obs
Current - 0.78*MAP





The calibrated ACRU configuration was subsequently used to generate daily flows at the EWR site, on the Mkuze, as well as at the Mkuze's inflow point to the Lake. Near-zero and zero simulated flows for the Mkuze were empirically patched (according to typical baseflow recessions recorded at this gauging station) before the EWR site flows were passed on to the aquatic ecology team.

COMPARISON WITH WR2012

The following table compares the natural MARs according to the ACRU simulations and the WR2012 simulations respectively.

Location	WR2012 Natural MAR (million m^3/a)	ACRU Natural MAR (million m^3/a)	Difference
Black Mfolozi	193	214	+ 11%
Mfolozi at mouth	733	1033	+40%
Mkuze at W3H008	159 (somewhat upstream)	178	+12%
Mkuze inflow to Lake St Lucia	304	273	-10%

POTENTIAL FOR ALIGNING DRIFT WITH A DIFFERENT SET OF HYDROLOGY

The DRIFT DSS that was populated and calibrated for the Reserve determination can, with relative ease, be recalibrated for a different set of daily hydrology. This process should not be too time-consuming or expensive (probably about 5 person-days). However additional time would be required to set up the hydrology for input into the DRIFT DSS. For this purpose WR2012 monthly flows for natural and current-day scenarios can be disaggregated by means of daily flow records for relevant gauges in the Study Area. Such disaggregation would require one person-day. Thereafter, in order to produce daily flows for different future catchment development scenarios, the WR2012 model configurations would need to be adjusted according to the details of each of the scenarios. This would be more time-consuming and a total of 5 person-days should be allowed for the reworking of the hydrology.

The results for the Mfolozi and Mkuze EWR sites were also used in the extrapolation to other nodes in the wider Usuthu-Mthlatuze area, and so this would also require redoing. Again, the process should not take too long (probably about 2 person days for the hydrology and a further 2 person-days for the EWR extrapolation). Redrafting of the report will take a further 2-person days.

ST LUCIA EWR ASSESSMENT

In the Inception Report, the idea was that the St Lucia EWR assessment would be based on the outcome of an Isimangaliso/GEF funded initiative on St Lucia, as much of the data collection and analysis for that project was identical to that required for the EWR assessment. The EWR assessment has just started. As mentioned already, this approach is dependent on the use of the ACRU simulated daily flows and daily sediment loads. Thus, if DWS is likely to require use of a different set of hydrology it may be worth considering postponing the St Lucia EWR assessment until such time as there is more clarity on the hydrology proposed for use, and the technical, time and cost implications of using that instead of the ACRU simulated daily flows that are currently being used. It should also be borne in mind that the St Lucia EWR assessment requires simulated daily sediment loads for the inflowing rivers to the Lake.

GUIDANCE ON WAY FORWARD

We request the DWS provide guidance to the team on the following:

- The need to reassess the EWR for the Mfolozi and Mkuze based on a different set of daily hydrology, acknowledging the time and cost implications to undertake this.
- Proceeding with the St Lucia EWR assessment, using the ACRU hydrology, or postponing the EWR assessment until there is clarity on the hydrology proposed for use. The latter having technical, time and cost implications.

Yours faithfully

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ADHISHRI SINGH
PROJECT LEADER

B.2. A COMPARISON BETWEEN THE EWRS FOR ACRU GENERATED DATA AND WR2012 DATA FOR THE MFOLOZI RIVER

This section provides a comparison between the EWRs for REC generated at EWR Sites BM1, BM2 and WM1, using ACRU data and using WR2012 data. The EWR tables for the WR2012 generated EWRs are also provided here. Those for the ACRU data are provided in Sections 19.3.1, 20.3.1 and 21.3.1, respectively.

B.2.1. BLACK MFOLOZI (BM1) RECOMMENDED ECOLOGICAL CATEGORY_C

The summary statistics for the EWR generated using ACRU data are:

MAR	31.784 MCM
S.Dev.	3.916
CV	0.123
Q75	0.719212963
Total IFR	9.568 (30.10% nMAR; excl. >=1:2 year return flood events)
Maint. Lowflow	2.910 (9.16% nMAR)
Drought Lowflow	1.143 (3.58 % nMAR)
Maint. Highflow	6.658 (20.95 % nMAR)

The summary statistics for the EWR generated using WR2012 data are:

Annual Flows (Mill. cu. m or index values):

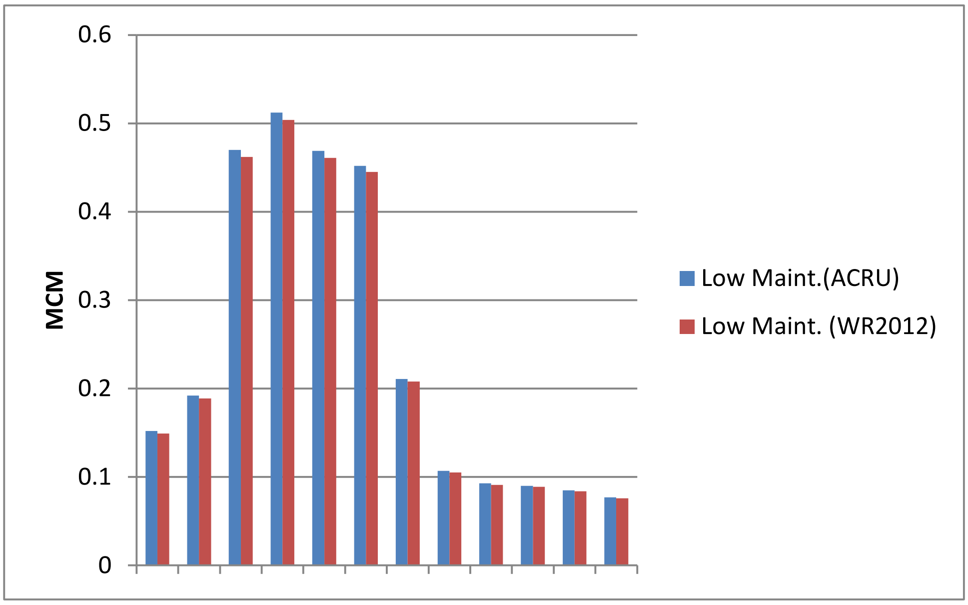
nMAR	31.261 MCM
S.Dev	21.654
CV	0.693
Q75	0.610

Total IFR	9.411 (30.10 % nMAR; excl. >=1:2 year return flood events)
Maint. Lowflow	2.862 (9.16 % nMAR)
Drought Lowflow	1.119 (3.58 % nMAR)
Maint. Highflow	6.548 (20.95 % nMAR)

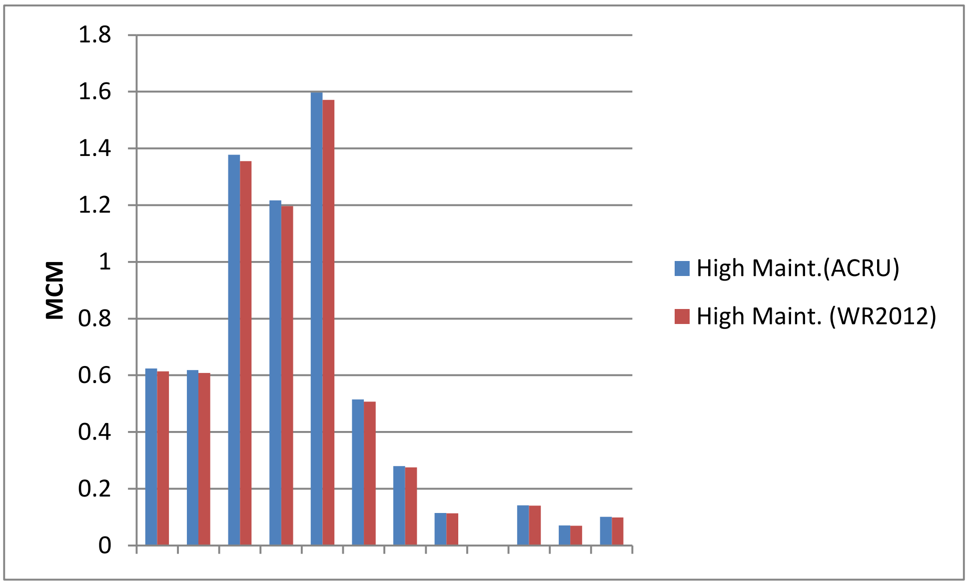
The monthly distributions (in MCM) for reach set of EWRs are provided in Appendix Table 3 and Appendix Figure 6 to Appendix Figure 8.

Appendix Table 3 BM1: EWR tables for REC using ACRU and WR2012 (units = MCM)

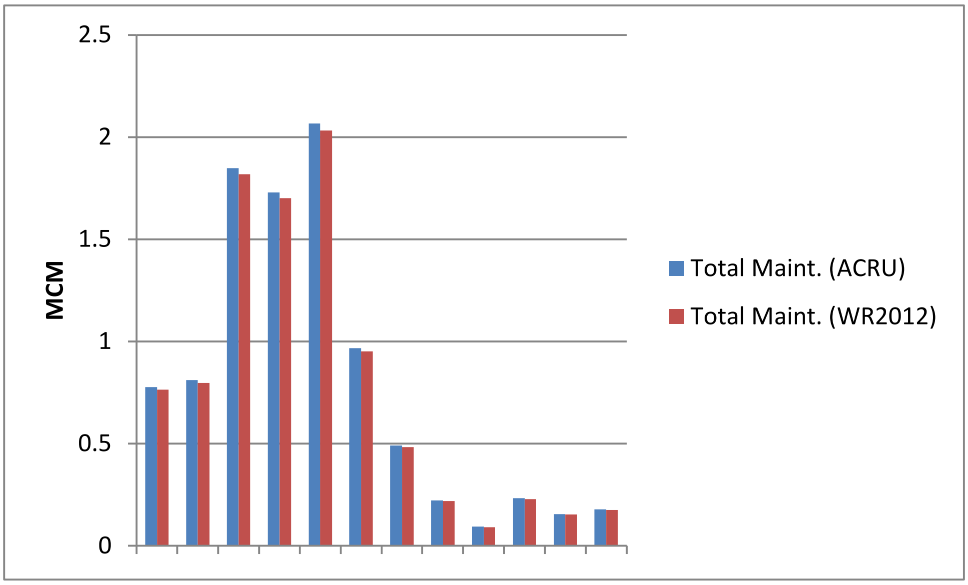
Month	Natural Flows	Lowflows		High Flows	Total Flows
	Mean	Low Maint.	Drought	High Maint.	Total Maint.
ACRU GENERATED					
Oct	2.328	0.152	0.061	0.624	0.776
Nov	2.562	0.192	0.072	0.618	0.81
Dec	4.815	0.47	0.184	1.378	1.848
Jan	5.319	0.512	0.196	1.217	1.729
Feb	6.474	0.469	0.175	1.597	2.067
Mar	2.894	0.452	0.174	0.515	0.967
Apr	1.957	0.211	0.07	0.28	0.49
May	1.223	0.107	0.047	0.115	0.222
Jun	0.621	0.093	0.044	0	0.093
Jul	1.54	0.09	0.043	0.142	0.232
Aug	0.679	0.085	0.041	0.071	0.155
Sep	1.374	0.077	0.038	0.101	0.178
WR2012 GENERATED					
Oct	1.637	0.149	0.06	0.614	0.763
Nov	3.096	0.189	0.071	0.608	0.797
Dec	4.369	0.462	0.181	1.355	1.818
Jan	4.984	0.504	0.193	1.197	1.701
Feb	5.384	0.461	0.172	1.571	2.032
Mar	4.167	0.445	0.171	0.507	0.951
Apr	2.583	0.208	0.069	0.275	0.483
May	1.51	0.105	0.039	0.113	0.218
Jun	0.923	0.091	0.043	0	0.091
Jul	0.948	0.089	0.042	0.14	0.228
Aug	0.698	0.084	0.04	0.07	0.153
Sep	0.961	0.076	0.037	0.099	0.175



Appendix Figure 6 BM1: Comparison of maintence lows flows generated using ACRU and WR2012.



Appendix Figure 7 BM1: Comparison of maintence high flows generated using ACRU and WR2012.



Appendix Figure 8 BM1: Comparison of total maintence EWR generated using ACRU and WR2012.

B.2.2. BLACK MFOLOZI (BM2) RECOMMENDED ECOLOGICAL CATEGORY_C

The summary statistics for the EWR generated using ACRU data are:

MAR	96.141 MCM
S.Dev.	3.916
CV	0.041
Q75	0.719212963
Total IFR	28.951 MCM (30.11% nMAR; excl. >=1:2 year return flood events)
Maint. Lowflow	12.570 MCM (13.08% nMAR)
Drought Lowflow	2.231 (2.32% nMAR)
Maint. Highflow	16.381 (17.04% nMAR)

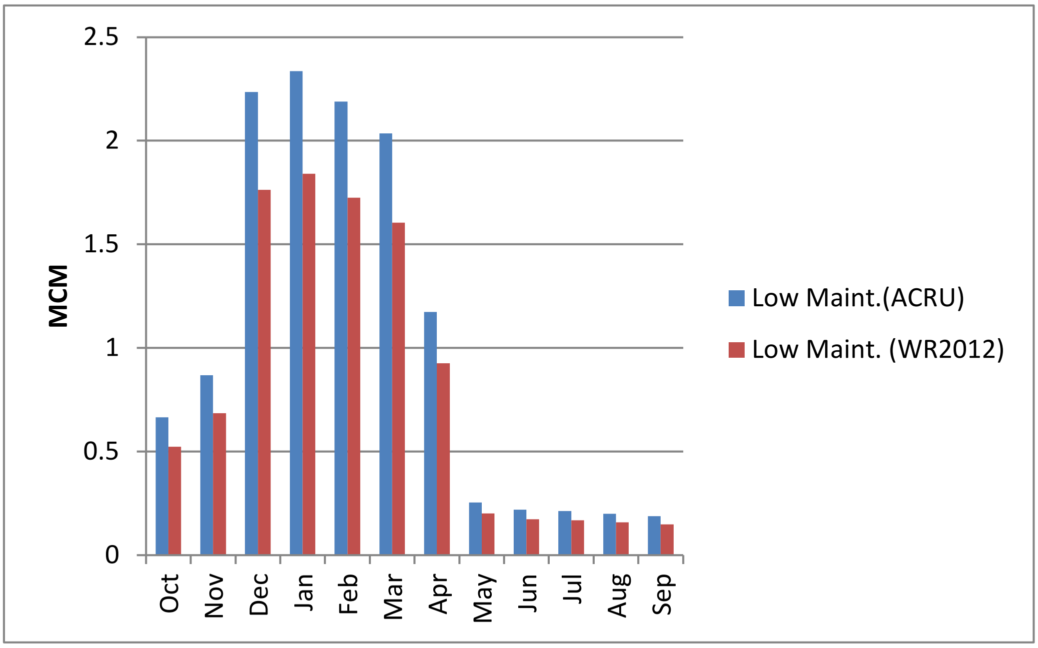
The summary statistics for the EWR generated using WR2012 data are:
Annual Flows (Mill. cu. m or index values):

MAR	75.794 MCM
S.Dev.	57.368
CV	0.757
Q75	1.610
Total IFR	22.825 (30.11 % nMAR; excl. >=1:2 year return flood events)
Maint. Lowflow	9.910 (13.07 % nMAR)
Drought Lowflow	1.759 (2.32 % nMAR)
Maint. Highflow	12.915 (17.04 % nMAR).

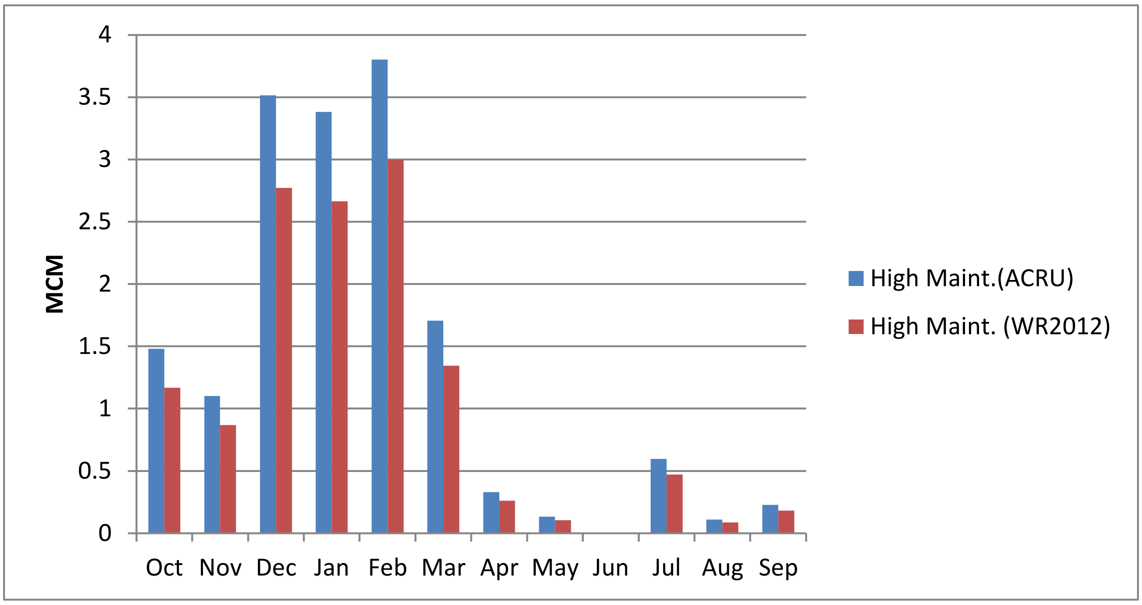
The monthly distributions (in MCM) for reach set of EWRs are provided in Appendix Table 4 and Appendix Figure 9 to Appendix Figure 11.

Appendix Table 4 BM2: EWR tables for REC using ACRU and WR2012 (units = MCM)

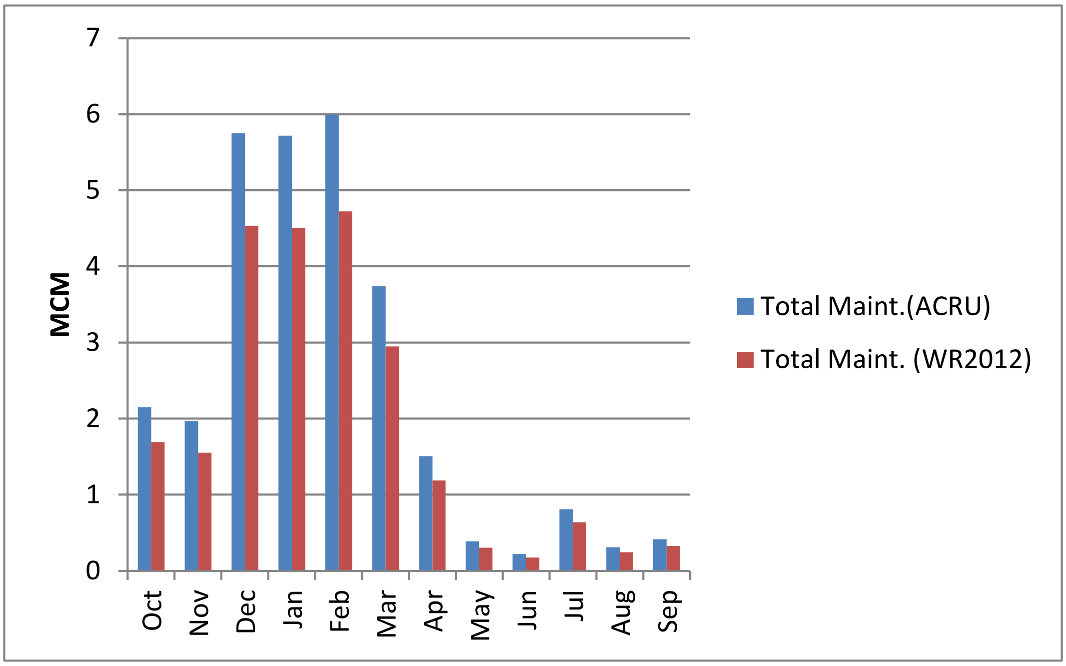
Month	Natural Flows	Lowflows		High Flows	Total Flows
	Mean	Low Maint.	Drought	High Maint.	Total Maint.
ACRU GENERATED					
Oct	5.942	0.664	0.132	1.481	2.146
Nov	5.953	0.867	0.151	1.1	1.967
Dec	13.655	2.235	0.308	3.515	5.75
Jan	15.78	2.335	0.299	3.381	5.717
Feb	17.933	2.188	0.28	3.802	5.989
Mar	7.666	2.035	0.286	1.706	3.74
Apr	4.308	1.174	0.192	0.33	1.503
May	2.561	0.254	0.131	0.133	0.387
Jun	1.391	0.219	0.114	0	0.219
Jul	13.92	0.212	0.114	0.597	0.809
Aug	2.994	0.199	0.115	0.109	0.308
Sep	4.038	0.188	0.109	0.228	0.416
WR2012 GENERATED					
Oct	4.213	0.523	0.104	1.168	1.691
Nov	7.384	0.684	0.119	0.867	1.551
Dec	10.48	1.762	0.243	2.771	4.533
Jan	12.199	1.841	0.236	2.665	4.506
Feb	12.989	1.725	0.221	2.997	4.722
Mar	9.82	1.604	0.225	1.345	2.949
Apr	5.937	0.926	0.151	0.26	1.186
May	3.553	0.2	0.103	0.105	0.305
Jun	2.312	0.173	0.09	0	0.173
Jul	2.507	0.167	0.09	0.471	0.638
Aug	1.87	0.157	0.091	0.086	0.243
Sep	2.53	0.148	0.086	0.18	0.328



Appendix Figure 9 BM2: Comparison of maintence lows flows generated using ACRU and WR2012.



Appendix Figure 10 BM2: Comparison of maintence high flows generated using ACRU and WR2012.



Appendix Figure 11 BM2: Comparison of total maintence EWR generated using ACRU and WR2012.

B.2.3. WHITE MFOLOZI (WM1) RECOMMENDED ECOLOGICAL CATEGORY_C

The summary statistics for the EWR generated using ACRU data are:

MAR	300.21 MCM
S.Dev.	3.916
CV	0.013
Q75	0.719212963
Total IFR	150.918 MCM (50.27% nMAR; excl. >=1:2 year return flood events)
Maint. Lowflow	76.663 MCM (25.54% nMAR)
Drought Lowflow	25.696 MCM (8.56% nMAR)
Maint. Highflow	74.255 MCM (24.73% nMAR).

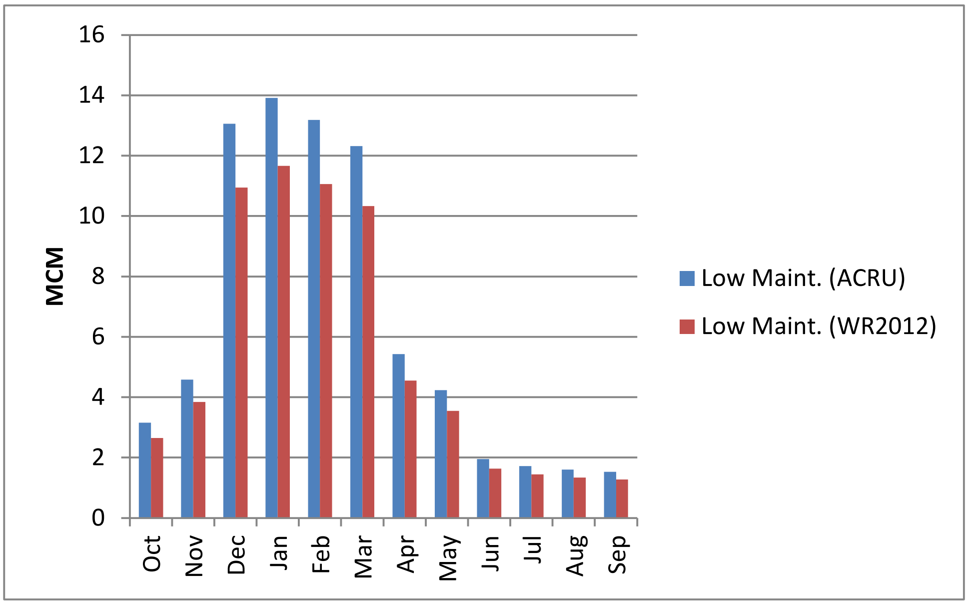
The summary statistics for the EWR generated using WR2012 data are:

MAR	251.647 MCM
S.Dev.	216.607
CV	0.861
Q75	5.550
Q75	0.265
Total IFR	126.504 MCM (50.27 %MAR; excl. >=1:2 year return flood events))
Maint. Lowflow	64.261 MCM (25.54 %MAR)
Drought Lowflow	21.539 MCM (8.56 %MAR)
Maint. Highflow	62.243 MCM (24.73 %MAR)

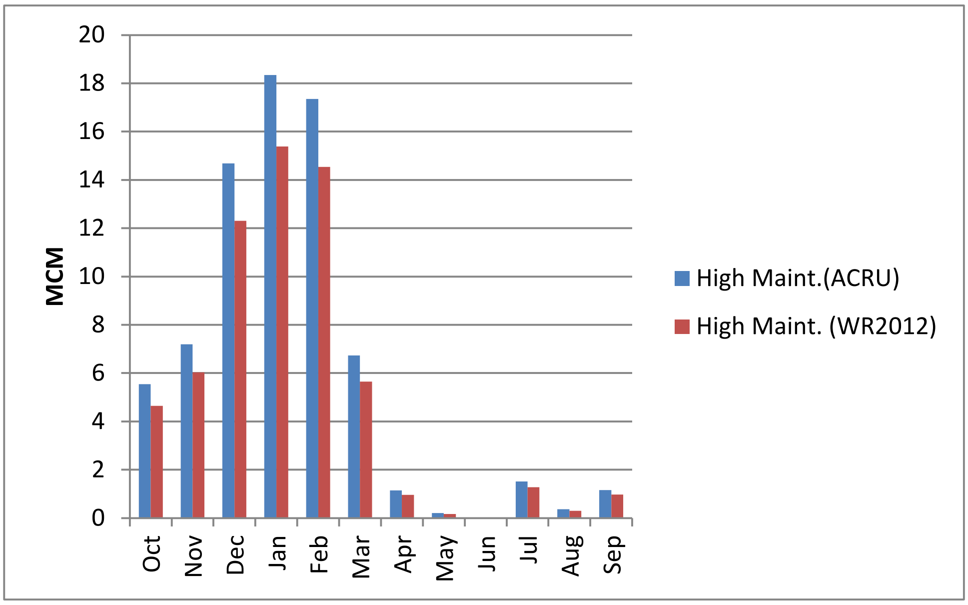
The monthly distributions (in MCM) for reach set of EWRs are provided in Appendix Table 5, and Appendix Figure 12 - Appendix Figure 14.

Appendix Table 5 WM1: EWR tables for REC using ACRU and WR2012 (units = MCM)

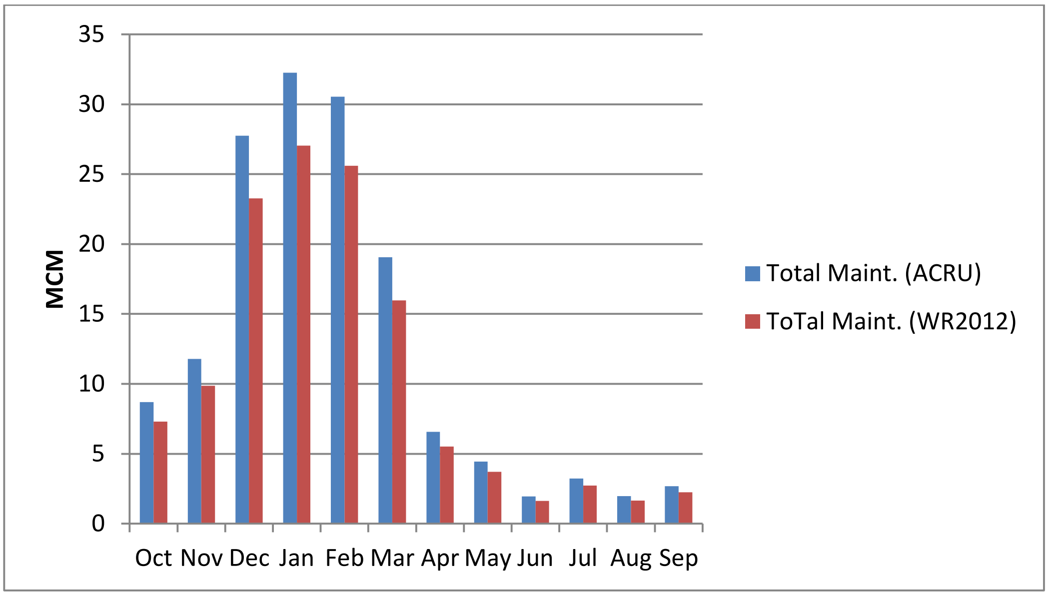
Month	Natural Flows	Lowflows		High Flows	Total Flows
	Mean	Low Maint.	Drought	High Maint.	Total Maint.
ACRU GENERATED					
Oct	18.698	3.158	0.951	5.545	8.704
Nov	26.166	4.578	1.35	7.199	11.777
Dec	46.329	13.06	4.988	14.685	27.746
Jan	58.821	13.911	3.975	18.348	32.259
Feb	57.71	13.188	4.156	17.35	30.538
Mar	31.064	12.321	4.969	6.733	19.054
Apr	15.737	5.425	0.959	1.15	6.574
May	9.413	4.232	0.967	0.202	4.434
Jun	5.221	1.948	0.833	0	1.948
Jul	10.834	1.718	0.854	1.518	3.237
Aug	6.904	1.598	0.862	0.363	1.962
Sep	13.313	1.525	0.832	1.162	2.687
WR2012 GENERATED					
Oct	14.026	2.647	0.797	4.648	7.295
Nov	22.7	3.837	1.132	6.034	9.872
Dec	30.334	10.947	4.181	12.31	23.257
Jan	34.477	11.661	3.332	15.38	27.041
Feb	36.864	11.055	3.484	14.543	25.598
Mar	27.245	10.328	4.165	5.644	15.972
Apr	14.312	4.547	0.804	0.964	5.511
May	8.346	3.547	0.811	0.169	3.717
Jun	6.431	1.633	0.698	0	1.633
Jul	7.327	1.44	0.716	1.272	2.713
Aug	6.155	1.34	0.723	0.304	1.644
Sep	43.43	1.278	0.697	0.974	2.252



Appendix Figure 12 WM1: Comparison of maintence lows flows generated using ACRU and WR2012.



Appendix Figure 13 WM1: Comparison of maintence high flows generated using ACRU and WR2012.



Appendix Figure 14 WM1: Comparison of total maintence EWR generated using ACRU and WR2012.