water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AND SANITATION
CHIEF DIRECTORATE: WATER ECOSYSTEMS

THE DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVES IN THE INKOMATI WATER MANAGEMENT AREA









MAIN REPORT

Report Number: RDM/WMA05/00/CON/CLA/0215

APRIL 2015

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REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa, April 2015. The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Main report. Compiled by D Louw and S Koekemoer for Rivers for Africa. DWS Report, RDM/WMA05/00/CON/CLA/0215.

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DEPARTMENT OF WATER AND SANITATION
CHIEF DIRECTORATE: WATER ECOSYSTEMS

THE DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVES IN THE INKOMATI WATER MANAGEMENT AREA

MAIN REPORT

Report Number: RDM/WMA5/00/CON/CLA/0215

Approved for IWR Water Resources by:

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ACKNOWLEDGEMENTS

This is a culmination of all the technical reports produced as part of this study. The study team and DWS as well as all other persons that contributed to the individual technical reports are acknowledged.

REPORT SCHEDULE

Version	Date
First draft	April 2015
Final	June 2015

During the course of the study the demarcations of the Water Management Area changed. This resulted in the Inkomati Water Management Area changing to the Inkomati-Usuthu Water Management Area. These changes are reflected in the text of the following reports although the title of the study and associated maps, headers and footers were left unchanged and conform to the original report format:

- R 5: RDM/WMA05/00/CON/CLA/0414 - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: **Resource Quality Objectives: Rivers and Wetlands.**
- R 6: RDM/WMA05/00/CON/CLA/0514 - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: **Resource Quality Objectives: Groundwater.**
- R 7: RDM/WMA05/00/CON/CLA/0115 - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: **Implementation report.**
- R 8: RDM/WMA05/00/CON/CLA/0215 - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: **Main report.**
- R 9: RDM/WMA05/00/CON/CLA/0315 - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: **Close out report.**

EXECUTIVE SUMMARY

INTRODUCTION

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2013 for the provision of professional services to undertake the determination of Water Resource Classes and associated Resource Quality Objectives (RQOs) in the catchments of the Inkomati[1]. IWR Water Resources was appointed as the Professional Service Provider (PSP) to undertake this study which is managed by Rivers for Africa for IWR Water Resources (DWA, 2013a).

The purpose of this report is to summarise the results of all the technical reports produced during the study.

STATUS QUO

The purpose of this task was to describe and document the status quo task which includes various components such as water use, economy, river and wetland ecology, identifying water quality problems and Ecosystem Goods, Services and Attributes (EGSA). This information was used to define the Integrated Units of Analysis (IUAs) and provide background information to assist with the catchment visioning process. Once the IUAs are delineated, Resource Units (RUs) and biophysical nodes must be identified for different levels of Ecological Water Requirement (EWR) assessment and setting of RQOs.

INTEGRATED UNITS OF ANALYSIS

The following 33 IUAs were delineated in the Inkomati.

X1 KOMATI RIVER	
IUA X1-1	Catchment upstream of Nooitgedacht Dam.
IUA X1-2	Komati River between Nooitgedacht and Vygeboom Dam.
IUA X1-3	All tributaries between Nooitgedacht and Vygeboom Dam excluding the main Komati River
IUA X1-4	Gladdespruit catchment.
IUA X1-5	Komati River downstream of Vygeboom Dam to Swaziland.
IUA X1-6	All tributaries downstream of Vygeboom Dam in X1-6 excluding the Gladdespruit.
IUA X1-7	Lomati catchment upstream of Swaziland.
IUA X1-8	Lomati catchment downstream of Driekoppies Dam.
IUA X1-9	Komati catchment downstream of Swaziland to the Lomati River confluence.
IUA X1-10	Komati catchment downstream of the Lomati River.
X2 CROCODILE RIVER	
IUA X2-1	Crocodile sub-catchment upstream of Kwena Dam.
IUA X2-2	Crocodile River downstream of the Kwena Dam to the Elands River.
IUA X2-3	Elands catchment upstream of the Weltevredespruit excluded.
IUA X2-4	Elands River downstream of X2-3 to the Ngodwana confluence, including the Weltevredenspruit, the Ngodwana River upstream of the Ngodwana Dam and the Lupelele River.
IUA X2-5	Elands River downstream of the Ngodwana River.
IUA X2-6	Crocodile River to the Nels River confluence.
IUA X2-7	Houtbos and Visspruit Rivers.
IUA X2-8	Nels, Wit, and Gladdespruit rivers.
IUA X2-9	Crocodile River to the Kaap confluence including the Blinkwater tributary.

[1] The Inkomati WMA's delineation changed during the course of the study. Although the project name remains unchanged, reference in the report is now made to the Inkomati Catchment. Note that this description excludes Swaziland and Mozambique.

IUA X2-10	Kaap catchment.
IUA X2-11	Crocodile River from the Kaap confluence to the Komati River.
IUA X2-12	Nsikasi River.
IUA X2-13	Northern tributaries of the Crocodile River located in the KNP.
SABIE-SAND RIVER	
IUA X3-1	Sabie catchment upstream of the Klein Sabie included confluence.
IUA X3-2	Sabie River downstream of X3-1 to the Marite confluence including the Goudstroom, MacMac, Motitsi and Marite upstream of Inyaka Dam.
IUA X3-3	Marite and Sabie River downstream of Inyaka Dam to the Sand confluence.
IUA X3-4	Sabaan, Noord-Sand, Bejani, Saringwa, Musutlu rivers.
IUA X3-5	Sabie River downstream of the Sand confluence to the RSA border.
IUA X3-6	Southern and northern tributaries of the Sabie in the KNP downstream of the Sand confluence including the Phabeni.
IUA X3-7	Mutlumuvi catchment.
IUA X3-8	Sand catchment to the Khokhovela included confluence.
IUA X3-9	Sand catchment downstream of the Khokovela confluence.
IUA X4: NWANEDZI AND NWASWITSONTSORIVERS: The whole X4 will be one IUA. The rivers are largely in the KNP and will not be affected by any scenario.	

HOTSPOTS

The hotspot represents a river reach with a high Integrated Environmental Importance (IEI) which could be under threat due to its importance for water resource use. The hotspots are therefore an indication of areas where detailed investigations would be required if development was being considered. These hotspots usually represent areas which are already stressed or will be stressed in future (Louw and Huggins, 2007; Louw *et al.,* 2010).

Hotspots are areas with high IEI and high Water Resource Use Importance (WRUI). IEI considers Present Ecological State (PES), Ecological Importance and Sensitivity (EIS), Freshwater EcoSystem Priority Areas (FEPAs) and Socio-Cultural Importance (SCI).

Of the 238 SQ reaches assessed, 117 had a VERY HIGH status. These areas are mostly situated in nature reserves and the Kruger National Park (KNP), and forestry with reasonable buffer zones.

The rivers where hotspots dominated were mostly on the main stems of the rivers. This could largely be attributed to the cumulative impact of water use and deteriorating water quality relating to industrial and urban development as well as mining. Seventeen hotspots were identified in the Komati catchment; eleven hotspots were identified in the Crocodile catchment while fourteen hotspots occurred in the Sabie-Sand catchment (X3).

ECOLOGICAL WATER REQUIREMENTS

The main emphasis of this task was on the EcoClassification and Ecological Water Requirement (EWR) determination at various biophysical nodes in the system. Twenty four EWR sites as determined during the various comprehensive EWR studies was accepted and tabled below:

- Fifteen EWR sites were selected in the Crocodile River system (X2) and Sabie-Sand River system (X3) (DWA, 2008a).
- Two EWR sites were selected on the Elands River in the Crocodile River system (X2) (Hill, 2003).
- Seven EWR sites were selected in the Komati River system (X1) (AfriDev, 2005a).

The 2006 Komati EWR results (AfriDev, 2006a) were updated using the updated natural and present day hydrology (pMAR). The PES results are summarised below as percentage of the natural Mean Annual Runoff (nMAR). The EWR results of the other studies are also provided.

EWR results for the EWR sites in the Inkomati

EWR site	nMAR	PMAR	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM	MCM	MCM		MCM[1]	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)
Crocodile River system												
C1	15.19	14.90	98%	A/B PES, REC[2]	3.8	24.8	1.54	10.13	0.93	6.14	4.69	30.9
				B/C AEC[3]	2.56	16.84	1.54	10.13	0.93	6.14	3.71	24.4
C2	47.11	44.80	95%	B PES, REC	23.53	49.95	9.23	19.58	3.50	7.43	26.85	57
				C AEC	11.39	24.18	9.23	19.58	3.03	6.44	17.43	37
C3	169.9	1515.2	892%	B/C PES	74.76	44	30.75	18.1	16.7	9.8	93.78	55.2
				B REC		A time series of requirements could not be generated as improvement of the PES required flows higher than the reference time series (present day), during the wet season.						
C4	754.1	528.3	70%	B PES, REC	216.4	28.7	74.66	9.9	46.8	6.2	260.16	34.5
				C/D AEC	99.54	13.2	74.66	9.9	38.7	5.1	160.62	21.3
C5	1006.2	637.9	63%	C PES	214.3	21.3	121.8	12.1	53.3	5.3	301.87	30
				B REC	349.2	34.7	121.8	12.1	74.5	7.4	404.50	40.2
				D AEC	121.8	12.1	121.8	12.1	29.2	2.9	214.33	21.3
C6	1063.1	525.2	49%	C PES	147.8	13.9	112.7	10.6	78.7	7.4	264.72	24.9
				B REC	323.2	30.4	112.7	10.6	140.3	13.2	466.71	43.9
				D AEC	123	11.6	47.84	4.5	48.9	4.6	152.03	14.3
C7	169	86.6	51%	C PES	25.2	14.9	11.16	6.6	10.82	6.4	38.87	23
				B REC	50	29.6	11.16	6.6	12.51	7.4	62.20	36.8
				D AEC	10.14	6	11.16	6.6	8.96	5.3	27.72	16.4
Sabie-Sand River system												
S1	140.18	109	78%	B/C PES	46.54	33.2	17	12.1	7.43	5.3	52.99	37.8
				B REC	61.82	44.1	17	12.1	8.55	6.1	64.90	46.3
				C/D AEC	29.02	20.7	17	12.1	6.31	4.5	43.46	31
S2	262.1	199.5	76%	B/C PES	51.90	19.8	29.1	11.1	11.5	4.4	73.39	28
				B REC	81.52	31.1	29.1	11.1	13.1	5	93.57	35.7
				C/D AEC	32.76	12.5	29.1	11.1	9.44	3.6	57.93	22.1
S3	495.86	322.1	65%	A/B PES/REC	155.2	31.3	48.1	9.7	31.7	6.4	183.5	37
				B/C AEC	101.2	20.4	48.1	9.7	26.8	5.4	134.4	27.1
S4	65.78	51.8	79%	A/B PES/REC	20.59	31.3	6.38	9.7	4.21	6.4	24.34	37
				B/C AEC	13.42	20.4	6.38	9.7	3.55	5.4	17.83	27.1
S5	157.09	89.7	57%	B/C PES	32.67	20.8	12.6	8	10.2	6.5	44.30	28.2
				B REC	47.44	30.2	12.6	8	11.2	7.1	57.02	36.3
				C/D AEC	15.39	9.8	12.6	8	8.48	5.4	31.10	19.8
S6	44.99	29.9	66%	C PES	9.99	22.2	4.63	10.3	2.83	6.3	14.58	32.4
				B AEC	14.49	32.2	6.03	13.4	2.83	6.3	17.37	38.6
				C/D AEC	6.21	13.8	4.63	10.3	2.56	5.7	11.56	25.7

[2] REC: Recommended Ecological Category

[3] AEC: Alternative Ecological Category

EWR site	nMAR	PMAR	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM	MCM	MCM		MCM[1]	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)
S7	28.88	17.3	60%	C PES	5.11	17.7	2.05	7.1	3.18	11	9.15	31.7
				B REC	7.65	26.5	3.23	11.2	3.81	13.2	11.38	39.4
				D AEC	2.71	9.4	2.05	7.1	2.95	10.2	7.77	26.9
S8	133.61	88.5	66%	B PES/REC	22.85	17.1	4.54	3.4	9.75	7.3	33.80	25.3
				C AEC	12.69	9.5	4.54	3.4	8.82	6.6	24.58	18.4
Elands												
ER 1	50.1			B PES, REC	18.45	36.82	4.9	9.79	6.01	12	24.46	48.82
ER 2	50.1			B PES, REC	68.46	33.98	21.77	10.8	22.23	11.03	90.7	45.02
Komati River system												
K1	158.6	108.5	68.38	B/C PES, REC	27.38	17.30			16.30	10.20	43.68	27.50
K2	545.6	318.6	58.41	C PES	50.87	9.30			49.00	9.00	99.87	18.30
K3	1022	489.8	47.95	D REC	101.1	9.90			74.46	7.30	175.55	17.20
G1	29.52	21.18	71.75	D PES, REC	5.89	19.90			2.05	7.00	7.94	26.90
T1	56.36	45.13	80.07	C PES, REC	12.75	22.60			7.15	12.70	19.89	35.30
L1	294.3	229.5	77.99	C PES, REC	34.46	11.70			16.50	5.60	50.96	17.30

1 Million Cubic Metres

The Revised Desktop Reserve Model (RDRM) (Hughes *et al*., 2012) was used to estimate EWRs at all desktop biophysical nodes, excluding those that fall in its totality in conservation areas. The results are summarised in the table below.

Summary of Desktop EWRs for the biophysical nodes in the Inkomati Catchment (Komati, Crocodile and Sabie Rivers)

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
						Low flows		Total flows	
			Natural	PD		10^6 m^3	MAR	10^6 m^3	MAR
Komati River system (X1)									
X1-1	X11A-01248	Vaalwaterspruit	26.3	22.4	C	3.73	14.2%	6.19	23.5%
X1-1	X11A-01295	Vaalwaterspruit	15.4	12.9	C	2.81	18.2%	4.20	27.2%
X1-1	X11A-01300		1.7	1.4	B	0.31	18.1%	0.48	28.1%
X1-1	X11A-01354		3.9	3.1	C	0.59	15.1%	0.96	24.5%
X1-1	X11A-01358	Vaalwaterspruit	6.6	5.7	C	1.13	17.3%	1.76	26.8%
X1-1	X11B-01272	Boesmanspruit	51.2	41.9	C	7.76	15.1%	12.38	24.2%
X1-1	X11B-01361		4.2	3.6	B/C	0.68	16.0%	1.14	27.0%
X1-1	X11B-01370	Boesmanspruit	4.8	3.5	B	0.91	19.0%	1.39	28.8%
X1-1	X11C-01147	Witkloofspruit	11.4	9.9	C	1.54	13.5%	2.51	22.1%
X1-2	X11D-01129	Klein-Komati	21.0	17.8	C	4.04	19.2%	5.76	27.4%
X1-2	X11D-01137	Waarkraalloop	11.7	10.9	C	2.18	18.6%	3.19	27.3%
X1-2	X11E-01237	Swartspruit	14.8	13.8	C	2.85	19.3%	4.13	27.9%
X1-2	X11F-01133	Bankspruit	6.5	5.8	B	1.32	20.3%	2.00	30.8%
X1-2	X11G-01143	Gemakstroom	10.4	7.9	C	1.82	17.5%	2.72	26.1%
X1-2	X11G-01188	Ndubazi	17.4	14.2	B	4.33	24.9%	6.07	34.9%
X1-3	X11D-01196	Komati	95.4	51.1	C	13.39	14.0%	19.17	20.1%
X1-3	X11D-01219	Komati	73.6	33.0	C/D	6.78	9.2%	9.04	12.3%
X1-3	X11E-01157	Komati	118.3	72.4	B/C	20.99	17.7%	30.31	25.6%
X1-4	X11K-01165	Poponyane	13.7	10.8	C	2.01	14.7%	3.12	22.7%
X1-4	X11K-01179	Gladdespruit	64.4	30.8	C	8.68	13.5%	13.04	20.2%

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
						Low flows		Total flows	
			Natural	PD		10^6 m^3	MAR	10^6 m^3	MAR
X1-4	X11K-01194	Gladdespruit	71.2	36.8	C	7.86	11.0%	13.59	19.1%
X1-4	X11K-01199		2.4	1.5	D	0.36	15.1%	0.53	22.3%
X1-5	X12K-01316	Komati	577.0	348.9	D	79.99	13.9%	122.33	21.2%
X1-6	X12A-01305	Buffelspruit	32.0	24.2	C	7.26	22.7%	9.69	30.3%
X1-6	X12B-01246	Hlatjiwe	22.1	17.1	C	5.04	22.8%	6.75	30.5%
X1-6	X12C-01242	Phophenyane	6.3	5.9	B	1.80	28.7%	2.35	37.5%
X1-6	X12C-01271	Buffelspruit	71.1	56.4	B	22.53	31.7%	28.76	40.5%
X1-6	X12D-01235	Seekoeispruit	97.0	80.0	C	22.54	23.2%	29.58	30.5%
X1-6	X12H-01318	Sandspruit	13.9	13.3	C	3.36	24.1%	4.43	31.7%
X1-6	X12H-01338	Sandspruit	4.4	4.3	B	1.24	27.9%	1.64	36.7%
X1-6	X12H-01340		4.8	4.3	B	1.48	30.6%	1.92	39.5%
X1-6	X12J-01202	Mtsoli	66.5	58.6	B	15.92	23.9%	22.26	33.5%
X1-6	X12K-01332	Mhlangampepa	3.4	3.4	B	1.06	30.7%	1.38	40.0%
X1-6	X12K-01333	Mlondozi	22.4	22.3	C	4.56	20.3%	6.34	28.2%
X1-7	X14A-01173	Lomati	84.4	72.0	B	23.24	27.5%	30.65	36.3%
X1-7	X14B-01166	Ugutugulo	20.9	14.3	B/C	4.88	23.4%	6.61	31.7%
X1-9	X13J-01141	Mzinti	6.3	4.2	D	0.66	10.5%	1.21	19.1%
X1-9	X13J-01205	Mbiteni	5.9	5.1	D	0.50	8.6%	1.04	17.6%
X1-9	X13J-01221	Komati	1000.3	535.0	D	137.12	13.7%	197.35	19.7%
X1-10	X13K-01068	Nkwakwa	5.4	5.4	C/D	0.61	11.2%	1.23	22.7%
X1-10	X13K-01114	Komati	1341.4	645.6	D	172.51	12.9%	242.23	18.1%
X1-10	X13K-01136	Mambane	1.8	1.8	D	0.24	13.1%	0.41	22.4%
X1-10	X13L-00995	Komati	1356.6	504.8	D	97.40	7.2%	150.08	11.1%
X1-10	X13L-01000	Ngweti	4.6	2.5	D	0.35	7.5%	0.67	14.5%
Crocodile River system (X2)									
X2-1	X21A-01008		na[2]	na	C/D	na	na	na	na
X2-1	X21B-00898	Lunsklip	9.6	8.4	C/D	1.78	18.4%	2.49	25.8%
X2-1	X21B-00925	Lunsklip	25.8	22.2	C	6.01	23.3%	8.07	31.3%
X2-1	X21B-00929	Gemsbokspruit	3.8	3.3	C/D	0.71	18.9%	0.99	26.3%
X2-1	X21C-00859	Alexanderspruit	28.8	26.2	C	6.81	23.6%	9.09	31.5%
X2-2	X21D-00938	Crocodile	124.8	104.5	C	24.51	19.6%	29.99	24.0%
X2-2	X21D-00957	Buffelskloofspruit	16.9	12.9	C	4.22	25.0%	5.50	32.6%
X2-2	X21E-00897	Buffelskloofspruit	8.4	6.6	B	2.15	25.6%	2.96	35.3%
X2-2	X21E-00947	Crocodile	125.1	104.7	B	30.35	24.3%	36.11	28.9%
X2-3	X21F-01046	Elands	35.1	31.6	C	9.49	27.1%	12.35	35.2%
X2-3	X21F-01081	Elands	50.8	46.8	C	13.90	27.4%	18.02	35.5%
X2-3	X21F-01091	Rietvleispruit	3.3	3.1	C	0.90	27.1%	1.17	35.4%
X2-3	X21F-01092	Leeuspruit	11.9	11.2	C/D	2.81	23.6%	3.70	31.2%
X2-3	X21F-01096	Dawsonsspruit	na	na	A	na	na	na	na
X2-3	X21F-01100	Leeuspruit	11.9	11.2	C	3.21	27.0%	4.17	35.1%
X2-4	X21G-01016	Swartkoppiespruit	11.4	9.7	C	2.77	24.4%	3.70	32.5%
X2-4	X21G-01090	Weltevredespruit	5.5	4.7	C	1.31	23.6%	1.77	32.0%
X2-4	X21H-01060	Ngodwana	59.6	36.2	B	7.61	12.8%	13.20	22.1%
X2-4	X21J-01013	Elands	151.5	124.1	C	33.97	22.4%	46.15	30.5%
X2-4	X21K-01007	Lupelule	29.4	22.9	B	6.59	22.4%	9.43	32.1%
X2-7	X22A-00824	Blystaanspruit	21.0	15.0	B/C	5.76	27.4%	7.42	35.3%
X2-7	X22A-00875	Houtbosloop	6.9	5.0	B/C	1.82	26.2%	2.36	34.2%
X2-7	X22A-00887	Beestekraalspruit	3.7	2.7	B/C	0.96	25.9%	1.26	33.9%
X2-7	X22A-00913	Houtbosloop	75.3	53.9	B	24.84	33.0%	31.11	41.3%
X2-7	X22A-00917	Houtbosloop	14.8	10.6	C	3.31	22.3%	4.40	29.7%

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
						Low flows		Total flows	
			Natural	PD		10^6 m^3	MAR	10^6 m^3	MAR
X2-7	X22A-00919	Houtbosloop	10.6	7.6	B/C	2.85	26.8%	3.69	34.7%
X2-7	X22A-00920		1.7	1.2	B	0.52	30.8%	0.67	39.4%
X2-7	X22C-00990	Visspruit	3.4	3.0	B/C	0.67	20.0%	1.05	31.1%
X2-8	X22C-01004	Gladdespruit	16.3	10.7	C	1.80	11.1%	3.39	20.9%
X2-8	X22D-00843	Nels	20.6	14.9	C	4.51	21.9%	6.09	29.6%
X2-8	X22D-00846		13.8	10.0	C	3.32	24.1%	4.39	31.9%
X2-8	X22E-00833	Kruisfonteinspruit	11.1	8.2	C	2.08	18.7%	2.96	26.6%
X2-8	X22E-00849	Sand	8.7	6.4	C	1.71	19.8%	2.40	27.7%
X2-8	X22F-00842	Nels	74.9	45.1	C	8.37	11.2%	14.21	19.0%
X2-8	X22F-00886	Sand	48.9	37.3	C	9.48	19.4%	13.41	27.4%
X2-8	X22F-00977	Nels	125.4	84.9	C/D	21.08	16.8%	30.24	24.1%
X2-8	X22H-00836	Wit	43.0	20.0	D	3.41	7.9%	6.39	14.9%
X2-9	X22K-01029	Blinkwater	7.6	6.8	C	1.44	19.0%	2.05	27.2%
X2-9	X22K-01042	Mbuzulwane	1.2	1.1	B	0.34	28.7%	0.46	38.5%
X2-9	X22K-01043	Blinkwater	5.9	5.4	B	1.43	24.2%	2.07	34.9%
X2-10	X23B-01052	Noordkaap	50.9	33.5	D	8.66	17.0%	11.96	23.5%
X2-10	X23C-01098	Suidkaap	61.8	37.8	C	20.12	32.6%	24.40	39.5%
X2-10	X23E-01154	Queens	39.5	25.0	C	7.26	18.4%	10.71	27.1%
X2-10	X23F-01120	Suidkaap	109.8	57.1	C	26.51	24.1%	34.04	31.0%
X2-12	X24A-00826	Nsikazi	2.0	1.9	C	0.48	24.2%	0.67	34.0%
X2-12	X24A-00881	Nsikazi	11.7	11.3	B	3.44	29.5%	4.75	40.6%
X2-12	X24B-00903	Gutshwa	25.4	24.8	D	4.11	16.2%	6.21	24.4%
X2-12	X24B-00928	Nsikazi	42.4	41.4	A/B	13.46	31.8%	18.65	44.0%
X2-12	X24C-00978	Nsikazi	52.3	42.0	B	16.06	30.7%	21.15	40.5%
Sabie-Sand River system (X3)									
X3-1	X31A-00741	Klein Sabie	14.6	11.8	C	2.15	14.7%	3.37	23.0%
X3-1	X31A-00783		12.1	9.5	C	3.17	26.1%	4.09	33.8%
X3-1	X31A-00786		4.7	3.6	B	1.82	39.1%	2.22	47.8%
X3-1	X31A-00794		na	na	B	na	na	na	na
X3-1	X31A-00796		na	na	B	na	na	na	na
X3-1	X31A-00803		na	na	B/C	na	na	na	na
X3-2	X31B-00792	Goudstroom	12.2	9.8	B/C	3.79	31.0%	4.75	38.9%
X3-2	X31E-00647a	Marite	79.9	62.8	B/C	20.58	25.8%	27.74	34.7%
X3-2	X31F-00695	Motitsi	43.9	35.8	C	7.82	17.8%	11.62	26.5%
X3-4	X31D-00773	Sabani	19.2	7.6	C/D	3.13	16.3%	3.75	19.5%
X3-4	X31H-00819	White Waters	28.9	16.2	C	7.51	25.9%	9.09	31.4%
X3-4	X31J-00774	Noord-Sand	45.1	20.2	D	4.21	9.3%	7.22	16.0%
X3-4	X31J-00835	Noord-Sand	12.0	11.0	D	2.91	24.2%	3.76	31.3%
X3-4	X31K-00713	Bejani	2.4	2.4	D	0.40	16.9%	0.61	25.7%
X3-4	X31L-00657	Matsavana	3.8	2.6	C	0.17	4.3%	0.65	16.8%
X3-4	X31L-00664	Saringwa	10.9	9.5	C	1.47	13.5%	2.67	24.5%
X3-4	X31L-00678	Saringwa	3.2	3.2	B/C	0.59	18.2%	1.00	30.8%
X3-4	X31M-00673	Musutlu	1.8	1.8	B/C	0.19	10.6%	0.34	19.0%
X3-6	X31K-00771	Phabeni	2.5	2.5	B	0.70	27.8%	0.97	39.0%
X3-7	X32E-00629	Nwarhele	10.6	9.9	C/D	1.93	18.2%	2.76	26.1%
X3-7	X32F-00628	Nwarhele	14.8	14.0	C/D	3.44	23.3%	4.63	31.3%
X3-8	X32B-00551	Motlamogatsana	15.4	10.4	C	2.75	17.9%	3.95	25.7%
X3-8	X32C-00558	Nwandlamuhari	49.7	25.0	C	7.64	15.4%	10.02	20.2%
X3-8	X32C-00564	Mphyanyana	3.1	2.0	C	0.05	1.6%	0.33	10.5%
X3-8	X32C-00606	Nwandlamuhari	53.2	33.7	C	8.77	16.5%	12.54	23.6%

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
			Natural	PD		Low flows		Total flows	
						10^6 m^3	MAR	10^6 m^3	MAR
X3-8	X32G-00549	Khokhovela	3.9	3.8	C	0.41	10.4%	0.67	17.0%
X3-9	X32H-00560	Phungwe	7.6	7.3	A	1.19	15.7%	1.98	26.1%

1 Mean Annual Runoff
2 Small SQ catchment areas (less than 3 km^2) and hence no hydrology modelled (small flows and inaccurate at this resolution).

SCENARIO EVALUATION AND WATER RESOURCE CLASSES

This task formed ***part*** of Step 4 and 5 within the integrated approach adopted for this study, i.e. the identification and evaluation of scenarios within the Integrated Water Resource Management (IWRM) Process. The purpose of these tasks was to recommended operational scenarios and preliminary Water Resource Classes for stakeholder evaluation.

The Inkomati is highly a stressed system with water use equal to or exceeding the available resource in most areas. The system is institutionally well developed in that there is a catchment management agency (referred to as the Inkomati-Usuthu Catchment Management Agency or IUCMA); several well managed irrigation boards as well as the Komati Basin Water Authority (KOBWA). The Department of Water and Sanitation also has a regional office located in Nelspruit.

In terms of physical infrastructure the Inkomati is not fully developed and there is scope for several new dams in the study area. The scenarios considered as part of this study therefore includes several infrastructure development options. While a workshop was held with stakeholders to identify scenarios, the development options were already well established as part of several previous studies.

These scenarios derived from these previous studies broadly consist of options to reduce the water requirements and options to increase the water supply. The water conservation and demand management options are incorporated into the water demand growth scenarios:

- **Komati River system**
  - Water Conservation & Water Demand Management.
  - Construction of the Silingane.
- **Crocodile River system**
  - Water Conservation & Water Demand Management.
  - Construction of the Mountain View Dam.
  - Construction of the Boschjeskop Dam.
- **Sabie River system**
  - Water Conservation & Water Demand Management.
  - Construction of the New Forest Dam.

A complicating factor in the Inkomati is the fact that all the major rivers within the study area form part of the larger Incomati River Basin which is shared with Swaziland and Mozambique. Two international agreements have relevance to the cross border flow into Mozambique. These are the Piggs Peak Agreement (TPTC, 1990) and the IncoMaputo Water Use Agreement (TPTC, 2002). The Piggs Peak agreement specifies a minimum flow in from the Crocodile and Komati rivers into Mozambique of 2 m^3/s. The arrangement within South Africa is that the Crocodile River will contribute 0.9 m^3/s while the Komati River contributes 1.1 m^3/s. While the Piggs Peak agreement has been superseded by the IncoMaputo Water Agreement (TPTC, 2002), this agreement has yet to be implemented in practice, at least in terms of the cross border flow which has been increased from the Piggs Peak agreement from 2 m^3/s to 2.6 m^3/s.

With respect to the EWR, the following three options were considered in each major river system (Komati, Crocodile and Sabie-Sand):

- No EWR.
- PES.
- REC.

In the Crocodile River system a further scenario referred to as the ‘Present Day EWR’ was also considered. This scenario stems from the Ecological Reserve study (DWA, 2010a,b) in which the recommendation was to maintain the present day flow.

The following four tables below summarise the scenario definition in the form of a matrix, where each row represents a scenario and the columns indicate each of the variables applicable to each scenario. The scenarios are grouped into four sub-catchments, the Komati, the Crocodile, the Sabie and the Sand River. The reason that the Sand River was separated from the Sabie is that it was found that many of the scenarios were applicable to either the Sabie (X31) or the Sand catchment, but not both.

Komati River system (X1): Scenario summary

Scenario	Scenario variables					
	Update water demands	Domestic growth and increase irrigation (plus restrictions so system does not fail)	IIMA[1] Flows	DARDLA[2]	Silingane Dam (DSMaguga)	EWR
K1	Yes	No	No	No	No	No
K2	Yes	No	No	No	No	Yes
K31	Yes	Yes	Yes	No	No	Yes
K32	Yes	Yes	Yes	No	No	No
K41	Yes	Yes	Yes	Yes	No	Yes
K42	Yes	Yes	Yes	Yes	No	No
K43	Yes	No	Yes	Yes	No	No
K5	WQ scenario (not for ecological assessment), includes mining aspects)					
K6	Yes	Yes	Yes	Yes	Yes	Yes

1 Interim IncoMaputo Agreement   2 Department of Agriculture, Rural Development and Land Administration

Crocodile River system (X2): Scenario summary

Scenario	Scenario Variables						
	Update water demands with revised PES EWR	Updated water demands	Domestic growth	IIMA Flows	Mountain View Dam (Kaap)	Boschjeskop Dam (Nels)	EWR
C1	Yes	No	No	No	No	No	No
C2	No	Yes	No	No	No	No	REC
C3	No	Yes	Yes	Yes	No	No	PES
C4	No	Yes	Yes	Yes	No	No	REC
C5	No	Yes	Yes	Yes	Yes	No	No
C61	No	Yes	Yes	Yes	Yes	No	REC
C62	No	Yes	Yes	Yes	Yes	No	PES
C71	No	Yes	Yes	Yes	No	Yes	REC
C72	No	Yes	Yes	Yes	No	Yes	No
C81	No	Yes	Yes	Yes	Yes	Yes	REC

Scenario	Scenario Variables						
	Update water demands with revised PES EWR	Updated water demands	Domestic growth	IIMA Flows	Mountain View Dam (Kaap)	Boschjeskop Dam (Nels)	EWR
C82	No	Yes	Yes	Yes	Yes	Yes	PES

Sabie River system (X31): Scenario summary

Scenario	Update water demands	Growth in water demands	EWR
S1	Yes	No	No
S2	Yes	No	Yes (REC)
S31	Yes	Yes	Yes (REC)
S32	Yes	Yes	No
S6	Yes	Minimised to meet REC	Yes (REC)

Sand River system (X32): Scenario summary

Scenario	Scenario Variables				
	Update water demands	Growth in water demands	Reinstate Sand Forestry	New Forest Dam (Mutlumuvi River)	EWR
S1	Yes	Yes, with no return flows	No	No	No
S4	Yes	Yes, with 50% return flows	Yes	No	No
S51	Yes	Yes, with 50% return flows	Yes	Yes	Yes REC
S52	Yes	Yes, with 50% return flows	Yes	Yes	No
S53	Yes	Yes, with 50% return flows	Yes	Yes	Yes PES
S71	Yes	Yes, with 25% return flows	Yes	Yes	Yes REC
S72	Yes	Yes, with 25% return flows	Yes	Yes	No
S73	Yes	Yes, with 25% return flows	Yes	Yes	Yes PES

INTEGRATED MULTI-CRITERIA RESULTS

The scenario scores for the four variables, Ecology, Ecosystem Services, Economy and Employment were determined (Chapter 7) and weights were selected to assess the balance between the ecological health and the socio-economic benefits (i.e. protection and use). Therefore a weight of 0.5 (or 50%) was assigned to the ecology and the remaining 50% was divided among the other three variables; Ecosystem Services (5%), Economy (20%) and Employment (25%).

Komati River system

Scenario K42 and K6 ranked the highest among the scenarios with both having similar scores. Scenario K6 had the highest employment score while Sc K42 had the highest economic score. The selection of either scenario for the purpose of classification would result in the same Water Resource Class and set of ECs for the biophysical nodes in the system. It was therefore concluded that for the Komati River system the Water Resource Class and the set of ECs for the biophysical nodes was not sensitive to the range of scenarios that were evaluated and analysed.

Crocodile River system

The scenario scores indicated that there is a large advantage in the socio-economic variable scores for Sc C82 compared to Sc C61, while the ecology is maintained at levels slightly above the PES (as represented by Sc C1). This implies Sc C82 is an improvement for both the ecology and socio-economics compared to current conditions (Sc C1) while Sc C61 only improves the ecology.

A further aspect to consider is that the ecological score for Sc C61 is the highest for all the scenarios and as such represents an “extreme” option and not a balanced outcome.

Sabie Sand River system

The Sabie scenario scores indicated that Sc S31 and S32 represented the “extreme” cases where either the ecological protection or the socio-economic benefits was respectively the best or worst. Scenario S6 was therefore formulated as a “compromise” where the growth in water needs for rural/urban areas are supplied from the Sabie River system in order to improve the ecological conditions of Sc S32 towards achieving the REC. Scenario S6 therefore represented the case where a balance was achieved between the need to supply growing water requirements for socio-economic activities while still providing protection of the ecology.

Scenario S6 in the Sabie implied that additional water for growth in water use in the urban domestic sector needed to be sourced and the proposed New Forest Dam in the Sand River system served as a solution to make more water available.

The Sand scenario scores indicated opposing outcomes between ecological protection and socio economic benefits and a compromise would most likely result in the optimum solution – “the desired balance between protection and use”. Considering the need for a possible New Forest Dam identified during the evaluation of the Sabie River system, and the ranking in the Sand, Sc 71 was recommended as the preferred scenario.

DRAFT WATER RESOURCE CLASSES: SUMMARY OF RECOMMENDATIONS AND IMPLICATIONS

It is proposed to gazette the Water Resource Classes and catchment configuration as in the Tables provided below for the immediate target ECs. RQOs were set for the short term ECs.

Komati River system

- The scenario immediately applicable:
  - Maintain the current ecological state and operation of the Komati and Lomati Rivers.
  - Institute measures (non flow-related) to achieve the REC in tributaries of the main rivers (relevant for future scenarios as well).

Implications: No implications to users. The REC in the Lomati River was not achieved under the current situation and the ecological status quo was maintained.

- Long-term scenario / the scenario that may be applicable in future (Sc K42):
  - Maintain the current ecological state.
  - Provision of IIMA flows.
  - Providing water for domestic growth up to the year 2030.
  - Reinstatement of fallow irrigation as suggested by DARDLA.

Implications: No negative economic implications as a whole but a reduction of the assurance of supply in irrigation downstream of Swaziland (other than the DARDLA irrigation).

Komati River system (X1): Draft Water Resource Classes and Catchment Configuration

Note: The red blocks indicate SQs which require non flow-related improvements to achieve the REC.

Note: The purple blocks indicate a change in the target EC once Sc K42 or similar is applicable.

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for:	
					Immediate[1]	Sc K42[2]
X1-1	II	X11A-01300		12.3	B	B
		X11A-01354		25.6	C	C
		X11A-01358	Vaalwaterspruit	23.6	C	C
		X11A-01295	Vaalwaterspruit	12.0	C	C
		X11A-01248	Vaalwaterspruit	30.2	C	C
		X11B-01370	Boesmanspruit	15.7	B	B
		X11B-01361		17.5	B/C	B/C
		X11B-01272	Boesmanspruit	29.1	C	C
X1-2	II	EWR K1	Komati	93	C	C
X1-3	II	X11C-01147	Witkloofspruit	33.5	C	C
		X11D-01129	Klein-Komati	39.6	C	C
		X11D-01137	Waarkraalloop	21.1	C	C
		X11E-01237	Swartspruit	29.3	B	B
		X11F-01133	Bankspruit	17.6	B	B
		X11G-01188	Ndubazi	22.3	B	B
		X11G-01143	Gemakstroom	14.9	C	C
X1-4	III	EWR G1	Mngubhudle	49.6	D	D
		X11K-01165	Poponyane	13.8	C	C
		X11K-01199		8.5	D	D
X1-5	II	EWR K2	Komati	80.8	C	C
X1-6	I	X12A-01305	Buffelspruit	33.6	B	B
		EWR T1	Teespruit	66.1	C	C
		X12B-01246	Hlatjiwe	22.8	C	C
		X12C-01242	Phophenyane	10.7	B	B
		X12C-01271	Buffelspruit	12.5	B	B
		X12D-01235	Seekoeispruit	26.7	C	C
		X12H-01338	Sandspruit	12.6	B	B
		X12H-01340		10.4	B	B
		X12H-01318	Sandspruit	8.3	C	C
		X12J-01202	Mtsoli	54.4	B	B
		X12K-01333	Mlondozi	23.8	B/C	B/C
		X12K-01332	Mhlangampepa	17.0	B	B
X1-7	II	X14A-01173	Lomati	47.7	B/C	B/C
		X14B-01166	Ugutugulo	24.8	C	C
		X14F-01085	Mhlambanyatsi	41.1	C	C
X1-8	III	EWR L1	Lomati	57.3	C	C/D
		X14G-01128	Lomati	23.5	D/E	D/E
X1-9	III	X13J-01214	Mgobode	24.2	C	C
		X13J-01205	Mbiteni	20.0	D	D
		X13J-01141	Mzinti	43.4	D	D
		EWR K3A	Komati	71.21	D	D
X1-10	III[3]	X13K-01114	Komati	5.2	D	D
		X13K-01136	Mambane	19.2	D	D
		X13K-01068	Nkwakwa	44.7	C/D	C/D

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for:	
					Immediate[1]	Sc K42[2]
		X13K-01038	Komati	35.3	E	E
		X13L-01000	Ngweti	44.9	D	D
		X13L-01027	Komati	10.7	E	E
		X13L-00995	Komati	3.1	D	D

1 Immediately applicable until Sc K42 or a similar scenario is implemented.
2 Applicable in the medium to long term.
3 Due to the large sections of river in an E EC, this IUA does not comply with a Level III Water Resource Class The Level III that has been allocated is applicable to the rest of the IUA which is in a D and C/D EC.

Crocodile River system

- The scenario immediately applicable:
  - The current situation which includes the release of a portion of the EWRs that were determined to maintain the PES.
  - Institute measures (non flow-related) to achieve the REC in tributaries of the main rivers (Elands, Crocodile and Kaap rivers) (relevant for future scenarios as well).

Implications: There were no implications to users as this scenario represents the current baseline. The REC in the downstream Crocodile River will not be met and the scenario will in the long term possibly result in deterioration in the PES.

- The scenario that may be applicable in the near future (medium term) (Sc C3):
  - Allow for future domestic growth.
  - Give effect to the IIMA.
  - Supply the full EWR to maintain the PES.

Implications: Some negative impact on GDP and jobs. The REC in the downstream Crocodile River will not be met. The ecological state may improve from Sc C1 but will likely still not achieve the PES.

- The scenario that may be applicable in the far future (long term) (Sc C62):
  - Supply the full EWR to maintain the PES.
  - Allow for future domestic growth.
  - Give effect to the IIMA.
  - Mountain View Dam development in the Kaap River.

Implications: Job losses in the irrigation sector due to the provision of water for the domestic section (improvement from Sc C3). The ecological implications are the same as for Sc C3.

- The scenario that may be applicable in the far future (next phase after Sc C62 has been implemented - Sc C82):
  - Dam developments in both the Kaap River (Mountain View) and the Nels (Boschjeskop) River.
  - Supply the full EWR to maintain the PES.
  - Allow for future domestic growth.
  - Give effect to the IIMA.

Implications: Jobs will increase from the baseline. The ecological implications are the same as for Sc C3.

Crocodile River system (X2): Draft Water Resource Classes and Catchment Configuration

The red blocks indicate SQs which require non flow-related improvements to achieve the REC.

Note: The purple blocks indicate SQs where the catchment configuration, in terms of the Target EC, is different between the current state and future scenario.

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for:			
					Im-mediate	Sc C3	Sc C62	Sc C82
X2-1	II	X21B-00898	Lunsklip	11.0	C/D	C/D	C/D	C/D
		X21B-00929	Gemsbokspruit	8.8	C/D	C/D	C/D	C/D
		X21B-00925	Lunsklip	21.5	C	C	C	C
		EWR C1	Crocodile	30.8	A/B	A/B	A/B	A/B
		EWR C2	Crocodile	30.1	B	B	B	B
		X21C-00859	Alexanderspruit	36.9	C	C	C	C
X2-2	II	EWR C3	Crocodile	58.3	B/C	C	C	C
		X21D-00957	Buffelskloofspruit	27.1	B/C	B/C	B/C	B/C
		X21E-00897	Buffelskloofspruit	14.6	B	B	B	B
X2-3	I	X21F-01100	Leeuspruit	12.9	C	C	C	C
		X21F-01092	Leeuspruit	1.0	C/D	C/D	C/D	C/D
		X21F-01091	Rietvleispruit	13.2	C	C	C	C
		EWR E1	Elands	55.6	B	B	B	B
X2-4	I	X21G-01090	Weltevredespruit	13.8	C	C	C	C
		X21G-01016	Swartkoppiespruit	13.8	C	C	C	C
		X21H-01060	Ngodwana*	20	B	B	B	B
		X21K-01007	Lupelule	20.0	B	B	B	B
X2-5	I	EWR E2	Elands	59	B	B	B	B
X2-6	II	X22B-00987	Crocodile	Linked to EWR C4[4]				
		X22B-00888	Crocodile					
		X22C-00946	Crocodile					
		X22J-00993	Crocodile					
X2-7	I	X22A-00824	Blystaanspruit	19.4	B	B	B	B
		X22A-00887	Beestekraalspruit	7.4	B/C	B/C	B/C	B/C
		X22A-00875	Houtbosloop	10.4	B	B	B	B
		X22A-00919	Houtbosloop	0.7	B/C	B/C	B/C	B/C
		X22A-00920		4.5	B	B	B	B
		X22A-00917	Houtbosloop	2.7	C	C	C	C
		X22A-00913	Houtbosloop	28.3	B	B	B	B
		X22C-00990	Visspruit	10.0	B/C	B/C	B/C	B/C
X2-8	II	X22D-00843	Nels	24.9	C	C	C	C
		X22D-00846		16.7	C	C	C	C
		X22F-00842	Nels	35.1	C	C	C	C
		X22E-00849	Sand	12.7	C	C	C	C
		X22E-00833	Kruisfonteinspruit	9.8	C	C	C	C
		X22F-00886	Sand	29.7	C	C	C	C
		X22F-00977	Nels	6.7	C/D	C/D	C/D	C/D
		X22C-01004	Gladdespruit	36.7	B/C	B/C	B/C	B/C

[4] The IUA results are represented by EWR C4 which is located in a different IUA but in the same Management Resource Unit

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for:			
					Im-mediate	Sc C3	Sc C62	Sc C82
		X22H-00836	Wit	59.2	D	D	D	D
X2-9	II	X22K-01042	Mbuzulwane	10.0	B	B	B	B
		X22K-01043	Blinkwater	16.3	B	B	B	B
		X22K-01029	Blinkwater	3.4	C	C	C	C
		EWR C4	Crocodile	41.3	C	C	B/C	C
X2-10	II	X23B-01052	Noordkaap	7.2	C	C	C	C
		X23C-01098	Suidkaap	22.9	B/C	B/C	B/C	B/C
		EWR K7	Kaap	11.2	C	C	C	C
		X23E-01154	Queens	31.0	B/C	B/C	B/C	B/C
		X23F-01120	Suidkaap	28.6	C	C	C	C
X2-11	II	EWR C5	Crocodile	23	C	C	C	B/C
		EWR C6	Crocodile	99	C	C	C	C
X2-12	II	X24A-00826	Nsikazi	27.8	C	C	C	C
		X24A-00860	Sithungwane	12.4	A	A	A	A
		X24A-00881	Nsikazi	10.3	B	B	B	B
		X24B-00903	Gutshwa	19.1	D	D	D	D
		X24B-00928	Nsikazi	11.9	A/B	A/B	A/B	A/B
		X24C-00969	Mnyeleni	12.4	A	A	A	A
		X24C-00978	Nsikazi	21.2	B	B	B	B
X2-13	I	X24E-00973	Matjulu	17.3	B	B	B	B
		X24E-00922	Mlambeni	39.2	A/B	A/B	A/B	A/B
		X24G-00902	Mitomeni	21.9	A	A	A	A
		X24G-00876	Komapiti	16.0	A	A	A	A
		X24G-00844	Mbyamiti	19.8	A	A	A	A
		X24G-00823	Muhlambamadubo	21.0	A	A	A	A
		X24G-00820	Mbyamiti	28.9	A	A	A	A
		X24G-00904	Mbyamiti	5.2	A	A	A	A
		X24H-00882	Vurhami	36.6	A	A	A	A
		X24H-00892	Mbyamiti	28.8	A	A	A	A

* Note, the B EC is relevant upstream of Godwana Dam. The dam and the short river distance downstream of the dam is in an E Category, but the management of the rest of the river upstream of the dam (20 km) must be in a B.

Sabie-Sand River systems

- The scenario immediately applicable:
  - Maintain the current ecological state and operation of the system.
  - Institute measures (non flow-related) to achieve the REC in the Sabie River upstream of the KNP and various tributaries (relevant for future scenarios as well).
  - May include the reinstatement of forestry in the Sand catchment.

Implications: No implications to users as this scenario represented the current baseline. This scenario will not however cater for an increase in domestic use in the Sabie River in the future. The REC in the Mutlumuvi River was not achieved under the current situation and the ecological status quo was maintained in this river.

- Long-term scenario / the scenario that may be applicable in future (Sc S71):
  - New dam development in the Mutlumuvi River.

- o Supply of the environmental flows supporting the REC in the Mutlumuvi River and downstream Sand River.
- o Assumed increase in return flows of 25% resulting from improved water supply to the Sand catchment.
- o Decreased transfer from the Sabie.

Implications: Significant economic improvement in GDP and jobs in the Sand River. Water for increased domestic growth in the Sabie River will be available. The REC will be maintained in all rivers except the Mutlumuvi River.

Sabie-Sand River system (X3): Draft Water Resource Classes and Catchment Configuration

The red blocks indicate SQs which require non flow-related improvements to achieve the REC.

The purple blocks indicate SQs where the catchment configuration, in terms of the Target EC, is different between the current state and future scenario.

IUA	Water Resource Class	Nodes	River	River length (Km)	Immediate	Sc S71
X3-1	I	X31A-00741	Klein Sabie	14.6	B/C	B/C
		X31A-00783		5.4	C	C
		X31A-00786		5.2	B	B
		X31A-00794		1.1	B	B
		X31A-00796		1.0	B	B
		X31A-00803		0.6	B/C	B/C
X3-2	I	EWR S1	Sabie	**57**	B	B
		X31B-00792	Goudstroom	8.8	B/C	B/C
		EWR S4	Mac-Mac	46.8	B	B
		EWR S2	Sabie		B	B
		X31E-00647a	Marite (US of dam)	19.9	B	B
		X31F-00695	Motitsi	42.8	B	B
X3-3	I	EWR S5	Marite	8.0	B/C	B/C
		EWR S3	Sabie		A/B	A/B
X3-4	III	X31D-00773	Sabani	19.8	C/D	C/D
		X31H-00819	White Waters	32.6	C	C
		X31J-00774	Noord-Sand	16.9	D	D
		X31J-00835	Noord-Sand	13.4	D	D
		X31K-00713	Bejani	17.7	D	D
		X31L-00657	Matsavana	12.8	C	C
		X31M-00673	Musutlu	40.3	B/C	B/C
		X31L-00664	Saringwa	28.9	C	C
		X31L-00678	Saringwa	16.6	B/C	B/C
X3-5	I	X33A-00731	Sabie		A/B	A/B
		X33A-00737	Sabie		A/B	A/B
		X33B-00784	Sabie		A/B	A/B
		X33B-00804	Sabie		A/B	A/B
		X33B-00829	Sabie		A/B	A/B
		X33D-00811	Sabie		A/B	A/B
		X33D-00861	Sabie		A/B	A/B
X3-6	I	X31K-00771	Phabeni	19.2	B	B

IUA	Water Resource Class	Nodes	River	River length (Km)	Immediate	Sc S71
		X31M-00763	Nwaswitshaka	56.0	A	A
		X33A-00661	Nwatindlopfu	25.9	A	A
		X33A-00806	Nwatimhiri	35.5	A	A
		X33B-00694	Salitje	35.4	A	A
		X33B-00834	Lubyelubye	20.7	A	A
		X33C-00701	Mnondozi	46.9	A	A
		X33D-00864	Mosehla	19.9	A	A
		X33D-00894	Nhlowa	9.9	A	A
		X33D-00908	Shimangwana	8.3	A	A
		X33D-00911	Nhlowa	5.7	A	A
X3-7	II	X32E-00629	Nwarhele	18.0	C	C
		X32E-00639	Ndlobesuthu	6.8	D/E	D/E
		EWR S6	Mutlumuvi		C	C
		X32F-00628	Nwarhele	6.5	C/D	C/D
X3-8	II	X32B-00551	Motlamogatsana	27.1	C	C
		EWR S7	Thulandziteka		C	C
		X32C-00558	Nwandlamuhari	15.1	C	C
		X32C-00564	Mphyanyana	11.9	C	C
		X32C-00606	Nwandlamuhari	1.2	C	C
		X32G-00549	Khokhovela	28.0	C	C
X3-9	I	X32H-00560	Phungwe	30.9	A	A
		EWR S8	Sand		B	B
		X32J-00651	Mutlumuvi	24.8	A	A

For each priority RU, priority indicators for which RQOs must be set were selected. The focus of this task was on the moderate priority units as all high priority units (usually represented by an EWR site) would require RQOs for all components.

Once this step was finalised, the RQOs were summarised in numerical and narrative form in a detailed technical report. These results were then summarised in the gazette template in the required format.

GROUNDWATER RESOURCE QUALITY OBJECTIVES

The process followed to develop groundwater RQOs can be summarised as follows:

- Collate and synthesize groundwater data (i.e. GRA II, DWS monitoring data and WARMS information) for each quaternary catchment in each groundwater unit in order to establish:
  - Borehole yields.
  - Groundwater levels.
  - Groundwater harvest and exploitation potential.
  - Existing groundwater (use) abstraction rates.
  - GroundWQ.
  - Baseflow potential.
  - Recharge.

The groundwater RQOs and appropriate numerical limits were based on what information is available and estimations using hydrogeological reasoning. It is understood that the Inkomati is not regarded as a high groundwater priority area and the status quo was largely based on a desktop assessment. In many cases not sufficient monitoring was available or collated to derive detailed RQOs. Where possible, the existing monitoring networks were taken into account in setting the RQOs. Although, the Resource Unit Prioritisation Tool is used it can be applied for rivers, wetlands and estuaries, currently no methodology exists for prioritising groundwater Resource Units (DWA, 2011b). As a result no official criteria and rating guideline was applied for the Inkomati RQO but prioritisation was based on the following main indicators:

- **Importance for users**: Some aquifers in the study area provide significant services for the environment and other users. The importance for users was evaluated with respect to the current and possible future use by the different water sectors.
- **Threat posed to users/receptors**: Depending on the pattern and scale of groundwater abstraction as well as the land use within the resource units, the different aquifers might be at risk of over-abstraction (indicated by aquifer stress and decline in water level) and/or pollution (indicated by decline in WQ), both of which were considered in the prioritisation.
- **Practical considerations**: RQOs can only be implemented and enforced if they can be measured. Hence, the focus was on identifying resource units with a sufficient groundwater monitoring network and existing baseline data to allow for comparison with data collected in the future.
- **Level of surface water – groundwater interaction**: Depending on the aquifer type and its interaction with surface water bodies it has greater or lesser relevance for maintaining the hydrological integrity and WQ of the ecosystem. The aquifer types occurring in the GU and their contribution to surface water low flows were considered, as these could impact on possible management options.

A summary of the criteria used for identifying groundwater priority areas is provided in Chapter 13. A number of water level monitoring boreholes occur throughout the Inkomati. However, the monitoring of ground WQ (collated through the DWS - WMS) is limited and should be expanded or, if possible, ceased monitoring sites should be re-instated.

CONSIDERATIONS FOR IMPLEMENTATION

The processes required to implement the NWRCS and give effect to the RQOs were identified and described in the form of an implementation or roll out plan for the Inkomati.

The overarching approach to be followed in the execution of the implementation plan is that a sequence of activities needs to be introduced to accommodate proposed future infrastructure developments, rollout of ongoing water resource management activities such as the verification of the lawful water use as well as seeking alignment with the progressive implementation of the DWS Reconciliation Strategy and the strategies of the District Municipalities. The implementation plan has been divided into two phases, namely, operation to maintain the status quo and operation to meet recommended EWRs at key points which are currently not being met.

The proposed way forward with regard to the formation of an Implementation Plan Management Committee (IPMC) is described separately for each major catchment comprising the Inkomati in Chapter 14.

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ACRONYMS

AMD	Acid Mine Drainage
CD: WE	Chief Directorate: Water Ecosystems
CEV	Chronic Effects Value
CROC-OC	Crocodile River Operations Forum
CS	Current State
DARDLA	Department of Rural Development and Land Affairs
DS	Downstream
DSS	Decision Support System
DWA	Department of Water Affairs (Change after 2008)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation (Change after May 2014)
EC	Ecological Category
EcoSpecs	Ecological Specifications
EGSA	Ecosystem Goods, Services and Attributes
EI	Ecological Importance
EIS	Ecological Importance and Sensitivity
ES	Ecological Sensitivity
EWR	Ecological Water Requirement
FEPA	Freshwater Ecosystem Priority Area
FRAI	Fish Response Assessment Index
GRA II	Groundwater Resource Assessment Phase II
GUA	Groundwater Units of Analysis
GU	Groundwater Unit
ICMA	Inkomati Catchment Management Agency
IEI	Integrated Environmental Importance
IIMA	Interim IncoMaputo Agreement
IPMC	Implementation Plan Management Committee
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
IUCMA	Inkomati-Usutgu Catchment Management Agency
IWAAS	Inkomati Water Availability Assessment Study
KJOF	Komati Joint Operations Forum
KNP	Kruger National Park
KOBWA	Komati Basin Water Authority
MAR	Mean Annual Runoff
MCM	Million Cubic Metres
MIRAI	Macro Invertebrate Response Assessment Index
MRU	Management Resource Unit
NFEPA	National Freshwater Ecosystem Priority Areas
NGA	National Groundwater Archive
nMAR	Natural Mean Annual Runoff
NWRCS	National Water Resource Classification System
NWRS	National Water Resource Strategy
PES	Present Ecological State
PESEIS	Present Ecological State and Ecological Importance - Ecological Sensitivity
pMAR	Present Day Mean Annual Runoff
PSP	Professional Service Provider
RDRM	Revised Desktop Reserve Model
REC	Recommended Ecological State
RHAM	Rapid Habitat Assessment Method

RQOs	Resource Quality Objectives
RU	Resource Unit
SASS 5	South African Scoring System version 5
Sc	Scenario
SCI	Socio Cultural Importance
SOF	System Operating Forum
SQ	Sub Quaternary catchment
TDS	Total Dissolved Salt
TIN	Total Inorganic Nitrogen
TPCs	Thresholds of Potential Concern
TPTC	Tripartite Permanent Technical Committee
TSS	Total Suspended Solids
TWQR	Target Water Quality Range
US	Upstream
VEGRAI	Vegetation Response Assessment Index
WARMS	Water Use Authorisation and Registration Management System
WMA	Water Management Area
WMS	Water Management System
WQ	Water Quality
WRUI	Water Resource Use Importance
WRYM	Water Resources Yield Model
WWTW	Waste Water Treatment Works
Fish species name abbreviations	
AURA	*Amphilius uranoscopus*
BANO	*Barbus anoplus*
BEUT	*Barbus eutaenia*
BMAR	*Labeobarbus marequensis*
CANO	*Chiloglanis anoterus*
CPAR	*Chiloglanis paratus*
CPRE	*Chiloglanis pretoriae*
VNEL	*Varicorhinus nelspruitensis*
Fish and Macro-invertebrate Habitats	
MV	Marginal Vegetation
SIC	Stones in Current

1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2013 for the provision of professional services to undertake the determination of Water Resource Classes and associated Resource Quality Objectives (RQOs) in the catchments of the Inkomati. IWR Water Resources was appointed as the Professional Service Provider (PSP) to undertake this study which is managed by Rivers for Africa for IWR Water Resources (DWA, 2013a).

1.2 STUDY AREA OVERVIEW

The study area comprises the Komati, Crocodile East and Sabie-Sand rivers (Figure 1.1). These three major tributaries of the international Incomati River Basin are operated largely independently of each other and are therefore described in this section as separate entities.

The Komati River rises in South Africa and flows into Swaziland, then re-enters South Africa where it is joined by the Crocodile River at the border with Mozambique, before flowing into Mozambique as the Incomati River. The Kruger National Park (KNP) is partially located in the Sabie and Crocodile catchments. The Crocodile River is located between the Komati and Sabie rivers.The Crocodile River joins the Komati River just before the border with Mozambique to form the Incomati River. The Sabie River catchment lies in the north of the Inkomati, entering Mozambique after flowing through the KNP.Once in Mozambique, the Sabie joins the Komati River. The Sabie River catchment is considered the most pristine of the six river catchments that cross over from South Africa to Mozambique (DWA, 2013a).

The study area is the catchments of the Inkomati and illustrated in Figure 1.1.

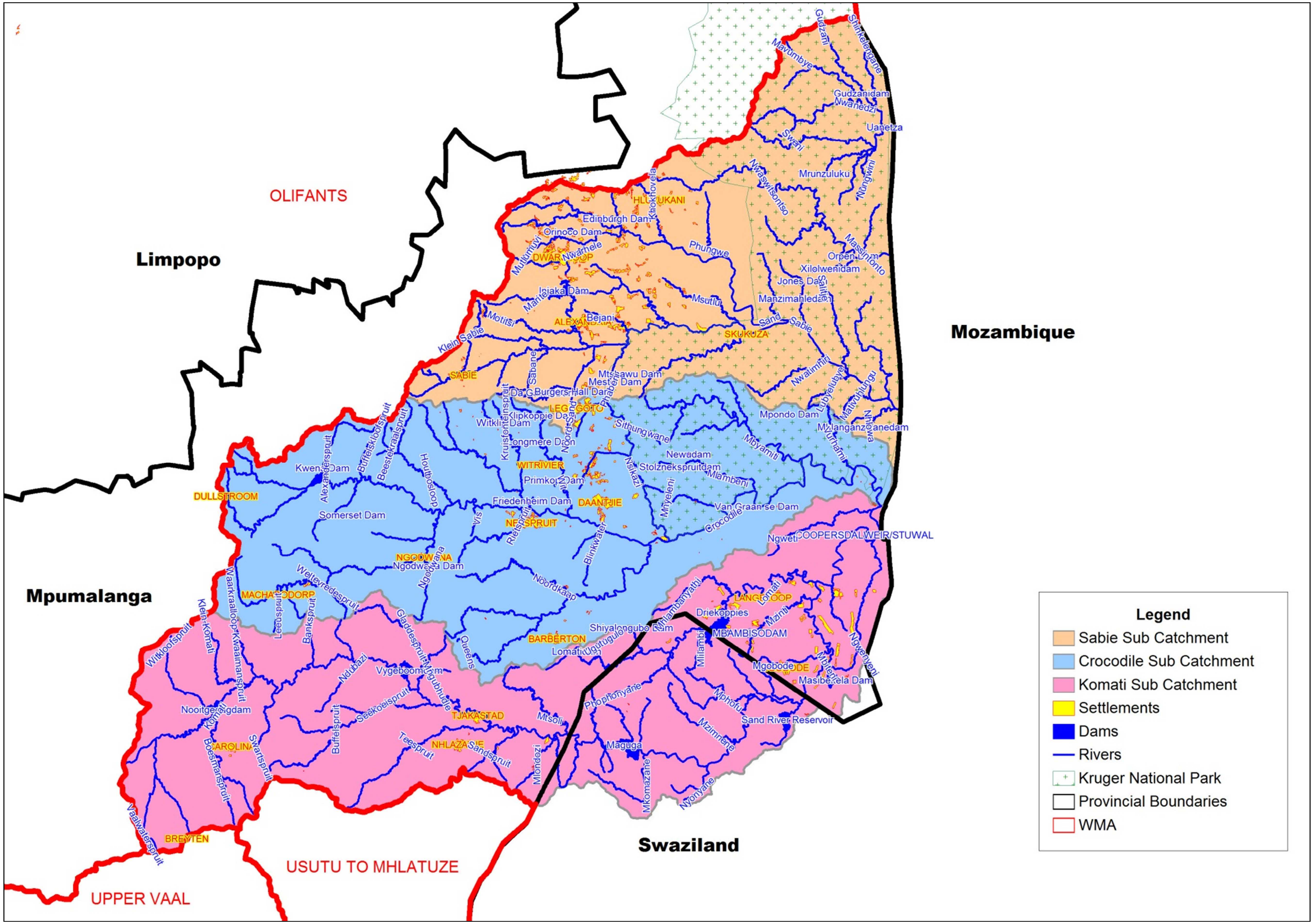


Figure 1.1 Study area – Catchments of the Inkomati (DWA, 2013a)

1.3 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the Water Resource Classification, the Reserve and RQOs (DWA, 2013a) are supplied in Table 1.1.

Table 1.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and Resource Units (RUs), and describe the status quo of the water resource(s).
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the Ecological Water Requirements (EWRs) and changes in non-water quality ecosystem goods, services and attributes.
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

This report summarises the technical report produced as part of step 1, 3, 4, 5, 6 and 7. References are made to each report at the start of the chapter and more detail can be found within the relevant reports.

1.4 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this report is to summarise the technical outcomes of the study.

The report outline is provided below.

Chapter 1: Introduction
This Chapter provides general background to the project.

Chapter 2: Status Quo
This chapter provides a summary of the current status of the water resources in the study area in terms of the water resource systems, the ecological characteristics, the socio-economic conditions and the community well-being based on various multi-disciplinary methodologies adopted during this task of the project.

Chapter 3: Integrated Units of Analysis
The Chapter summarises the delineation of Integrated Units of Analysis (IUA) in order to establish broader-scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on ecological conditions at a sub-quaternary scale.

Chapter 4: Hotspot Identification
The Chapter outlines hotspots which are river reaches with a high Integrated Environmental Importance and could be under threat due to its importance for water resource use. The areas would require detailed investigations if development was being considered.

Chapter 5: Ecological Water Requirements
The main aspect of the Chapter is EcoClassification and EWR determination at various biophysical nodes in the system. This chapter summarises the EWRs set during the 2006 comprehensive EWR study at seven key biophysical or EWR sites.

Chapter 6: Description of Scenarios

This Chapter focuses on identifying and describing the various operational scenarios that were evaluated during the study.

Chapter 7: Ecological Scenario Consequences

The results of the ecological consequences of the various scenarios are presented in this Chapter.

Chapter 8: Ecosystem Services Scenario Consequences

The results of impact of the different scenarios on Ecosystem Services are presented in this Chapter.

Chapter 9: Economic Scenario Consequences

The results of different scenarios as it impacted on the different economic sectors are presented in this Chapter.

Chapter 10: Water Quality (User) Consequences

The approach undertaken to include non-ecological water quality into the consequences evaluation and the results are provided in this Chapter.

Chapter 11: Water Resource Classes

The recommended Water Resource Classes among the scenarios are presented. Conclusions and recommendations are provided.

Chapter 12: River Resource Quality Objectives

This chapter outlines the RQOs of the various components per Integrated Unit of Analysis. RQOs are provided for hydrology of Rivers expressed in terms of flow at biophysical nodes and EWR sites and river habitat, biota and water quality. The Chapter also includes RQOs for habitat and biota in HIGH priority wetlands and narrative and numerical RQOs for groundwater expressed in terms of guidelines and limitations of groundwater abstractions.

Chapter 13: Groundwater Resource Quality Objectives

The delineation of Groundwater Units is outlined in this Chapter and the process followed to develop groundwater RQOs is also provided. A summary of the criteria used for identifying groundwater priority areas and groundwater RQOs are included.

Chapter 14: Implementation Considerations

The chapter describes the principles and aspects to consider for implementing the National Water Resources Classification System including the actions needed as well as a timeline to give effect to the RQOs. Monitoring to measure whether the RQOs are being achieved is also provided.

Chapter 15: References

Chapter 16: Appendix A: Visioning Summary

Infomration regarding the stakeholders' catchment vision for the Inkomati is provided.

Chapter 17: Appendix B: Report Comments

Report comments from the Client are provided.

2 STATUS QUO

This chapter is an extract from report: DWA (2013b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: Status Quo assessment, Integrated Unit of Analysis delineation and biophysical node identification. Prepared by: IWR Water Resources. Authored by: Mallory S, Louw D, Deacon A, Holland, M, Huggins G, Kotze P, Mackenzie J, Scherman P, Van Jaarsveld P,. DWA Report, RDM/WMA05/00/CON/CLA/ 0213. September 2013.

2.1 BACKGROUND

The purpose of this task was to describe and document the status quo task which includes various components such as water use, economy, river and wetland ecology, identifying water quality problems and Ecosystem Goods, Services and Attributes (EGSA). This information was used to define the Integrated Unit of Analysis (IUA) and provide background information to assist with the catchment visioning process. Once the IUAs are delineated, Resource Units (RUs) and biophysical nodes must be identified for different levels of Ecological Water Requirement (EWR) assessment and setting of RQOs.

2.2 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the Water Resource Classification, the Reserve and RQOs are supplied in Table 2.1.

Table 2.1 Integrated study steps

Step	Description
1	**Delineate the units of analysis and Resource Units, and describe the status quo of the water resource(s).**
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the Ecological Water Requirements and changes in non-water quality ecosystem goods, services and attributes.
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

This Chapter as well as Chapters 3 and 4 form part of Step 1, i.e. delineating the IUAs and describing the status quo of the water resources for each IUA.

2.3 WATER RESOURCES STATUS QUO ASSESSMENT

Water resource zones (based on similar water resource operation), location of significant water resource infrastructure (including proposed infrastructure) and distinctive functions of the catchments within the context of the larger system were identified and are described in this report.

Upper Komati (X11 and X12): The water resources of the Upper Komati are dominated by two large dams, the Nooitgedacht and Vygeboom dams from which water is transferred out of the catchment to power stations. There is limited other use in these upper reaches, although domestic requirements are increasing rapidly and there are large areas under commercial forestry.

Lower Komati (X13): The Lower Komati is dominated by extensive irrigation, mostly sugarcane. Water for these activities is supplied mostly from the Maguga Dam, located in Swaziland. Domestic use in this area is increasing rapidly as towns and villages expand and water service delivery improves.

Lomati (X14): The Lomati catchment is similar to the Lower Komati with extensive irrigation, supplied in this case from the Driekoppies Dam which is located on the border of Swaziland and South Africa. Domestic use is also significant in this catchment. Two smaller dams (Lomati and Shiyalongubo) located in the upper reaches of the Lomati catchment (upstream of Swaziland) transfer water to the Kaap River catchment. There are also significant areas of afforestation in the upper reaches of the Lomati catchment.

Upper Crocodile (X21): The Kwena Dam, located in the Upper Crocodile, is by far the most important dam in the Crocodile catchment. Water from this dam supplements the water supply to irrigators along the Crocodile as well as to major urban centres of Nelspruit and Kanyamazane. While a large proportion of the water used in the Crocodile catchment is sourced from the Upper Crocodile, water use in the upper Crocodile itself is limited. There is limited irrigation in the Elands River catchment and in Schoemanskloof along the Crocodile River. Commercial forestry is however a major water user in this area as is the industrial water use associated with the paper mill located at Ngodwana. Domestic water use is limited.

Middle Crocodile (X22): The Middle Crocodile has limited water resources of its own with the large irrigators and domestic users (Mbombela municipality) abstracting water from the Crocodile River, supplemented with releases from the Kwena Dam. However, within the White River area several small dams are located, including the Witklip, Klipkopjes, Longmere and Primkop dams which supply water to the town of White River as well as to irrigators. There are also large areas of forestry in the Middle Crocodile with resulting streamflow reduction.

Kaap (X23): The Kaap River does not have any significant dams and irrigators rely on run-of-river as well as small farm dams to meet their water requirements. The domestic water requirements of Barberton are met mostly from the Lomati Dam, located in the neighbouring Lomati catchment. Water is also transferred from the Shiyalongubo Dam (also located in the Lomati catchment) to irrigators in the Louws Creek area (lower Kaap). There are significant areas of forestry on the mountain ranges surrounding the Kaap River catchment.

Lower Crocodile (X24): The Lower Crocodile catchment is characterised by extensive irrigation, supplied from the Crocodile with flows supplemented with releases from the Kwena Dam. The rainfall in this area is however too low for forestry. A large part of this catchment is located within the Kruger National Park and is undeveloped. Domestic use is very limited but there is a significant industrial use associated with the sugar mill located near Malelane.

Upper and Middle Sabie (X31): There are two significant dams in the Sabie catchment, the Da Gama Dam, which supplies irrigators, and the much larger Inyaka Dam which was built primarily to supply domestic users in the Sand River and support the EWR of the Lower Sabie. Domestic use in the Sabie catchment has grown rapidly over the past few years and there are now significant abstractions from the Sabie River for domestic use. In addition to the irrigators supplied from the Da Gama Dam, there are large areas of irrigation in the Upper Sabie which rely on run-of-river abstractions and numerous farm dams. The Upper Sabie is well known for its extensive commercial afforestation with resulting streamflow reduction.

Sand River (X32): The Sand River, a major tributary of the Sabie River, is significantly drier than the neighbouring Sabie River and with insignificant water resources development; irrigation is limited to two run-of-river schemes. The catchment is however home to a large semi-rural population with large water requirements which are now largely met by transfer from the Inyaka Dam in the Sabie River catchment. There is limited forestry development on the eastern escarpment of the Sand River catchment.

Lower Sabie (X33): The lower reaches of the Sabie River lie within the KNP and are undeveloped. However, the ecological sustainability of the Sabie River is dependent on sound management of the catchment, river and dam upstream of the KNP.

X40: The X40 catchments are very dry and lie entirely within the KNP. These catchments are undeveloped.

2.4 GROUNDWATER USE

Groundwater classification is used to define the present status of the groundwater resource and to identify ways to manage the groundwater resource in a sustainable manner. Groundwater classification aims in this regard to maintain a balance between the protection of a groundwater resource (including dependent ecosystems) and its use to meet economic and social demands.

The delineation of Groundwater Units of Analysis (GUA) is based on hydrogeological criteria and might not necessarily correlate to quaternary surface water catchments or surface water units of analysis. A total of 19 GUAs were delineated based on the following criteria:

- Surface water units of analysis as part of this project.
- The four main Inkomati sub-catchments were considered, namely the Komati, Crocodile, River/Sand and the undeveloped X4 sub-catchment in the KNP.
- The quaternary drainage areas were considered as the basis of delineation.
  - o Quaternary drainage areas with similar hydrogeological characteristics were grouped into one GUA. The dolomites were a far as possible grouped into separate GUA, while including the quaternary drainage areas contributing to its run-off.
- Hydrogeological criteria (including geology, geomorphology and topography).

From the available ~ 4900 geo-sites only ~2500 sites contain information on either water level or yield. From these geo-sites only ~1000 sites have a coordinate accuracy of less than 1 km. The results are summarised as follows:

- Komati River system (X1)
  - o Average water levels range from 7 to 25 m below surface; with the deepest water levels found in the Nelspruit Suite basement (GUA1-6) and Karoo (basalt) (GUA1-7) aquifers.
  - o Highest borehole yields are associated with the Barberton basement aquifer (GUA1-5), while yields below the population (Inkomati) average are found in GUA1-2 to GUA1-4. It must be noted that a limited number of boreholes with yield data were available for these GUAs and might distort the assessment.
  - o The deepest average borehole depth is found in the Nelspruit Suite basement- (GUA1-6) and the Karoo- (basalt) (GUA1-7) aquifers. Drilling depths below the population (Inkomati) average are found in GUA1-2, GUA1-4 and GUA1-5.
- Crocodile River system (X2)
  - o Average water levels range from 13 to 24 m below surface, while the deepest water levels are found in the Pretoria Group- (GUA2-1) and the Basement (GUA2-5) aquifers respectively.

    - Highest borehole yields are associated with the Malmani dolomites (GUA2-3), while yields above the population (Inkomati) average are also found in GUA2-1 to GUA2-5. The lowest borehole yields are associated with the basement complex (GUA2-4) aquifer.
    - Average borehole depths range from 43 to 74 m below surface.
- Sabie-Sand River system (X3)
    - Average water levels range from 8 to 19 m below surface, which is considerably shallower than in the Komati- and Crocodile sub-catchments.
    - Borehole yields are unfortunately also generally lower compared to the Komati and Crocodile sub-catchment. The Basement (GUA3-3 and GUA3-4) aquifers have a higher average yield in comparison to the Karoo (GUA3-5) aquifers.
    - Average borehole depths range from 50 to 90 m below surface. Despite shallower water levels compared to the Komati and Crocodile sub-catchments, the drilling depths are on average deeper than the these sub-catchments.
- X4 River system
    - Average water levels are 15 m below surface with an average borehole yield of 1.5 l/s, which is lower than the total population (Inkomati) average.

2.5 STATUS QUO OF THE ECONOMY

The environmentally sustainable development and management of water resources of the Komati River, Crocodile River and Sabie-Sand River systems is a serious and complex issue if one takes into account the vast potential for economic development within the catchment which requires water to ensure that the development does take place and can also be sustained. It is technically challenging and often entails difficult trade-offs between social, economic and political considerations.

The Kaap River, Crocodile River and the Sabie-Sand River catchments face a number of water resource challenges. Greatest of these challenges is sharing scarce water resources between various competing needs. Already, a large part of the catchment is threatened by water scarcity or an already over allocation of water – and yet there are new needs for water that must still be met.

The economic significance of water uses in the Inkomati is dominated by primary sectors such as irrigated agriculture and commercial forestry, subsequently by secondary industries in particular saw and sugar mills as well as a pulp and paper processing plants. Tertiary flow of the economy represents the tourism sector. The Inkomati covers the very important economic hubs of Mbombela Local Municipality (Nelspruit) and Nkomazi Local Municipality which together represent more than 61% of the industrial output of the study area.

It is also a very important agricultural region hosting large sugar cane production areas throughout the study area with the accompanying sugar mills. A large variety of other agricultural products are produced varying from vegetable, citrus and macadamia production in the catchment.

The Inkomati catchment area includes some of the most popular tourist and holiday areas in the country varying from a holiday destinations along the Panorama Route, including Sabie and Hazyview. The KNP forms part of the Crocodile and Sand River catchments, and still one of the most popular tourist destinations for local and international tourists. The catchment has a large number of holiday resorts and game farms which further enhances the importance of tourism in the catchment.

A total of 14 Economic Regions were identified across the Inkomati, 4 economic zones in the Komati River system, 7 economic zones in the Crocodile system and 3 economic zones in the

Sabie-Sand system. In all the regions the agricultural related industry is prominent. Irrigation agriculture with commercial forestry is present in all three the catchments, while the majority of industries are located in the Crocodile catchment.

2.6 WATER QUALITY ISSUES

General land use practices that pose water quality problems within the study area include the following:

- Non-point source pollution from agriculture (pesticides, fertilizers).
- Non-point source pollution from residential areas (urban and rural townships) e.g. stormwater run-off, washing in rivers.
- Point source pollution from urban infrastructure (e.g. non-compliant wastewater treatment works, saw mills and paper and pulp mills in the X3 Sabie catchment, sugar mills and processing facilities in the X2 Crocodile catchment).
- Microbiological counts and nutrient concentrations are problematic in many catchments, as indicated by high algal growth.
- The presence of alien invasive plants, removal of vegetation and overgrazing within the riparian zone of rivers, which results in erosion and sedimentation.
- Dams are scattered throughout the catchments, which impact on the movement of sediment, and temperature and oxygen levels.
- Mining and manufacturing water quality issues were reported in a 2012 study on the Crocodile catchment (Palmer *et al*., 2012), i.e. chemicals from metal processing, such as iron and manganese; acid mine drainage; water seepage and improper closure of mine dumps.

The following Water Quality (WQ) hotspots have been identified and summarised below.

Komati River system (X1):

1. Gladdespruit (X11K-01194): Impacts are related to a reduction in low-flows due to forestry, water quality problems due to acid mine drainage from old gold mines, sulphates and raw sewage, erosion and sedimentation, alien invasives and trout dams.
2. Komati River (X13J-01130): Sewage effluent and extensive settlements resulting in elevated nutrients.
3. Teespruit (X12E-01287): Sewage effluent resulting in elevated nutrients in the lower reaches.
4. Boesmanspruit (X11B-01272): Four open-cast mines in the Boesmanspruit catchment have impacted on water quality in the area.
5. Seekoeispruit (X12D-01235): A number of Waste Water Treatment Works (WWTWs) result in elevated nutrients and increased salination around Badplaas.
6. Lomati River (X14E-01151, X14G-01128, X14H-01066): Stretch includes Driekoppies Dam and impacts on temperature and oxygen; also elevated nutrients from irrigation return flows.
7. Middle Komati River (X13G-01282, X13H-01281, X13H-01277, X13H-01280): Irrigation return flows.
8. Lower Komati River (X13K-01114, X13J-012210, X13J-01210, X13J-01149): Irrigation return flows.
9. Lower Komati River (X13K-01114, X13J-012210, X13J-01210, X13J-01149): Irrigation return flows.
10. Lower Komati River (X13K-01038, X13L-01027, X13L-00995): Extensive agricultural activities and irrigation return flows, exacerbated by low flows.

Crocodile Riversystem (X2)

1. Crocodile River (X22K-00981): Extensive urban impacts from the Kanyamazane and Kabokweni area, including High Risk WWTW at Kabokweni which drains into the Crocodile River.
2. Crocodile River (X24C-01033): Impacts are from extensive settlements on the left bank and irrigation on the right bank.
3. Crocodile River (X24D-00994): Urban impacts, including extensive irrigation effluent impacting on water quality due to the Critical Risk WWTW at Malelane and the High Risk WWTW at Mhlatikop.
4. Crocodile River (X24H-00880): Irrigation effluent and upstream impacts.
5. Crocodile River (X24H-00934): Extensive irrigation effluent impacting on water quality and a Critical Risk WWTW at Komatipoort.
6. Crocodile River (X24F-00953): Extensive irrigation effluent impacting on water quality and a Critical Risk WWTW at Hectorspruit.
7. Gutshwa River (X24B-00903): Extensive urban and rural impacts from the Kabokweni and Malekutu towns.
8. Elands River (X21F-01046; around Machadodorp only): Urban impacts, including the Critical Risk WWTW at Machadodorp and ferro-chrome processing.
9. Noord-Kaap (X23B-01052): Mining and water treatment impacts present.
10. Kaap River (X23G-01057): Mining activities and forestry in the upper catchment.
11. Elands River (X21K-01035): Impacts from Sappi Ngodwana directly into the Elands, and from impacts on the lower end of the Ngodwana Dam.
12. Crocodile River (X22J-00993): Urban impacts from Nelspruit. Diffuse source releases from Papas Quarry at the confluence with the Gladdespruit, is a source of increased manganese concentrations in the Crocodile River.
13. Crocodile River (X22J-00958): Urban impacts from Nelspruit.
14. Crocodile River (X22K-01018): Upstream impacts from Nelspruit, Kanyamazane and Kabokweni areas.
15. Wit River (X22H-00836): Urban impacts from White River and Kabokweni and agricultural impacts.

Sabie and Sand River systems (X3 and X4):

1. A tributary into the Sabie River (X31K-00752): Effluent discharge from the Manghwazi WWTW causing high nutrient levels and introducing hazardous microbiological organisms into the system.
2. Sabie River (X31D-00755): Hazyview WWTW. In addition, vegetation removal is high and irrigation is extensive within this catchment, with moderate irrigation effluent impacting on water quality.
3. Ndlobesuthu (X32E-00639): Urban run-off, effluent discharge and vegetation removal represent predominant and critical impacts. Sedimentation and erosion is serious. Indirect impacts are probably high turbidity and nutrient levels, the latter indicated by elevated algal growth.
4. A tributary - Klein Sand River/Acornhoek (into Marite River: X31E-00647): Effluent discharge from the Acornhoek WWTW causing high nutrient levels and introducing hazardous microbiological organisms into the system. According to the DWA State of Rivers report, conditions are poor in the Klein Sand River, due to clearing of riparian vegetation and resultant erosion, coupled with alien plant infestation (DWAF, 2002).
5. Marite River (X31E-00647): Urban run-off and effluent from urban areas are the predominant water quality related impacts, along with extensive afforestation, vegetation removal and erosion, which most likely results in high turbidity levels and nutrient concentrations.

6. Marite River (X31G-00728): High algal growth is evident probably due to high nutrient inputs from irrigation run-off and agriculture. Erosion, alien vegetation, and vegetation removal are also evident, with small impacts relating to urban run-off/effluent, sedimentation, and overgrazing. Indirect impacts are probably high turbidity and nutrient levels. According to the Inkomati Reserve Study of 2007 – 2010 (DWA, 2009a), increased suspended solids loads, elevated nutrients and toxics, as well as temperature and oxygen fluctuations at low flows occur. This is due to extensive citrus cultivation in the area and clearing for subsistence farming. The diatom *A. minutissimum* indicates anthropogenic disturbances and the presence of diffuse pollutants (upstream citrus farming) (EWR 5). According to the PESEIS study Fact Sheets (DWS, 2014a) irrigation run-off is moderate, which may result in pesticide and fertilizers discharging into the river.
7. Noord-Sand (X31J-00774): High algal growth is evident probably due to urban and irrigation run-off/effluent. Extensive vegetation removal and moderate afforestation probably results in high turbidity levels. Moderate impacts associated with erosion, alien vegetation, overgrazing and irrigation effluent are also evident. Indirect impacts are probably high turbidity and nutrient levels.
8. Noord-Sand (X31J-00835): Urban run-off and effluent from urban areas are the predominant impacts, with moderate levels of algal growth being the likely result of effluent discharges. Alien vegetation, overgrazing and irrigation effluent are also evident. Indirect impacts are probably high turbidity and nutrient levels.
9. Bejani (X31K-00713): Urban run-off, effluent discharge (i.e. Mkhuhlu WWTW) and vegetation removal represent serious impacts. Sedimentation and algal growth is high, with moderate erosion impacts. Indirect impacts are probably high turbidity and nutrient levels, especially since algal levels are high, as well as hazardous microbiological organisms.
10. A tributary that flows into Inyaka Dam, proximate to Marite River (X31G-00728): Effluent discharge from the Maviljan WWTW causing high nutrient levels and introducing hazardous microbiological organisms into the system.
11. Thulandziteka (X32A-00583): The Reserve study of 2007 – 2010 (DWA, 2009a) indicated a C Category for this river, with elevated nutrients, turbidity and toxics present. Impacts on temperature and oxygen were also seen due to fluctuating flows.

2.7 ECOLOGICAL GOODS, SERVICES AND ATTRIBUTES STATUS QUO

The present-day status in terms of Ecosystem Services, based on the economic and social importance assessed from a literature review as well as mapping information, is described. The objective of describing communities and their well-being is to provide the baseline against which to estimate changes in social wellbeing for each of the scenarios that will be evaluated. It should be noted that the objective in describing and valuing the use of aquatic ecosystems is to determine the way in which aquatic ecosystems are currently being used in each IUA, and to qualitatively estimate the value generated by that use. This will provide the baseline against which the scenarios can be compared.

The population estimate for the catchments of the Inkomati is approximately 2 350 000 people or about 4.5% of the total South African population. It is estimated, based on the 2011 Census (Census, 2011) that approximately 67% of the population are living in the rural areas. Many of the settlements in the Inkomati that are classified as rural are being upgraded through the provision of services, and it might now be more appropriate to classify much of the population in these settlements as urban rather than rural. The term “peri urban” or “closer settlement”, is sometimes used.

Five different land use forms that reflect types of EcoSystem Services that might be associated with the usage have been identified. The land use based zones are:

- Recreation and Game Parks: Here the usage is largely recreational linked to the aesthetic appeal. The KNP and adjacent game parks make up the bulk of these zones.
- Commercial Agriculture and Forestry Plantation: This is largely given over to zones dominated by commercial farming entities. Utilisation of ecological goods and services tends to be low and restricted often to farm workers or incidental recreational aspects.
- Subsistence Agriculture: These areas are dominated by subsistence agriculture but in areas where population densities are relatively low. Utilisation of ecological goods and services tends to be higher here and the populations that make use are often poor and marginal.
- Rural Closer Settlement – Subsistence: These are the former homeland/tribal areas that have generally higher population densities than the purely subsistence areas. In some instance densities are high enough to be categorised as closer settlement/informal urban. Utilisation of ecological goods and services tends to be higher here and the populations that make use of them are often poor and marginal. However, the population densities are such that resources tend to be under pressure. Bushbuckridge is a typical example.
- High Density Formal Urban: These are the Sub Quaternary catchments (SQs) heavily influenced by the formal towns such as Nelspruit, Hazyview, Sabie, and Malelane and the surrounding suburbs and satellite townships. The utilisation of ecological goods and services tends to be low as the populations tend to be urbanised and alienated from direct use of the resources.

The most important Ecosystem Services associated with the overall system and likely to be impacted by changes in operational and management scenarios are the following:

- Recreational fishing.
- Subsistence fishing.
- Other recreational aspects associated with the rivers.
- Thatch grass harvesting.
- Reed harvesting.
- Other Riparian vegetation usage including usage of plants for medicinal purposes.
- Sand mining.
- Waste water dilutions.
- Floodplain agricultural usage of subsistence purposes.
- The aesthetic value of the river and associated aquatic systems in their intersection with the recreation value of the KNP and other associated features.
- Dis-benefits associated with malaria, bilharzia, black fly and livestock disease.

There were no scores in the "Very High" importance range. The bulk of those scoring HIGH did so either because of the recreation and aesthetic value associated with the conservation areas such as the KNP or the high dependence on resources associated with poor and vulnerable communities located within the SQ (Table 2.2).

Table 2.2 Sub Quaternary reaches with high Ecosystem Services dependence

SQ number	River	Summary of Status Quo and linked Ecosystem Services Importance
X13B-01347		River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive so social value is considered to be high.
X13B-01348		River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive so social value is considered to be high.
X14C-01212	Phophonyane	Upper reaches (upper 50%) comprised solely of commercial agriculture (sugar cane) with no presence of human habitation. River extends past the Piggs peak area so

SQ number	River	Summary of Status Quo and linked Ecosystem Services Importance
		elevated tourism/recreational value. Lower reaches (lower 50%) extends into the Komati township which has extensive rural homestead and informal agriculture along the river.
X14C-01203	Phophonyane	River section extends into the Lomati township which has extensive rural homesteads and informal agriculture along the river.
X14D-01174	Lomati	River section extends into the Lomati township which has extensive rural homesteads and informal agriculture along the river.
X14E-01172	Mlilambi	The upper reaches of the river section is located in Swaziland, and an area comprised of scattered rural homesteads, informal agricultural plots and open terrain. The lower reaches of the river extends into an area of higher population density (linked to the Hlohlo township) and extensive informal subsistence farm plots.
X13B-01270	Umlambongwe nya	Upper reaches of the river section extends through plantation forestry, and a large farm dam. The river then passes the rural village of Ndzingeni (which contains both households and industrial features). The lower half of the river section extends through a mosaic of rural homesteads with informal agriculture, open terrain.
X13C-01364	Mbuyane	The river section headwaters are located in Malolotja Nature Reserve in Swaziland. Much of the river extent is, however, a mosaic of rural homesteads, informal agriculture and open terrain.
X13D-01323	Komati	Much of the river extent is a mosaic of rural homesteads, informal agriculture and open terrain. Formal small-holdings noted. .
X13E-01389	Nyonyane	River section extends largely through a mosaic of open terrain and formal smallholdings (small-scale agriculture). Rural homesteads noted but not extensive
X13E-01346	Komati	Upper reaches of the river section comprised of open terrain. Mid-reaches extend north of a large rural settlement of Bhalekane and extensive informal agricultural fields. Commercial agriculture also present on the lower reaches.
X13F-01252	Mzimnene	Upper portions of the river section comprised of plantation forestry. Upper and mid-section of the river extend through a mosaic of open terrain, and rural homestead with extensive informal agriculture. Lower reaches extend into moderate density township (Bhalekane) with commercial agriculture on the river banks
X13G-01261	Mphofu	Upper reaches of the river extends through a mosaic of plantation forestry and natural forests. Lower reaches extend through rural settlement (low density homesteads) with extensive informal agricultural plots.
X13G-01216	Mbulatana	River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive along much of the river extent so social value is considered to be high.
X13G-01259	Mphofu	River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive along much of the river extent so social value is considered to be high.
X13G-01282	Komati	River section is flanked on both banks by extensive commercial agriculture. Beyond the agricultural fields, is extensive rural settlement (low-density homestead) which flanks the river on certain sections.
X13H-01197	Mhlangatane	River section extends through a mosaic of low-density, rural homesteads with extensive informal agricultural plots present and open terrain. Commercial agriculture is present on the lower reaches of the river.
X13H-01226		River section extends through a mosaic of low-density, rural homesteads with extensive informal agricultural plots present and open terrain. Commercial agriculture is present on the lower reaches of the river.
X13H-01299		Upper reaches of the river section extends through rural settlements (rural homesteads) and extensive informal agricultural fields. Mid-reaches of the river section extend into open terrain/natural terrain with no human presence before discharging into the Sand River Reservoir. Lower reaches extend below the dam wall and cross commercial agricultural land.
X13H-01281	Komati	Small section of river which extends through commercial agricultural land, with rural homesteads found on the north bank.
X13J-01214	Mgobode	River section extends through open terrain and informal agricultural plots, of which the plots are linked to the Mgodobe Township located further down the river. The mid-reaches of the river extend through open terrain. The lower reaches of the river extend through the Madadeni Township, with some informal agricultural plots noted.
X13J-01141	Mzinti	River section is extends through extensive informal agricultural plots on it upper reaches, which are linked to the large Magogeni township located further down the river. The river extends through two additional large townships (Skoonplaas and Boschfontein). The lower reaches of the river include open terrain and an additional township (Mzinti).
X13K-01068	Nkwakwa	River section extends through a mosaic of open terrain, rural townships and limited informal agricultural plots. Lower-reaches of the river extend through commercial agriculture.
X14E-01151	Lomati	The river section is located in Swaziland and extends through extensive commercial

SQ number	River	Summary of Status Quo and linked Ecosystem Services Importance
		agriculture (sugar cane). The river extends into the Hlohlo township before discharging into the Driekoppies Dam in South Africa.
X24A-00826	Nsikazi	Upper reaches of the river section extends through Legogote Township and Manzini. Mid-reaches are comprised of open terrain and passes the Makoko Township.
X24C-00978	Nsikazi	Upper reaches of the river section passes the Ehlanzeni township, and then extends through open/natural terrain, associated with a nature reserve. Lower reaches of the river passes the Matsulu township.
X31K-00713	Bejani	River extends through open terrain. Marongwana township located on the north bank on the upper reaches of the river. Much of the mid and lower-reaches extend through extensive rural townships.
X31M-00673	Musutlu	River extends through open terrain. Three large townships located on the banks of the river.
X32E-00629	Nwarhele	Upper section low population density some forestry then very dense settlement of Shatale and Dwarsloop.
X32E-00639	Ndlobesuthu	Short river section with very dense settlement of Marijane and Dwarsloop.

2.8 ECOLOGICAL STATUS QUO: RIVERS

Data from the Present Ecological State and Ecological Importance - Ecological Sensitivity (PESEIS) project (DWS, 2014a) was used as the baseline for the status quo assessment of 237 river reaches covering the study area. The PES is described in terms of Ecological Categories (EC) of A to F with A being almost natural and F meaning critically modified. Reasons for the change from natural are provided and it is indicated whether these are flow (e.g. abstraction) or non-flow (e.g. riparian vegetation removal or land use practices) related.

2.8.1 Komati River system (X1)

The Komati River in South Africa and Swaziland is extensively modified through flow regulation and inundation (large number of dams and weirs). In the lower Komati downstream of Swaziland there are basically no sections of river left that have not been inundated. Other notable impacts in the Komati catchment include forestry, some mining in the upper areas, sections with extensive alien vegetation, overgrazing and sedimentation.

There are 10 SQ reaches in a B PES (outside of Swaziland). Most of these reaches are upstream of Swaziland. The reasons for the relatively good state are due to inaccessibility related to the mountainous terrain. The upper Komati (upstream from Swaziland) is primarily in a C (and B/C) Present Ecological State (PES) with the most significant impacts being irrigation, agriculture, mining, flow regulation, inundation, forestry and alien vegetation. Downstream of Swaziland and the eastern sections of Swaziland is dominated by D rivers, with seven SQ reaches in an unacceptable D/E and E PES. The reasons for these are inundation, irrigation to the river's edge and return flows, barriers, sedimentation and flow regulation. A summary is provided in Table 2.3.

Table 2.3 Komati River system (X1): River PES and key drivers resulting in modification from natural

SQ reach	River	PES (EC)	Primary PES driver
X11A-01300		B	Non-flow: Sedimentation from grazing.
X11A-01354		C	Non-flow: Barriers of many farm dams and inundation of habitat.
X11A-01358	Vaalwaterspruit	C	Non-Flow: Barriers (farm dams), inundation, grazing.
X11A-01295	Vaalwaterspruit	C	Flow: Upstream farm dams and in tributaries. Non-Flow: Agricultural fields, grazing, mines in tributaries.
X11A-01248	Vaalwaterspruit	C	Non-Flow: Agricultural fields, grazing. Flow: Upstream farm dams and in tributaries.
X11B-01370	Boesmanspruit	B	Non-Flow: Grazing.

SQ reach	River	PES (EC)	Primary PES driver
X11B-01361		B/C	Non-flow: Linked to grazing, bed and channel disturbance, agricultural fields and alien vegetation.
X11B-01272	Boesmanspruit	C	Non-flow: Grazing, alien vegetation. Flow: Upstream dams and large dam (Boesmanspruit Dam).
X11C-01147	Witkloofspruit	C	Flow: Dams, irrigation. Non-flow: Barrier effect of farm dams, agricultural fields, grazing, alien vegetation.
X11D-01129	Klein-Komati	C	Non-flow: Barrier effect and inundation from numerous farm dams. Flow: Not as important as above, but also plays a role as many dams in tributaries (but probably mostly for trout).
X11D-01137	Waarkraalloop	C	Non-flow: Barrier effect and inundation from numerous farm dams. Grazing.
X11D-01219	Komati	C/D	Flow: Upstream Nooitgedacht Dam with no environmental releases.
X11D-01196	Komati	C	Flow: Upstream Nooitgedacht Dam with no environmental releases.
X11E-01237	Swartspruit	C	Non Flow: WQ (trout), barriers. Agricultural fields.
X11E-01157	Komati	B/C	Flow: Upstream Nooitgedacht Dam and no release for EWRs.
X11F-01133	Bankspruit	B	Non-flow: Related to agriculture.
X11F-01163	Komati	B	Flow: Upstream Nooitgedacht Dam with no environmental releases.
X11G-01188	Ndubazi	B/C	Non-flow: Forestry.
X11G-01143	Gemakstroom	C	Non-flow: Barriers and inundation.
X11G-01142	Komati	B/C	Flow: Upstream Nooitgedacht Dam with no environmental releases.
X11G-01177	Komati	B/C	Flow: Upstream Nooitgedacht Dam with no environmental releases.
X11H-01140	Komati	C	Flow: Upstream Nooitgedacht Dam with no environmental releases.
X11H-01140	X11H-01140b	D	Immediately downstream of Vygeboom Dam.
X11J-01106	Mngubhudle	D	Flow: Mine, forestry, abstractions, interbasin transfer. Non-Flow: Physical disturbance from mine and forestry. WQ: Mine.
X11K-01165	Poponyane	C	Flow: Abstractions. Non-Flow: Barriers.
X11K-01199		D	Non-Flow: Barriers and inundation. Flow: Abstractions.
X11K-01179	Gladdespruit	C	Flow: Upstream flow abstractions and transfer.
X11K-01194	Gladdespruit	C	Flow: Upstream abstractions and transfer.
X11K-01227	Komati	B/C	Flow: Upstream dams and operation.
X12A-01305	Buffelspruit	C	Non-Flow: Forestry.
X12B-01246	Hlatjiwe	C	Non-Flow: Forestry, barriers, inundation.
X12C-01242	Phophenyane	B	Non-flow: Linked to grazing.
X12C-01271	Buffelspruit	B	Non-flow: Agriculture and grazing.
X12D-01235	Seekoeispruit	C	Non-Flow: Linked to agricultural fields, grazing, and urbanization. WQ: Linked to town.
X12E-01287	Teespruit	C	Non-Flow: Linked to subsistence agriculture and urban areas.
X12G-01200	Komati	C	Flow: Upstream dams and operation.
X12H-01338	Sandspruit	B	Non-Flow: Linked to impacts in the riparian zone due to overgrazing, trampling and vegetation removal.
X12H-01340		B	Non-Flow: Linked to impacts in the riparian zone due to overgrazing, trampling and vegetation removal.
X12H-01318	Sandspruit	C	Non-Flow and WQ: Linked to agricultural practices, and

SQ reach	River	PES (EC)	Primary PES driver
			Mooiplaas at source of river.
X12H-01296	Komati	B/C	Upstream dams and operation.
X12H-01258	Komati	B/C	Upstream dams and operation.
X12J-01202	Mtsoli	B	Non-flow: Forestry.
X12K-01333	Mlondozi	C	Non-flow and WQ: Linked to agricultural practices, and urbanisation.
X12K-01332	Mhlangampepa	B	Non-flow: Impacts linked to grazing.
X12K-01316	Komati	D	Flow: Upstream dams and operation. Non Flow: Agricultural fields and vegetation removal. WQ: Mining.
X13J-01214	Mgobode	C	Non-flow: Vegetation removal and overgrazing/ trampling.
X13J-01141	Mzinti	D	Non-flow: Agricultural fields, urbanization, overgrazing, vegetation removal and aliens, large dams and inundation. WQ: Sedimentation and algal growth. Flow: Abstraction for irrigation.
X13J-01205	Mbiteni	D	Non-flow: Agricultural fields, urbanization, grazing, vegetation removal and aliens. WQ: Sedimentation and runoff/effluent. Flow: Abstraction for irrigation.
X13J-01221	Komati	D	Flow: Upstream flow modification and abstraction for irrigation. WQ: Run-off/effluent, algal growth. Non-flows: Vegetation removal and aliens, agricultural fields, dams and inundation.
X13J-01210	Komati	D/E	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Farm dams and inundation, channel disturbance, vegetation removal and aliens. WQ: Sedimentation and irrigation return-flows, algal growth.
X13J-01149	Komati	D/E	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Agricultural fields, bed and channel disturbance, overgrazing, vegetation removal and aliens, farm dam inundation. WQ: Sedimentation and run-off/effluent, algal growth.
X13J-01130	Komati	D/E	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Dams and inundation, vegetation removal and aliens, agricultural fields, bed and channel disturbance. WQ: Sedimentation and run-off/effluent, algal growth.
X13K-01136	Mambane	D	Non-flow: Agricultural fields, bed and channel disturbance, vegetation removal, aliens and overgrazing/ trampling. Flow: Abstraction
X13K-01068	Nkwakwa	C/D	Non-flow: Dams and inundation, vegetation removal, grazing, bed and channel disturbance. Flow: Abstraction for irrigation.
X13K-01114	Komati	D	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Dams and inundation, bed and channel disturbance, vegetation removal, agricultural fields, overgrazing and trampling, bed and channel disturbance. WQ: Sedimentation and run-off/effluent, algal growth.
X13K-01038	Komati	E	Non-flow: Bed and channel disturbance, dams and inundation, vegetation removal and aliens, agricultural fields. Flow: Upstream flow modification and abstraction for irrigation. WQ: Run-off/effluent, algal growth.
X13L-01000	Ngweti	D	Non-flow: Farm dams and inundation, vegetation removal, agricultural fields, overgrazing. Flow (4): Abstraction for irrigation.
X13L-01027	Komati	E	Non-flow: Bed and channel disturbance, dams and inundation, vegetation removal, agricultural fields, roads. Flow Upstream flow modification and abstraction for irrigation. WQ: Run-off/effluent, algal growth, sedimentation.
X13L-0995	Komati	D	Flow: Upstream flow modification and abstraction for irrigation.

SQ reach	River	PES (EC)	Primary PES driver
			Non-flow: Bed and channel disturbance, dams and inundation, alien vegetation, urbanization, roads. WQ: Run-off/effluent, industries, algal growth, sedimentation.
X14A-01173	Lomati	**B/C**	Non-flow: Agricultural fields, forestry, overgrazing and trampling.
X14B-01166	Ugutugulo	**C**	Non-flow: Forestry, alien vegetation, agricultural fields. Flow: Abstraction for irrigation.
X14F-01085	Mhlambanyatsi	**C**	Non-flow: Forestry, vegetation removal and aliens, bed and channel disturbance.
X14G-01128	Lomati	**D/E**	Non-flow: Large dams inundation, agricultural fields, overgrazing, vegetation removal and aliens, bed and channel disturbance. Flow: Upstream flow modification and abstraction for irrigation, increased flows. WQ: Sedimentation and run-off/effluent, algal growth.
X14H-01066	Lomati	**D**	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Agricultural fields, overgrazing, vegetation removal and aliens, bed and channel disturbance, farm dams and inundation. WQ: Sedimentation and algal growth.

2.8.2 Crocodile River system (X2)

The Crocodile River system is heavily utilised and possibly over-allocated. In terms of flow regulation, the Elands River is probably the least impacted. Impacts in the main Crocodile River are dominated by Kwena Dam operation and flow regulation of the downstream river for irrigation. Specific impacts are associated with increased (above natural) flows during the dry season, daily fluctuations due to the pumping and abstraction regime and abstraction of flows to such a degree that the river stops flowing at localised stretches. Irrigation return flows and urban runoff impact on water quality. In tributaries such as the Elands, Kaap and Nels rivers, extensive forestry take place. The lower Crocodile River and its tributaries from the Nsikazi River are bordered by or fall within the KNP.

Upstream of the Kaap River confluence, the PES is dominated by a C EC. Downstream of the Kaap River confluence, the Crocodile River is in a D with most of the tributaries being in an excellent state as they are mostly located within the KNP.

Twenty one SQ reaches are in an A, B or B/C PES. Of these, fifteen fall within the KNP from source to confluence with the Crocodile River or borders the KNP.

There is one SQ with PES lower than a D (PES D/E: X22H-00836). This SQ represents the Wit River with extensive upstream flow modification (abstraction for irrigation), agricultural fields, farm dams and inundation as well as water quality problems with associated algal growth. The two most downstream Crocodile River SQ reaches have instream components that result in an E PES for instream components. The reason for this is due to the extensive sugarcane irrigation on the right bank with cessation of flow at localised areas and water quality problems particularly related to irrigation return flows and temperature fluctuations related to flow modification (abstraction). A summary is provided in Table 2.4.

Table 2.4 Crocodile River system (X2): River PES and key drivers resulting in modification from natural

(Blue shading in column one and two refers to rivers that are in totality in the greater KNP)

SQ reach	River	PES (EC)	Primary PES driver
X21A-01008		C/D	Non-flow: Bed and Channel disturbance, small (farm) dams, inundation.
X21A-00930	Crocodile	C	Non-flow: Small (trout) dams, inundation, grazing (land-use). WQ: Nutrients.
X21B-00929	Gemsbokspruit	C/D	Non-flow: Small (farm) dams, inundation, recreation. WQ: Algal growth.
X21B-00898	Lunsklip	C/D	Flow: (many small dams also in tributaries). Non-flow: Small (farm) dams, inundation, recreation. WQ: Nutrients (algal growth).
X21B-00925	Lunsklip	C	Flow: Many small dams. Non-flow: Small (farm) dams, inundation. WQ: Algal growth.
X21B-00962	Crocodile	C	Flow: Abstraction and various small dams in catchment. Non-flow: Agricultural fields, grazing (land-use). WQ: Nutrients (algal growth),
X21C-00859	Alexanderspruit	C	Non-flow: Agricultural fields, small (farm) dams, inundation, forestry.
X21D-00957	Buffelskloofspruit	C	Non-flow: Agriculture, livestock, limited forestry.
X21D-00938	Crocodile	C	Flow: Large dam (Kwena), increased flows.
X21E-00897	Buffelskloofspruit	B	Non-flow: Forestry (natural areas/nature reserves).
X21E-00947	Crocodile	B	Flow: Kwena Dam, increased flows.
X21E-00943	Crocodile	C	Flow: Kwena dam regulation, abstraction, irrigation. Non-flow: Agricultural fields, roads. WQ: Algal growth, runoff/effluent: Irrigation.
X21F-01046	Elands	C	Flow: Large number of small dams. Non-flow: Recreation (trout lodges), grazing (land-use). WQ: Nutrients.
X21F-01100	Leeuspruit	C	Non-flow: Small (farm) dams, grazing (land-use). WQ: Urban runoff (Machadodorp and Emthonjeni).
X21F-01091	Rietvleispruit	C	Flow: Many small farm/trout dams. Non-flow: Small (farm) dams, inundation, grazing (land-use). WQ: Increased nutrients.
X21F-01092	Leeuspruit	C/D	Non-flow: Small (farm) dams, grazing (land-use). WQ: Urban runoff (Machadodorp and Emthonjeni).
X21F-01081	Elands	C	Flow and Non-flow: Small (farm) dams, inundation, grazing (land-use),
X21G-01090	Weltevredespruit	C	Non-flow: Forestry, farming. WQ: Algal growth.
X21G-01016	Swartkoppiespruit	C	Non-flow: Small (farm) dams, recreation and forestry. WQ: Nutrients (algal growth).
X21G-01037	Elands	D	Flow: Various small dams. Non-flow: Bed and channel disturbance, small (farm) dams, inundation, roads, recreation, farming. WQ: Urban runoff, nutrient enrichment.
X21G-01073	Elands	C	Flow: Upstream small dams. Non-flow: Bed and channel disturbance, roads, vegetation removal. WQ: Increased nutrients.
X21H-01060	Ngodwana	C	Flow: Large dams. Non-flow: Forestry.
X21J-01013	Elands	C	Non-flow: Agricultural fields, forestry, roads, irrigation. WQ: Nutrients (algal growth).
X21K-01007	Lupelule	B	Non-flow: Forestry.

SQ reach	River	PES (EC)	Primary PES driver
X21K-01035	Elands	D	Flow: Ngodwana and other smaller dams. Non-flow: Forestry, roads, vegetation removal. WQ: Nutrients and runoff/effluent: Industries.
X21K-00997	Elands	C	Flow: Ngodwana and other smaller dams. Non-flow: Forestry, roads, vegetation removal. WQ: Nutrients and runoff/effluent: Industries.
X22A-00875	Houtbosloop	B/C	Non-flow: Forestry.
X22A-00887	Beestekraalspruit	B/C	Non-flow: Forestry.
X22A-00824	Blystaanspruit	B/C	Non-flow: Forestry.
X22A-00920		B	Non-flow: Forestry.
X22A-00919	Houtbosloop	B/C	Non-flow: Forestry.
X22A-00917	Houtbosloop	C	Non-flow: Forestry.
X22A-00913	Houtbosloop	C	Non-flow: Low water crossings, agriculture, abstraction.
X22B-00987	Crocodile	C	Flow: Kwena dam flow regulation, canals, abstraction (irrigation). Non-flow: Agricultural fields. WQ: Ngodwana (industrial) and nutrients.
X22B-00888	Crocodile	C	Flow: Kwena dam flow regulation, canals, abstraction (irrigation). Non-flow: Agricultural fields. WQ: Ngodwana (industrial) and nutrients.
X22C-00990	Visspruit	B/C	Non-flow: Forestry, irrigation.
X22C-01004	Gladdespruit	C	Non-flow: Forestry and associated roads with bed and channel disturbance, alien vegetation.
X22C-00946	Crocodile	C	Flow: Kwena Dam and canal flows modification, abstraction (Irrigation). WQ: Runoff/effluent: Irrigation.
X22D-00843	Nels	C	Non-flow: Forestry and associated roads with bed and channel disturbance, vegetation removal and aliens.
X22D-00846		C	Non-flow: Forestry and associated roads with bed and channel disturbance, vegetation removal and aliens.
X22E-00849	Sand	C	Non-flow: Forestry and associated low water crossings with bed and channel disturbance, vegetation removal and aliens.
X22E-00833	Kruisfonteinspruit	C	Non-flow: Forestry and associated low water crossings with bed and channel disturbance, vegetation removal and aliens (Witklip Dam).
X22F-00842	Nels	C	Non-flow: Forestry, bed and channel disturbance, vegetation removal and aliens. Flow; Some abstraction for irrigation.
X22F-00886	Sand	C	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Large dam (Witklip Dam), forestry, bed and channel disturbance, vegetation removal and aliens.
X22F-00977	Nels	C/D	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Agricultural fields, farm dams and inundation. WQ: Runoff/effluent and associated algal growth.
X22H-00836	Wit	D/E	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Forestry, many large and small dams and inundation. WQ Algal growth.
X22J-00993	Crocodile	D	Flow: Kwena Dam flow regulation. Non-flow: Roads, urbanization. WQ: Urban runoff, nutrients (WWTW).
X22J-00958	Crocodile	C	Flow: Upstream flow modification and abstraction for irrigation. WQ: Runoff/effluent and associated algal growth. Non-flow: Roads, urbanization, industries.
X22K-01042	Mbuzulwane	B	Non-flow: Small farm dams.
X22K-01043	Blinkwater	B	Non-flow: Small farm dams.
X22K-01029	Blinkwater	C	Non-flow: Agricultural fields, alien vegetation.

SQ reach	River	PES (EC)	Primary PES driver
X22K-00981	Crocodile	C	Flow: Upstream flow modification and abstraction for irrigation. WQ: Runoff/effluent and associated algal growth.
X22K-01018	Crocodile	C	Flow: Upstream flow modification and abstraction for irrigation. WQ: Runoff/effluent and associated algal growth. Non-flow: Roads
X23B-01052	Noordkaap	D	Non-flow: Agricultural fields, bed and channel disturbance, vegetation removal. WQ: Runoff/effluent and associated algal growth.
X23C-01098	Suidkaap	C	Non-flow: Forestry. Flow: Abstraction for irrigation.
X23E-01154	Queens	C	Non-flow: Forestry. Flow: Abstraction for irrigation.
X23F-01120	Suidkaap	C	Flow: Abstraction for irrigation. Non-flow: A diversity of impacts: Bed and channel disturbance, vegetation removal and aliens, agricultural fields, farm dams and inundation.
X23G-01057	Kaap	D	Flow: Abstraction for irrigation. WQ: Runoff/effluent and associated algal growth. Non-flow: A diversity of impacts: Bed and channel disturbance, vegetation removal and aliens, agricultural fields, farm dams and inundation.
X24A-00826	Nsikazi	C	Non-flow: Rural impacts - Agricultural fields, vegetation removal, overgrazing and trampling.
X24A-00860	Sithungwane	A	Non-flow: Mostly natural areas, some roads and vegetation removal.
X24A-00881	Nsikazi	B	Non-flow: Mostly natural areas, some roads, small dams and vegetation removal.
X24B-00903	Gutshwa	D	Non-flow: Rural impacts - Agricultural fields, vegetation removal, overgrazing and trampling.
X24B-00928	Nsikazi	A/B	Flow: Mostly natural areas, upstream flow modifications in tributaries. Non-flow: Vegetation removal.
X24C-00969	Mnyeleni	A	Impacts very low.
X24C-00978	Nsikazi	B	Impacts very low.
X24C-01033	Crocodile	C/D	Flow: Upstream flow modification and abstraction for irrigation. WQ: Runoff/effluent and associated algal growth. Non-flow: Roads, urbanization, bed and channel disturbance, alien vegetation, vegetation removal.
X24D-00994	Crocodile	C/D	Flow: Upstream flow modification and abstraction for irrigation. WQ: Runoff/effluent and associated algal growth. Non-flow: Bed and channel disturbance, vegetation removal and agricultural fields.
X24E-00973	Matjulu	B	
X24E-00922	Mlambeni	A/B	
X24E-00982	Crocodile	D	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Roads, vegetation removal and agricultural fields. WQ: Runoff/effluent and associated algal growth.
X24F-00953	Crocodile	D	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Farm dams and inundation. Vegetation removal, bed and channel disturbance. WQ: Runoff/effluent and associated algal growth.
X24G-00902	Mitomeni	A	
X24G-00876	Komapiti	A	
X24G-00844	Mbyamiti	A	
X24G-00823	Muhlambamadubo	A	
X24G-00820	Mbyamiti	A	
X24G-00904	Mbyamiti	A	

SQ reach	River	PES (EC)	Primary PES driver
X24H-00882	Vurhami	A	
X24H-00892	Mbyamiti	A	
X24H-00880	Crocodile	D	Flow: Upstream flow modification and abstraction for irrigation. Non-flow: Roads, vegetation removal and agricultural fields. WQ: Runoff/effluent and associated algal growth.
X24H-00934	Crocodile	C/D	Flow: Upstream flow modification and abstraction for irrigation. WQ: Runoff/effluent and associated algal growth. Non-flow: Roads, vegetation removal and agricultural fields.

2.8.3 Sabie-Sand River system (X3)

A large section of the eastern part of this catchment falls within the Greater KNP. All the SQs in the Greater KNP are either in a B or A PES apart from one SQ in the Sabie River which is in a C due to the presence of dams and weirs. There are three SQs in the Sabie River which borders the KNP and are in a C PES.

The Sabie River system outside of the KNP is dominated by forestry and irrigation for agriculture (orchards). Some WQ deterioration is associated with Sabie town effluents. Outside of the KNP, the majority of the SQs are in a C with five SQs in a D EC. There are six SQs which are in a B or B/C PES.

The Sand River outside of the Greater KNP is dominated by forestry in the upper areas and subsistence agriculture with extensive erosion, overgrazing and human settlements on the lower lying areas. The PES is mostly a C with three D PES SQ reaches. It must be noted though that many of the rivers with their sources in the Drakensberg have A to B sections followed by a much lower PES in the lower section of an SQ (as low as E PES). A summary is provided in Table 2.5.

Table 2.5 X3: Sabie-Sand sub-catchment: River PES and key drivers resulting in modification from natural

(Blue shading in column one and two refers to rivers that are in totality in the greater KNP)

SQ reach	River	PES (EC)	Primary PES driver
X31A-00741	Klein Sabie	C	Non-flow: Alien vegetation, forestry. WQ: Sabie town, lower reaches.
X31A-00778	Sabie	C	Non-flow: Forestry, urbanization. WQ: Sawmills, urban runoff.
X31A-00783		C	Non-flow: Forestry.
X31A-00786		B	Non-flow: Forestry, natural areas/nature reserves, recreation.
X31A-00794		B	Non-flow: Forestry (natural areas/nature reserves).
X31A-00796		B	Non-flow: Forestry (natural areas/nature reserves).
X31A-00799	Sabie	C	Non-flow: Bed and channel disturbance, alien vegetation, Forestry.
X31A-00803		B/C	Non-flow: Alien vegetation, forestry, vegetation removal.
X31B-00756	Sabie	B/C	Non-flow: Forestry, agriculture. WQ: Nutrients enrichment (irrigation return flows).
X31B-00757	Sabie	C	Non-flow: Forestry, agriculture. WQ: Nutrients enrichment (Sabie town runoff).
X31B-00792	Goudstroom	B/C	Non-flow: Forestry.
X31C-00683	Mac-Mac	B/C	Non-flow: Forestry, (natural areas/nature reserves). WQ: Very limited, saw mill?
X31D-00755	Sabie	C	Flow: Irrigation abstraction (and forestry).

SQ reach	River	PES (EC)	Primary PES driver
			Non-flow: Agricultural fields, recreation, vegetation removal, forestry.
X31D-00772	Sabie	C	Non-flow: Agricultural fields, inundation, vegetation removal.
X31D-00773	Sabani	C/D	Flow: Abstraction, various small instream dams. Non-flow: Agricultural fields, forestry (upper reaches), small (farm) dams, inundation. WQ: Irrigation return flows.
X31E-00647	Marite (US[1] of dam)	B/C	Non-flow: Forestry, vegetation removal.
X31F-00695	Motitsi	C	Non-flow: Forestry, vegetation removal. WQ: Graskop town.
X31G-00728	Marite	C/D	Flow: Inyaka Dam, increased flows, irrigation. Non-flow: Agricultural fields. WQ: Nutrients (algal growth).
X31H-00819	White Waters	C	Flow: Large dam, abstraction (irrigation). Non-flow: Forestry, agricultural fields. WQ: agricultural return flows.
X31J-00774	Noord-Sand	D	Flow: Small farm dams. Non-flow: Small (farm) dams, inundation, roads, urbanization, vegetation removal, highly populated rural area. WQ: Nutrient enrichment runoff/effluent: Urban areas.
X31J-00835	Noord-Sand	D	Flow: Abstraction. Non-flow: Agricultural fields, highly populated rural and urban area, small (farm) dams, and roads. WQ: Runoff/effluent: Urban areas.
X31K-00713	Bejani	D	Non-flow: Bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), urbanization, vegetation removal. WQ: Nutrient enrichment, runoff/effluent: Urban areas.
X31K-00715	Sabie	C	Flow: Upstream abstraction (irrigation). Non-flow: Agricultural fields highly populated rural area and Mkhuhlu town, (KNP: Natural areas/nature reserves on right bank). WQ: Nutrient enrichment, irrigation return flows.
X31K-00750	Sabie	C	Flow: Limited (Inyaka Dam) and abstraction (irrigation). Non-flow: Agricultural fields highly populated rural area and Mkhuhlu town, (KNP: Natural areas/nature reserves on right bank). WQ: Nutrient enrichment, irrigation return flows.
X31K-00752	Sabie	C	Flow: Inyaka Dam releases and abstraction (irrigation). Non-flow: Rural area, subsistence farming, agriculture, bed and channel disturbance, overgrazing/trampling, recreation, vegetation removal. WQ: Hazyview town, irrigation return flows.
X31K-00758	Sabie	C	Flow: Inyaka Dam releases and abstraction (irrigation). Non-flow: Agriculture, bed and channel disturbance, overgrazing/trampling, recreation, vegetation removal. WQ: Hazyview town, irrigation return flows.
X31K-00771	Phabeni	B	
X31L-00657	Matsavana	C	Non-flow: Bed and channel disturbance, overgrazing/trampling, grazing (land-use), vegetation removal. WQ: Nutrient enrichment.
X31L-00664	Saringwa	C	Non-flow: Bed and channel disturbance, low water crossings, overgrazing/trampling, sedimentation, grazing (land-use), urbanization, vegetation removal.

SQ reach	River	PES (EC)	Primary PES driver
			WQ: Nutrient enrichment.
X31L-00678	Saringwa	B/C	Non-flow: Impacts only in lower reaches - overgrazing/trampling, sedimentation, grazing (land-use), urbanization, vegetation removal. WQ: Nutrient enrichment.
X31M-00673	Musutlu	B/C	Non-flow: Low water crossings, natural areas/nature reserves, recreation, roads, grazing (land-use).
X31M-00681	Sabie	B/C	Flow: Upstream abstraction (irrigation). Non-flow: Natural areas/nature reserves/recreation. WQ: Upstream impacts (nutrients, erosion).
X31M-00739	Sabie	B	Flow: Upstream abstraction (irrigation). Non-flow: Natural areas/nature reserves/recreation. WQ: Upstream impacts (nutrients, erosion).
X31M-00747	Sabie	B	Flow: Upstream abstraction (irrigation). Non-flow: Natural areas/nature reserves/recreation. WQ: Upstream impacts (nutrients, erosion).
X31M-00763	Nwaswitshaka	A	
X32A-00583	Thulandziteka	D	Non-flow: Agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. WQ: Algal growth. Flow: Abstraction for irrigation.
X32B-00551	Motlamogatsana	C	Non-flow: Agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. Flow: Abstraction for irrigation. WQ: Runoff/effluent and associated algal growth.
X32C-00558	Nwandlamuhari	C	Non-flow: Agricultural fields, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. Flow: Abstraction for irrigation. WQ: Runoff/effluent and associated algal growth.
X32C-00564	Mphyanyana	C	Non-flow: Agricultural fields, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. WQ: Runoff/effluent and associated algal growth.
X32C-00606	Nwandlamuhari	C	Non-flow: Agricultural fields, roads, vegetation removal.
X32D-00605	Mutlumuvi	D	Non-flow: Impacts associated with rural agriculture: agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. Flow: Abstraction for irrigation. WQ: Runoff/effluent and associated algal growth.
X32E-00629	Nwarhele	C/D	Non-flow: Forestry, rural influences (agriculture and urbanization). WQ: Runoff/effluent and associated algal growth. Flow: Abstraction for irrigation.
X32E-00639	Ndlobesuthu	D/E	Non-flow: Impacts associated with rural agriculture: agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. WQ: Runoff/effluent and associated algal growth.
X32F-00597	Mutlumuvi	C/D	Non-flow: Impacts associated with rural agriculture: agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. Flow: Abstraction for irrigation.
X32F-00628	Nwarhele	C/D	Non-flow: Impacts associated with rural agriculture: agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal.

SQ reach	River	PES (EC)	Primary PES driver
			WQ: Runoff/effluent and associated algal growth.
X32G-00549	Khokhovela	C	Non-flow: Impacts associated with rural agriculture: agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. WQ: Runoff/effluent and associated algal growth.
X32G-00565	Sand	C	Non-flow: Impacts associated with rural agriculture: agricultural fields, bed and channel disturbance, overgrazing/trampling, sedimentation, grazing (land-use), vegetation removal. WQ: Runoff/effluent and associated algal growth. Flow: Abstraction for irrigation.
X32H-00560	Phungwe	A	
X32H-00578	Sand	C	Non-flow: Natural areas/nature reserves, sedimentation.
X32J-00602	Sand	B	
X32J-00651	Mutlumuvi	A	
X32J-00730	Sand	B	
X33A-00661	Nwatindlopfu	A	
X33A-00731	Sabie	B	
X33A-00737	Sabie	B	
X33A-00806	Nwatimhiri	A	
X33B-00694	Salitje	A	
X33B-00784	Sabie	B	
X33B-00804	Sabie	B/C	Non-flow: Natural areas/nature reserves, roads, small dam and inundation.
X33B-00829	Sabie	A/B	
X33B-00834	Lubyelubye	A	
X33C-00701	Mnondozi	A	
X33D-00811	Sabie	B	
X33D-00861	Sabie	B	
X33D-00864	Mosehla	A	
X33D-00894	Nhlowa	A	
X33D-00908	Shimangwana	A	
X33D-00911	Nhlowa	A	
X31E-00647	Marite (DS[2] of Dam)	D	Flow: Inyaka dams flow regulation. Non-flow: Forestry, vegetation removal, subsistence farming, over grazing, erosion. WQ: Inyaka Dam, highly populated rural areas.

1 Upstream 2 Downstream

2.8.4 Nwanedzi and Nwaswitsontso River system (X4)

The Nwanedzi/Nwaswitsontso rivers are seasonal systems that mostly originate in the KNP and drain separately through the Lebombo Mountains towards the Inkomati River in Mozambique. The Nwaswitsontso River is the only river originating outside the Park and the first 5 km of 97 km falls outside the KNP and adjacent Reserve areas. The occurrence of dams, overgrazing, erosion and agriculture renders this SQ (X40C-00513) an EC of a B. The rest of the Nwaswitsontso River tributaries (X40C and X40D) are mostly unmodified and in an A Category.

The Nwanedzi River system consists of the Nwanedzi and Sweni tributaries (X40A and X40B), and the majority of these seasonal streams are unmodified. The only adverse impacts in the two tributaries are tourist roads, river crossings and small dams. The lower section of the Nwanedzi River are rated a B Category due to dams and abstraction for a tourist camp.

The Sweni River system (X40B) runs mainly through a wilderness area with very little notable impacts and is in an A PES. Impacts on this river include overgrazing by game, water abstraction for tourist facilities and erosion.

2.9 ECOLOGICAL STATUS QUO: WETLANDS

Quaternary catchments within the X1, X2, X3 and X4 secondary catchments were assessed for potential wetland importance by combining the frequency of different wetland types (National Freshwater Ecosystem Priority Areas (NFEPA) classification of types) and the total extent of all wetland types (area) within each quaternary, and scoring the result on a scale of 0 to 3 where 0 = no potential importance and 3 = high potential importance. NFEPA wetland spatial data were used for the analysis (Nel *et al.*, 2011), and the presence of NFEPA wetland clusters (non-riverine wetland clusters of significance) and wetland Freshwater Ecosystem Priority Area (FEPAs) (the final wetland FEPAs selected by review) as well as Ramsar sites was also considered for the scoring. Only wetlands classified as "natural" were used for the analysis.

Seventeen SQs were highlighted as having potentially high wetland importance, 28 contained wetland NFEPAs and together 40 were highlighted for PES scoring (Table 2.6).

Table 2.6 Final wetland PES scores after verification using Google Earth Pro ©

SQ reach code	SQ name	Median	PES	Primary PES Driver
X11A-01248	Vaalwaterspruit	2	C	Flow modification and landuse activities.
X11A-01354		2	C	Flow reduction and landuse activities.
X11B-01272	Boesmanspruit	2	C	Landuse activities.
X11C-01147	Witkloofspruit	2	C	Flow modification.
X11D-01129	Klein-Komati	2	C	Flow reduction activities.
X11E-01237	Swartspruit	1.5	B/C	Landuse activities, WQ.
X11G-01143	Gemakstroom	1.5	B/C	Flow. Non-flow and WQ aspects.
X11H-01140	Komati	2	C	Flow modification and overgrazing.
X11K-01194	Gladdespruit	1.5	B/C	Landuse activities.
X12A-01305	Buffelspruit	1.5	B/C	Forestry and Invasive vegetation.
X12C-01271	Buffelspruit	1	B	Landuse activities, overgrazing.
X12D-01235	Seekoeispruit	2	C	Urbanisation and landuse activities.
X12E-01287	Teespruit	1.5	B/C	Flow and non-flow related impacts
X13J-01149	Komati	3.5	D/E	Flow modification and agriculture
X13J-01205	Mbiteni	3	D	Flow, non-flow and WQ impacts.
X13J-01221	Komati	3	D	Flow modification, agricultural encroachment.
X13K-01068	Nkwakwa	3	D	Flow modification and reduction.
X13L-01000	Ngweti	3.5	D/E	Flow modification and reduction, dams.
X14G-01128	Lomati	4	E	Dams, flow modification and reduction.
X21A-00930	Crocodile	2	C	Many small dams, landuse activities, some urbanisation and small pockets of alien woody species.
X21A-01008		2.5	C/D	Flow reduction and small dams.
X21B-00898	Lunsklip	2	C	Many small dams, landuse activities, some urbanisation and small pockets of alien woody species.
X21B-00929	Gemsbokspruit	2	C	Small dams and pockets of forestry.
X21C-00859	Alexanderspruit	2.5	C/D	Dams, irrigation, forestry.
X21F-01046	Elands	2	C	Many small dams and agricultural encroachment.

SQ reach code	SQ name	Median	PES	Primary PES Driver
X22C-01004	Gladdespruit	2	C	Afforestation/Invasive plants, landuse encroachment.
X22H-00836	Wit	4	E	Flow modification, Dams.
X23C-01098	Suidkaap		C	Afforestation/Invasive plants.
X23E-01154	Queens	2	C	Afforestation/Invasive plants.
X23G-01057	Kaap		D	Afforestation/Invasive plants and flow modification.
X24H-00934	Crocodile		C/D	Flow modification.
X31F-00695	Motitsi	2	C	Forestry.
X32A-00583	Thulandziteka	2.5	C/D	Vegetation removal and overgrazing.
X32B-00551	Motlamogatsana	2.5	C/D	Vegetation removal and overgrazing.
X32D-00605	Mutlumuvi	3	D	Vegetation removal and overgrazing.
X33A-00806	Nwatimhiri	0	A	In KNP.
X40A-00469	Nwanedzi	2	C	Weirs.

3 INTEGRATED UNITS OF ANALYSIS

This chapter is an extract from report: DWA (2013b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: Status Quo assessment, Integrated Unit of Analysis delineation and biophysical node identification. Prepared by: IWR Water Resources. Authored by: Mallory S, Louw D, Deacon A, Holland, M, Huggins G, Kotze P, Mackenzie J, Scherman P, Van Jaarsveld P,. DWA Report, RDM/WMA05/00/CON/CLA/0213. September 2013.

3.1 PROCESS TO DETERMINE IUA

An IUA is a broad scale unit (or catchment area) that contains several biophysical nodes. These nodes define at a detail scale specific attributes which together describe the catchment configuration of the IUA. Scenarios are assessed within the IUA and relevant implications in terms of the Water Resource Classes (commonly referred to as Management Classes) are provided for each IUA. The objective of defining IUAs is therefore to establish broader-scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on ecological conditions at a SQ scale.

Zones have been established for water resource use, economics, EGSA and ecology. All of these zones are based on the concept of identifying areas that are similar in terms of these specific components, have similar land use (and resulting impacts), and can be managed as a logical entity. Overlaying these zones leads to the identification of IUAs which are similar from all the various components perspective and, as it can be managed as an entity, is a logical unit for which scenarios can be designed and evaluated.

The process of IUA delineation is summarised in a flow diagram, Figure 3.1. Once the IUAs are delineated, biophysical nodes must be identified for different levels of EWR assessment.

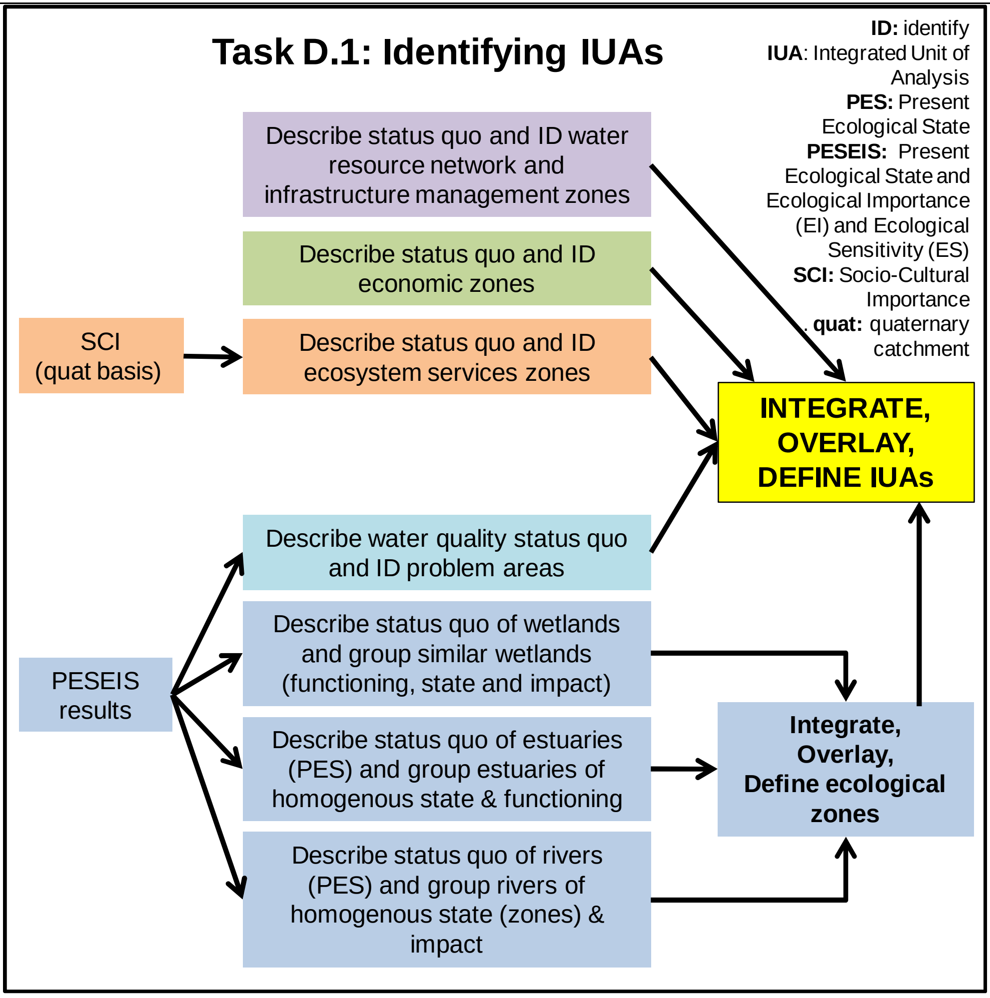


Figure 3.1 Summary of process to identify IUAs

3.2 DESCRIPTION OF STATUS QUO PER IUA

The selected IUAs are illustrated in Figure 3.2 to Figure 3.5 at the end of the chapter. The status quo for all the different components is described for each IUA in the sub-sections below.

3.2.1 IUA X1-1 (Catchment upstream of Nooitgedacht Dam)

Water resources: Surface water

This IUA consists of the headwater catchments of the Komati River up to and including the Nooitgedacht Dam. In addition to the Nooitgedacht Dam, the only other significant Dam is the Boesmanspruit Dam which supplies the town of Carolina. Water from the Nooitgedacht Dam is transferred to the Olifants River catchment for cooling of the coal-fired power stations located there. There are limited farm dams in the catchment but several waste water containment dams which are supposed to contain the highly acidic runoff from coal mines in the area.

This area is relatively flat and a large proportion of this IUA is endorheic, as is evidenced by the large number of natural plans. Land use in the catchment is mostly grazing and dry land crops. There is limited irrigation of maize in this IUA.

Water resources: Ground water

The geology underlying the IUA is mainly represented by the shales, sandstones and coal beds of the Karoo Super Group. These weathered and fractured aquifers are generally not of high water bearing capacity and as a result groundwater use for domestic or irrigation from these aquifers is minimal.

Economy

The most significant economic activities in the IUA are the coal collieries that have a significant economic impact as well as employment. A large part of the IUA is used for grazing and dry land crops.

Ecosystem Services

For the most part, the river sections extend through commercial farmland. There is virtually no presence of human habitation in proximity to river. Carolina Town is however within 2 km of the river and is the largest single area of population density in the IUA. Low to Moderate social value is associated with Ecosystem Services as utilisation is very low.

Ecology (rivers)

The IUA is dominated with C PES, with two SQs in a B PES and one in a B/C PES. Impacts are largely non flow-related due to agriculture (grazing and dry-land), barrier effects and inundation due to numerous farm dams and some alien vegetation. Flow also plays a role due to the mostly run of river abstractions for irrigation and the farm dams.

Ecology (wetlands)

At the quaternary scale, X11A, X11B and X11C all score high for wetland importance, with frequent and extensive wetlands (covering 24.24, 19.55 and 26.99 km^2 respectively). These quaternaries include frequent NFEPA wetlands as well as wetland clusters and X11A and X11B also have close proximity to Chrissiesmeer pans. Wetland types are dominated by pans, depressions, channelled valley-bottom wetland and some seeps and flat areas, although several of the channelled valley-bottom wetlands are artificial and associated with mostly small dams (with the exception of the backup zone of Nooitgedacht Dam. The SQs that were highlighted as priority wetlands include X11A-01248 (Vaalwaterspruit), X11A-01354, X11B-01272 (Boesmanspruit) and X11C-01147 (Witkloofspruit). The PES was predominantly a Category C with the main PES drivers being flow modification and landuse activities such as agriculture and overgrazing. Integrated Ecological Importance and Sensitivity (EIS) were mostly moderate to high.

IUA rationale

All the SQs are upstream of Nooitgedacht Dam and not influenced by Nooitgedacht Dam's operation. Land uses are similar in all SQs (mostly dry land agriculture) and the PES varies between a B and C EC.

3.2.2 IUA X1-2 (Komati River between Nooitgedacht and Vygeboom Dam)

Water resources: Surface water

This IUA consists of the main stem of the Komati River commencing immediately downstream of the Nooitgedacht dam and ending with the Vygeboom Dam. Other than the Vygeboom Dam, there is no significant storage in the IUA. There is however a weir located on the river between the two dams from which water is pumped by Eskom for transfer to the Olifants system. The other significant abstraction is from the Vygeboom Dam, also for transfer to the Olifants.

This IUA is relatively flat in the upper reaches but becomes increasingly incised progressing downstream, although the catchment flattens out again in the Dam. Land use is grazing, dry land crops and limited irrigation.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the shales, mudrock and quartzites of the Pretoria Group with the Malmani dolomite outcrop forming the "Great Escarpment" which in turn overlies the crystalline igneous and metamorphic Basement rocks of the Barberton Super Group. Within the IUA, a close inter-dependence exists between groundwater and surface water. Although groundwater is limited to rural domestic supplies, as well as for game and livestock watering in the drier parts, further (large scale) development of groundwater is likely to directly impact on the availability of surface water.

Economy

There is a weir located on the river from which water is pumped to the Olifants. Other than the water transfer there is some limited irrigation that is happening from the river, but it is mostly used for domestic consumption.

Ecosystem Services

The IUA extends through commercial farmland and open terrain with commercial forestry in parts. There is little presence of human habitation, with the exception of farm houses, found in proximity to the river. Overall, a low population density is found in the IUA. The presence of farm dams is noted and therefore the associated recreational use and also some land set aside for nature reserves. The IUA has a low to moderate social value.

Ecology (rivers)

The IUA consists of the main Komati River which is dominated by changes in flow largely due to the operation of Nooitgedacht Dam. The 6 SQs consist of two C ECs and one C/D immediately below the dam. The PES is mostly a result of the changes in flow regime from Nooitgedacht Dam. Further downstream the river is more protected (game reserves) and the flow impact improves slightly as tributaries bring in some flow and variability. These three SQs are in a B and B/C (2) EC.

Ecology (wetlands)

At the quaternary scale X11D scored high for wetland frequency and X11D, X11E, and X11G all have NFEPA wetlands as well as wetland clusters. Wetland types are dominated by pans, depressions and flat areas. The only SQ that was highlighted as a priority wetland was X11H-01140 (Komati) where the predominant wetland type is channelled valley-bottom wetlands, although about half of these are artificial and associated with backup from the Vygeboom Dam. The wetland PES for this SQ is a C, with the main PES drivers being flow modification and overgrazing. Integrated EIS was high.

IUA rationale

The main river was placed in its own IUA as it is operated and functions completely differently to the tributaries. The main river is dominated by the operation (and transfers) from Nooitgedacht Dam. The resulting ECs range from a C/D (below the dam) and improve downstream as tributary inflows mitigate the impact of Nooitgedacht Dam.

3.2.3 IUA X1-3 (All tributaries between Nooitgedacht and Vygeboom Dam excluding the main Komati River)

Water resources: Surface water

This IUA consists of the tributaries which feed into the main stem of the Komati River, represented by the X1-2 IUA. Storage in this catchment is limited to a few small farm dams. These tributaries become increasingly steep and mountainous as one proceeds down the Komati River. Land use consists of grazing, limited dry land crops and irrigation, and forestry in the high lying areas.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by rocks of the Pretoria Group with the Malmani dolomite outcrop forming the “Great Escarpment” which in turn overlies the crystalline igneous and metamorphic Basement rocks of the Barberton Super Group. These weathered and fractured aquifers are generally not of high water bearing capacity. Although higher borehole yields are expected in the dolomite aquifer, the topography, geomorphic conditions, land use and the availability of surface water in this region, resulted in an un-developed resource. Groundwater use for domestic or irrigation in these aquifers is minimal.

Economy

The main economic activity in the IUA is commercial forestry which contributes a significant amount to the local economy as well as employment in the IUA. There are also a number of irrigated crops in the IUA.

Ecosystem Services

The IUA extends through commercial farmland and open terrain with forestry in parts. There is little presence of human habitation, with the exception of farm houses, found in proximity to the river. Overall a low population density is found in the IUA. The presence of farm dams is noted and therefore the associated recreational use. The aesthetic features of the IUA with some notable waterfalls is worthy of mention although the IUA has a low social value overall.

Ecology (rivers)

The six SQs mostly have non-flow related impacts which are dominated by the effect of barriers (farm and trout dams) and inundation. Other impacts link to agriculture (grazing, some limited irrigation and dryland agriculture. Of the six SQs, four are in a C EC, one in a B EC and one in a B/C EC. The B and B/C SQs are in a good state as the river is within a gorge (i.e. inaccessible) for large sections of the SQ.

Ecology (wetlands)

At the quaternary scale X11D scored high for wetland frequency and X11D, X11E, and X11G all have NFEPA wetlands as well as wetland clusters. Wetland types are dominated by pans, depressions and flat areas. The SQs that were highlighted for priority wetlands include X11D-01129 (Klein Komati), X11E-01237 (Swartspruit) and X11G-01143 (Gemakstroom). The PES was predominantly a B/C with the main PES drivers being landuse activities such as agriculture and overgrazing. Integrated EIS was mostly moderate to high (Swartspruit).

IUA rationale

The tributaries to the Komati in IUA X1-2 are independent from the operation of the main river. Land uses are mostly similar - dry land agriculture and grazing. The PES is mostly in a C due to non-flow related impacts.

3.2.4 IUA X1-4 (Gladdespruit catchment)

Water resources: Surface

This IUA consist of the Gladdespruit tributary, which is undeveloped in terms of storage with only a few small farm dams. The catchment is mountainous with the river rising on the Highveld escarpment and descending over 800 m to the low-lying plateau on which the Vygeboom Dam is located.

There are large areas of forestry in the upper reaches of the IUA but grazing is also a prominent land use activity. There is limited dry land agriculture in the lower reaches of this IUA. There is also a large Nickel mine in this IUA which has recently expanded from a purely underground operation to an open-cast operation.

Water use in this IUA consists mainly of transfers to the Vygeboom Dam in support of the transfers to the Olifants system. Other water use is limited irrigation in the lower reaches and water use by the mine, which is also limited.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by rocks of the Pretoria Group with the Malmani dolomite outcrop forming the "Great Escarpment" which in turn overlies the crystalline igneous and metamorphic Basement rocks of the Barberton Super Group. These weathered and fractured aquifers are generally not of high water bearing capacity. Although higher borehole yields are expected in the dolomite aquifer, the topography, geomorphic conditions, land use and the availability of surface water in this region, resulted in an un-developed resource. Groundwater use for domestic or irrigation in these aquifers is minimal.

Economy

The main economic activities in the IUA are mining, agriculture and forestry. The Nickel mine located in the IUA has a very large economic impact on the local economy and employs a large labour force.

Ecosystem Services

IUA extends through commercial farmland and open terrain with commercial forestry in parts. The IUA section headwaters are located on a plateau of open terrain and include the Nkomati Mine and the Nelshoogte Nature Reserve and cradle of life bio-park. There are some Game and trout lodges. There is moderate presence of human habitation, found in proximity to the river. Overall a low population density is found in the IUA. The presence of farm dams is noted and the recreational use associated with these and land set aside for nature reserves increases value of Ecosystem Services to a moderate score.

Ecology (rivers)

There are five SQs, two in a D and three in a C EC. The causes and sources are a combination of flow, non-flow and WQ related. The WQ issues are linked to the mine in the upper area reach X11J-01106. The flow impacts are related to abstraction and an interbasin transfer from the Gladdespruit catchment to the Vygeboom Dam. Non-flow related impacts are the barrier and inundation effect of numerous farm dams and impacts with reference to farm dams.

Ecology (wetlands)

At the quaternary scale X11K scored high for wetland extent, with 11.26% of the catchment comprising wetlands. Both NFEPA wetlands as well as priority wetland clusters also occur in the quaternary. Wetland types are dominated by channelled valley-bottom wetlands (many associated with tributaries) with some flat areas and seeps. The only SQ that was highlighted as a priority wetland was X11K-01194 (Gladdespruit). The PES was a B/C with the main PES drivers being landuse activities such as agriculture, overgrazing and some forestry. Integrated EIS was moderate).

IUA rationale

The Gladdespruit warrants its own IUA as it is different to other tributaries downstream of Vygeboom Dam and the main river. It is however a very varied catchment due to the varied land uses. The catchment is dominated by transfers to Vygeboom Dam, mining and forestry.

3.2.5 IUA X1-5 (Komati River downstream of Vygeboom Dam to Swaziland)

Water resources: Surface

This IUA consists of the main stem of the Komati River from the outlet of the Vygeboom Dam down to the Swaziland border. This stretch of river is relatively flat but flows through a deeply incised valley. Land use in this IUA is mainly grazing with limited dryland crops. There are no dams along this stretch of river although there are a few small weirs.

The main water use in this IUA is domestic use which is abstracted directly from the river to supply the numerous villages in the area. In addition there is limited irrigation supplied out of the river.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic Basement rocks of the Barberton Super Group. These Basement aquifers have no primary porosity and have a low groundwater potential. The alluvial sand deposits of unconsolidated clayey silts forms primary aquifer of high yielding potential along watercourses and valleys but may be limited in extent.Within the IUA a close inter-dependence exists between groundwater and surface water. Although groundwater is limited to rural domestic supplies, as well as for game and livestock watering in the drier parts, further (large scale) development of groundwater is likely to directly impact on the availability of surface water.

Water resources: WQ

There are no hotspots in this IUA.

Economy

The river is used mostly for domestic water consumption by the rural settlements that line the river. Other uses include grazing and nature conservation, with a section of the IUA cutting through the Songimvelo Nature Reserve. The economic impact of the river is limited to minor irrigation activities that are supplied out of the river and nature conservation.

Ecosystem Services

The IUA starts within commercial farming and plantation forestry and then extends through open terrain and through the large, rural townships (Tjakastad). The IUA also includes the Songimvelo Nature Reserve. As there is an increasing population density and evidence of some intensive utilisation of the Ecosystem Services combined with recreational and aesthetic aspects linked to the river the IUA has a moderate to Ecosystem Services value.

Ecology (rivers)

The main Komati River consists of five SQs of which three is in a B/C and one in a C EC. Most of the impacts are flow related due to upstream dams and the operation of the dams. The river is still in a reasonable condition, mostly as it is situated in some protected areas such as Songimvelo and is inaccessible in other areas. One SQ (X12K-01316) is in D PES due to the same flow-related issues as the upstream SQs, but also includes barriers and inundation impacts from weirs, as well as WQ issues from mining and extensive agricultural fields and vegetation removal.

Ecology (wetlands)

At the quaternary scale a portion of X11K is considered and scored high for wetland extent, with 11.26% of the catchment comprising wetlands. Both NFEPA wetlands as well as priority wetland clusters also occur in this quaternary. Other quaternaries (X12H, X12K and X12G) did not score high for priority wetlands. Wetland types are dominated by channelled valley-bottom wetlands (many associated with tributaries) with some flat areas and seeps. No SQs were highlighted as priority wetlands.

IUA rationale

As with the Komati River upstream of Vygeboom Dam, this stretch is dominated by the operation of Vygeboom Dam and is very different to the north and south flowing tributaries. It therefore warrants an IUA on its own. The PES is similar (B/C and C) due to similar land uses and protection in areas such as Songimvelo Nature Reserve.

3.2.6 IUA X1-6 (All tributaries downstream of Vygeboom Dam in X1-6 excluding the Gladdespruit)

Water resources: Surface water

This IUA consist of all the tributaries flowing into the Komati River within X1-5. The terrain is similar to that of X1-2, i.e., a flat high-lying escarpment area with tributaries flowing steeply to the Komati through deeply incised valleys. There are no significant dams in this IUA and a limited number of small farm dams. Land use consists mostly of forestry as well as grazing with limited dry land agriculture. Water use in this area consists of domestic supply to villages and small areas of irrigation.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic Basement rocks of the Barberton Super Group. These Basement aquifers have no primary porosity and have a low to moderate groundwater potential. Groundwater is largely for rural domestic supplies while use for irrigation is minimal.

Economy

The main economic activities in the IUA are commercial forestry plantations and dry land agriculture. The main water consumption is from domestic users in the rural settlements with small pockets of irrigation. Commercial forestry has a significant impact on the local economy.

Ecosystem Services

The IUA is made up of a number of tributaries and land utilisation is highly varied. The upper forestry dominated areas give way to more open terrain with commercial mixed farming and then an increasing population density. The towns of Badplaas and associated eManzana are in the IUA as is Elukwatini and associated subsistence agriculture. As there is an increasing population density and evidence of some intensive utilisation of the Ecosystem Services linked to the river, the IUA has a moderate to high Ecosystem Services value.

Ecology (rivers)

The SQs consists of various tributaries. Of the 12 SQs, five SQs form part of the Seekoeispruit. Two of these five SQs are in a B and three in a C PES. The major reasons are forestry in the upper reaches and agricultural practices with resulting overgrazing and trampling in the lower reaches. The other seven SQs are situated in five different tributaries. Four of the SQs are in a B and three in a C PES. The reasons are all non-flow related linked and dominated by overgrazing, trampling and vegetation removal. Forestry is present in one tributary and some WQ issues due to urbanisation are present in some of the SQs. The SQs with a B PES is mostly due to areas that are protected due to the nature of the topography.

Ecology (wetlands)

At the quaternary scale only X12D scored high for wetland extent with 8.9% of the catchment comprising wetlands. X12A, B, C, D, E, F and G all have NFEPA wetlands as well as priority wetland clusters. Wetland types are dominated by seeps and flat areas in the upper reaches and channelled valley-bottom wetlands in the lower reaches. At the SQ scale the Buffelspruit (X12A-01305, X12C-01271), Seekoeispruit (X12D-01235) and the Teespruit (X12E-01287) were highlighted as priority wetlands. The Buffelspruit has a wetland PES of B and B/C for the two SQs respectively with mostly natural seeps and channelled valley-bottom wetlands with an integrated EIS of moderate to high. The main PES driver is forestry, invasive vegetation and overgrazing. The Seekoeispruit has a wetland PES of C and moderate EIS, while the Teespruit wetlands are in a B/C Category and have high EIS with extensive channelled valley-bottom wetlands.

IUA rationale

The north and south flowing tributaries are different from the main river and sufficiently similar to each other to warrant its own IUA. Land use consists of forestry in some of the upper parts of the river, with trampling, overgrazing, vegetation removal, i.e. non-flow related impact. Areas that are in a B PES are protected in inaccessible areas.

3.2.7 IUA X1-7 (Lomati catchment upstream of Swaziland)

Water resources: Surface water

This IUA consist of the headwater catchments of the Lomati River. There are two small but significant dams in this IUA, the Lomati Dam which transfers water to Barberton and the Shiyalongubo Dam which transfers water to irrigators in the Louws Creek River, a tributary of the Kaap River.

This IUA is located on the escarpment in a relatively mountainous area. The dominant land use is forestry although there is also some grazing.

While there is no direct water use in this catchment, the yield made available from the two dams is transferred out of the catchment.

Water resources: Ground water

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic Basement rocks of the Barberton Super Group. These Basement aquifers have no primary porosity and have a low to moderate groundwater potential. Groundwater is largely used for rural domestic supplies while use for irrigation is minimal.

Water resources: WQ

There are no hotspots in this IUA.

Economy

The IUA has extensive commercial forestry activities that have a significant economic impact on the economy. Minimal grazing of livestock is taking place. There is no direct water use in the IUA but the transferred water out of the IUA does have some economic value.

Ecosystem Services

This is a very low population density IUA with extensive forestry. The Barberton Nature Reserve falls partly within the IUA and overall the IUA has a low social value.

Ecology (rivers)

This IUA consists of only two SQs, both in the upper Lomati catchment and in a reasonably good state (B/C PES). The impacts are mostly non-flow related in the form of forestry, vegetation removal and aliens, and bed or channel disturbance.

Ecology (wetlands)

There were no priority wetlands highlighted in X14A or X14B.

IUA rationale

These two SQs do not warrant an IUA on its own, but the exclusion of Swaziland in this assessment has isolated these two rivers from the downstream IUAs.

3.2.8 IUA X1-8 (Lomati catchment downstream of Driekoppies Dam)

Water resources: Surface water

This IUA consists of the Lomati River downstream of the Swaziland border and down to the confluence with the Komati River. The large Driekoppies Dam is located in this IUA although there are also numerous farm dams as well.

The area is mostly very flat although bordered by mountains in the North West. Land use consists mostly of extensive irrigated crops although there is also some grazing of livestock. There are also numerous villages in this area.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic Basement rocks of the Nelspruit Suite and Barberton Super Group. These Basement aquifers have no primary porosity and have a low groundwater potential. However, deeply weathered and fracture zones may yield boreholes that sustain small scale irrigation and rural domestic supplies. Alluvial aquifers are only present in the IUA to a very limited extent. Groundwater use occurs throughout the area and is largely for rural domestic supplies of which many residents are entirely dependent on groundwater.

Economy

The main economic activities in the IUA are irrigation crops and grazing. The irrigation crops consists mainly of sugarcane, citrus, vegetables and avocado. There is some commercial forestry and saw milling in the IUA. There are a number of large settlements and are significant domestic water users.

Ecosystem Services

Large sections of the IUA are comprised of plantation forestry, commercial agriculture (including sugar cane), and open terrain. Within 2 km of the river is the large Shongwe settlement. Part of the IUA is located within the Driekoppies Dam. With regard to the river section located downstream of the Driekoppies Dam land-use is exclusively intensive agriculture on the north bank, and the upper portions of the south bank. Five large townships are located on the south bank of the river. The Social value is considered to be moderate to high.

Ecology (rivers)

The Lomati main stream in this IUA flows from the Driekoppies Dam immediately downstream of Swaziland, and due to the impact of the large dam, the first SQ has a PES of a D/E. The main stream is further influenced by flow-related impacts of upstream flow modification, abstraction for irrigation, and increased flows, as well as non-flow impacts such as large dams and inundation, and poor land-use, resulting in a D PES river. The one tributary (Mhlambanyatsi) is impacted by non-flow factors such as forestry and vegetation removal, and present a C PES river.

Ecology (wetlands)

At the quaternary scale X12G and X14H scored high for wetland frequency and extent. None of these wetlands are NFEPA wetlands or priority wetland clusters however. Wetland types are dominated by seeps in the upper reaches (not associated with the main channel), artificial channelled valley-bottom wetlands associated with the Driekoppies Dam and floodplain wetlands along the Lomati River. At the SQ scale the Lomati River (X14G-01128) was highlighted as a priority wetland due to extent but these are largely artificial or downstream of the Driekoppies Dam and hence have a wetland PES of E and moderate integrated EIS. The main PES driver is dams and flow modification and reduction.

IUA rationale

The Lomati River downstream of Driekoppies Dam is in its own IUA due to the role in operation and land use that Driekoppies Dam plays. One tributary is excluded and though very different to the Komati River, it did not warrant an IUA on its own.

3.2.9 IUA X1-9 (Komati catchment downstream of Swaziland to the Lomati River confluence)

Water resources: Surface water

This IUA consist of the lower Komati River from the Swaziland border to the confluence with the Lomati River. There are two small but significant dams in this IUA, the Mambiso and Masibikela dams, the latter of which is an off-channel storage dam. The area is flat and dominated by irrigated crops, mostly sugar cane although there is also extensive stock grazing taking place.

Water in this area, supplied from the Maguga Dam, is used mostly to irrigate sugar cane while there is also significant domestic use.

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic rocks of the Nelspruit Suite and the Barberton Super Group including the volcanic rocks of the Lebombo Group (Karoo Super Group). These weathered and fractured aquifers are generally not of high water bearing capacity but the potential to sustain small scale water supplies to communities is possible. Alluvial aquifers are only present in the IUA to a very limited extent. Many rural villages occurring in this region are in all probability dependent on groundwater for domestic water supplies.

Economy

The main economic activity in the IUA is irrigation of sugarcane. Extensive livestock grazing takes place in the IUA. The main water users in the IUA are the irrigators and the domestic water users.

Ecosystem Services

The IUA extends largely through open terrain and low intensity informal agricultural plots, of which the plots are linked to the myriad peri-urban and urban settlement that ensure a high population density. There are patches of commercial agriculture and intense subsistence agriculture as well. As there is an increasing population density and evidence of some intensive utilisation of the Ecosystem Services linked to the river the IUA has a moderate to high Ecosystem Services value. However, density of utilisation probably means resource sustainability is compromised.

Ecology (rivers)

The Komati main stem leaves Swaziland as a PES D river, and the three downstream SQs deteriorate all to PES D/E status, mainly due to upstream flow modification and abstraction for irrigation. Additional impacts are non-flow related with the main influences being dams and associated inundation, as well as changes in land cover due to agriculture and human inhabitation. The three tributaries (PES D rivers) flowing into the Komati are mostly affected by non-flow aspect comprising agriculture (fields, grazing,large dams and associated inundation) and other impacts on land cover (urbanization, vegetation removal and alien plants).

Ecology (wetlands)

At the quaternary scale X13J scored high for wetland extent with 23.5km^2 of wetlands. Both NFEPA wetlands and priority wetland clusters also occur in the quaternary. Wetland types are dominated by channelled valley-bottom and floodplain wetlands. At the SQ scale the Komati (X13J-01149, X13J-01221) and Mbiteni Rivers (X13J-01205) were highlighted as priority wetlands. The Komati and Mbiteni wetlands have a PES of D and D/E with moderate EIS. The main PES drivers are flow modification and agriculture.

IUA rationale

The main river (and tributaries) is all dominated by dams, inundation, subsistence agriculture, rural settlements, and sugarcane. Although the operation from Maguga Dam and other infrastructure play a major role in the river, the non-flow aspects dominate. The IUA ends at the Lomati confluence due to a change in land use downstream and change in flow regime from the Lomati River.

3.2.10 IUA X1-10 (Komati catchment downstream of the Lomati River)

Water resources: Surface water

This IUA consist of the Komati River and tributaries downstream of the confluence of the Lomati and Komati rivers, down to the confluence with the Crocodile River. There are numerous farm dams in this IUA, many of which are used as off-channel storage, as well as numerous weirs on the main stem of the river. The area is very flat. Land use is mostly irrigated crops with the remainder of the area used for grazing.

Water in this IUA, supplied from the Maguga and Driekoppies dams, is used for irrigation, mostly sugar cane although there is also significant domestic use and water use by the Komati sugar mill (limited).

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic rocks of the Nelspruit Suite and the Barberton Super Group including the volcanic rocks of the Lebombo Group (Karoo Super Group). These weathered and fractured aquifers are generally not of high water bearing capacity but the potential to sustain small scale water supplies to communities is possible. Alluvial aquifers are only present in the IUA to a very limited extent. Many rural villages occurring in this region are in all probability dependent on groundwater for domestic water supplies.

Economy

The main economic activities in the IUA are irrigation crops and sugar milling. The biggest economic contributors are irrigated crops like sugarcane, macadamia, citrus, avocado and banana and the Komati sugar mill. These activities have a significant economic impact as well as employment impacts.

Ecosystem Services

The IUA includes mixed land use including high density peri-urban and urban settlement and low density but very high intensity irrigated commercial agriculture. The dense settlement includes high reliance on Ecosystem Services although constrained sustainability but the lower density commercial areas probably have little Ecosystem Services reliance. Overall, the IUA has a moderate Ecosystem Services value.

Ecology (rivers)

The receiving main stem in the Komati emerge from IUA X1-9 as a D/E PES. Initially it improves to a D PES, but then the following two SQs deteriorate to an E PES, and ends again with a D PES at the confluence with the Crocodile River. Impacts affecting the Komati are varied, with upstream flow modification and abstraction for irrigation (flow related), bed and channel disturbance, dams and inundation (non-flow related), run-off/effluent and algal growth (WQ) being the major factors.

The tributaries are all in a rather poor state of a C/D to D PES, mainly due to non-flow impacts such as vegetation removal, agricultural fields, overgrazing/ trampling, bed and channel disturbance, farm dams and inundation. Flow related impacts, mainly abstraction for irrigation, also add to the influence on the PES.

Ecology (wetlands)

At the quaternary scale X13K scored high for wetland frequency, although neither NFEPA wetlands nor priority wetland clusters occur in the quaternary. Wetland types are dominated by channelled valley-bottom with some unchannelled valley-bottom wetlands and flat areas. At the SQ scale the Nkwakwa (X13K-01068) and Ngweti Rivers (X13L-01000) were highlighted as priority wetlands. Both these rivers however have poor wetland PES categories (D and D/E respectively) with low EIS. Wetlands are mostly artificial or are dams with the main PES drivers being flow modification and reduction and inundation by dams.

IUA rationale

The main river in this IUA is mostly in an E PES due to the inundation and barrier impacts. The main river (and tributaries) therefore warrants its own IUA as the management of this IUA will be different from upstream.

3.2.11 IUA X2-1 (Crocodile sub-catchment upstream of Kwena Dam)

Water resources: Surface water

This IUA consists of the catchment upstream of the Kwena Dam. In addition to farm dams and numerous trout dams, the Kwena Dam, the largest and most important dam in the Crocodile River catchment, is located at the outlet to this this IUA.

This IUA rises at over 2000 m on the escarpment and forms increasingly deep valleys moving downstream towards Kwena Dam. Landuse consists of forestry, grazing, irrigation and dry-land crops, trout farming. Water use in the IUA consists of limited irrigation and domestic use.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the shales, mudrock and quartzites of the Pretoria Group. The area is further characterised by Intrusive lithologies (diabase dykes and sills) which may act as barriers to groundwater flow and form shallow perched aquifer. These fractured aquifers are generally not of high water bearing capacity. Groundwater development in the area is largely for rural domestic supplies, as well as for game and livestock watering. However, groundwater use in the agricultural sector might be underestimated.

Economy

Economic activities in the IUA are mainly commercial forestry, grazing, trout fishing and irrigation. The irrigated crops in the IUA include citrus and maize. There are both gum and pine plantations in the IUA. Tourism in the form of trout fishing and recreation is also prevalent in the IUA.

Ecosystem Services

The IUA largely includes open terrain and grazing land. The only major human settlement is Dullstroom Town. A number of small dams are noted in the IUA and upstream of Kwena Dam and farming is mixed with forestry and irrigation noted as present. Tourism and recreation associated with the river and dams are an important aspect of the area. As such, recreational and aesthetic aspects of Ecosystem Services are important.

Ecology (rivers)

The reaches in this zone are all moderately modified falling in a PES of C to C/D. The impacts are mostly non-flow related in the form of small farm and trout dams, livestock farming (grazing) and recreation. Some WQ related impacts are also associated with this land-use type (increased nutrients and sediment runoff). The large number of small dams also impact on the flow to some extent.

Ecology (wetlands)

All three quaternaries scored high for wetland density and extent, with X21A and B having small portions in the Verloren Valei Nature Reserve RAMSAR site. Both quaternaries have NFEPA wetlands as well as priority wetland clusters. The wetlands are dominated by high altitude seeps, with some channelled valley-bottom wetlands in the vicinity of Kwena Dam. The wetland PES ranges from C to C/D with integrated EIS generally High or Very High. Impacts are mostly small dams and agricultural encroachment.

IUA rationale

The river upstream of Kwena Dam and the one tributary flowing into Kwena Dam is not influenced by the Kwena Dam. The land use is similar (trout fishing and dams, grazing) and the ecological state is similar (C dominant). This warrants these SQs to be in one IUA.

3.2.12 IUA X2-2 (Crocodile River downstream of the Kwena Dam to the Elands River)

Water resources: Surface water

This IUA consists of the Crocodile River and tributaries from the Kwena Dam to the confluence of the Elands River. There are a few small farms dams in the IUA.

The terrain consists of a deeply incised valley although the valley bottom is sufficiently wide for extensive agricultural lands. Land consists mostly of forestry and grazing with irrigation in lower lying areas. Water use consists of irrigation, with water supplied out of the Kwena Dam and tributaries.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by rocks of the Pretoria Group and to the east the outcropping Malmani dolomite. The area is further characterised by Intrusive lithologies (diabase dykes and sills) which may act as barriers to groundwater flow and form shallow perched aquifer. The alluvial sand deposits of unconsolidated clayey silts forms primary aquifer of high yielding potential along watercourses and valleys but may be limited in extent. The fractured Pretoria Group aquifers are generally not of high water bearing capacity and although the groundwater potential of the dolomites is suspected to be high no information concerning utilization and exploration potential is readily available. Groundwater development in the area is largely for rural domestic supplies, as well as for game and livestock watering. However, groundwater use in the agricultural sector might be underestimated.

Economy

The main economic activities in the IUA are commercial forestry and commercial agriculture. The IUA has both pine and gum plantations with irrigation of crops like citrus and macadamia taking place.

Ecosystem Services

The river section extends largely through a river valley with commercial agriculture/orchards noted along much of the extent. Much of the agriculture is concentrated on the river banks and few settlements were noted other than sporadic farm houses. Some tourism elements were noted and as such recreational and aesthetic aspects of Ecosystem Services are of moderate importance.

Ecology (rivers)

The reaches in this zone range from largely natural (B PES) for the upper Crocodile River (X21E-00947) and northern Buffelkloofspruit (X21E-00947) to moderately modified condition (C PES) for the southern Buffelkloofspruit (X21D-00957) and lower Crocodile River reaches (X21D-00938, X21E-00943). The primary impact in this zone is related to flow regulation by the Kwena Dam, while non-flow related impacts (especially in the tributaries) are related to forestry, agriculture and livestock farming activities.

Ecology (wetlands)

There were no SQs that were highlighted for wetland importance.

IUA rationale

The main river is dominated by the releases of Kwena Dam to the Elands River. As the Elands River contributes significant flow (and natural patterns) to the Crocodile River, the impact of Kwena Dam is somewhat mitigated. The Crocodile River upstream of the Elands River to Kwena Dam therefore warrants its own IUA. Two tributaries are included in this IUA with mostly non-flow regulated impacts.

3.2.13 IUA X2-3 (Elands catchment upstream of the Weltevredespruit (excluded))

Water resources: Surface water

This IUA consists of the upper reaches of the Elands River catchment. There are a few farms dams and trout dams in the catchment and a small dam which supplies water to Machadodorp. The catchment rises on the escarpment and is generally undulating although becoming increasingly mountainous as the river drops down the escarpment in near Waterval Boven. Land uses consist of forestry, grazing and dry-land crops.

There is limited water use in this IUA, consisting mostly of domestic use in towns such as Machadodorp, Waterval Boven and increasing water use by eco-resorts. There is limited irrigation in this catchment and the water use by the smelter located near Machadodorp is also limited.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the shales, mudrock and quartzites of the Pretoria Group. The area is further characterised by Intrusive lithologies (diabase dykes and sills) which may act as barriers to groundwater flow and form shallow perched aquifer. These fractured aquifers are generally not of high water bearing capacity. Groundwater development in the area is largely for rural domestic supplies, as well as for game and livestock watering. However, groundwater use in the agricultural sector might be underestimated.

Economy

The main economic activities in the IUA are mining, forestry, tourism and a ferrochrome smelter. There are some gold mining activities in the vicinity of Machadodorp as well as a ferrochrome smelter which has a significant impact on the local economy. There are some forestry and livestock grazing in the IUA. Settlements like Machadodorp and Waterval Boven has domestic users as well as tourism activities and resorts that make use of the water.

Ecosystem Services

The IUA largely includes open terrain and grazing land. The only major human settlements are Waterval Boven and Machadodorp. A number of small dams are noted in the IUA and farming is mixed. Tourism and recreation associated with the river are an important aspect of the area. As such recreational and aesthetic aspects of Ecosystem Services are important.

Ecology (rivers)

The reaches in this zone are all moderately modified falling in a PES of C to C/D. The impacts are mostly non-flow related in the form of small farm and trout dams, livestock farming (grazing) and recreation. Some WQ related impacts are also associated with this land-use type (increased nutrients and sediment runoff) as well as the runoff and waste water treatment works of Machadodorp and Waterfall Boven towns.

Ecology (wetlands)

At the quaternary scale X21F scored high for wetland occurrence with both NFEPA wetlands as well as priority wetland clusters present. Wetlands are dominated by high altitude seeps, with some flat areas. Only the Elands River (X21F-01046) was highlighted for priority wetlands with a PES C and a HIGH integrated EIS. Impacts are mostly small dams and agricultural encroachment.

IUA rationale

No major water infrastructure, landuse and impacts are similar and this warrants the rivers to fall into its own IUA. At the lower end of the IUA Waterval Boven occurs in the reach and the WQ impacts will affect the downstream reach of the IUA.

3.2.14 IUA X2-4 (Elands River downstream of X2-3 to the Ngodwana confluence, including the Weltevredenspruit, the Ngodwana River upstream of the Ngodwana Dam and the Lupelele River)

Water resources: Surface water

This IUA consists of the Eland River and tributaries downstream of Waterval Boven and ending at the confluence with the Ngodwana River. The Lupelele River is included in this IUA. In addition to small farm dams, the Ngodwana dam is located in this IUA. This dam supplies water to the SAPPI paper mill. The landscape consists of a deeply incised but wide-bottom valley. The landuse consists of extensive forestry with grazing and irrigators crops. Water in this IUA is used equally for irrigation and industrial use at the SAPPI Paper Mill.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by rocks of the Pretoria Group and to the east the outcropping Malmani dolomite. The area is further characterised by Intrusive lithologies (diabase dykes and sills) which may act as barriers to groundwater flow and form shallow perched aquifer. The alluvial sand deposits of unconsolidated clayey silts form primary aquifer of high yielding potential along watercourses and valleys but may be limited in extent. The fractured Pretoria Group aquifers are generally not of high water bearing capacity and although the groundwater potential of the dolomites is suspected to be high, no information concerning utilization and exploration potential is readily available. Groundwater development in the area is largely for rural domestic supplies, as well as for game and livestock watering. However, groundwater use in the agricultural sector might be underestimated.

Economy

The IUA is characterised by extensive pine and gum plantations with the Ngodwana Mill having the biggest economic impact on the IUA both from an economic perspective as well as from an employment perspective. Irrigation of crops and livestock grazing are other agriculture related activities in the IUA

Ecosystem Services

The IUA largely runs through the river valley with commercial agriculture and orchards located in direct proximity to the river, and along the river banks. Tourism related lodges were noted although no settlements were present with the Sappi mill occurring in the lower reach of the river. The tributaries that contribute to the IUA consist of low density commercial farming and forestry areas. Ecosystem Services utilisation is low although some aesthetic and recreational aspects are important in limited sections.

Ecology (rivers)

All of the reaches in this zone are moderately modified (C PES) except the Lupelule stream (X21K-01007) that is largely natural (B PES). Impacts are mostly non-flow related associated with forestry, farming, irrigation and the presence of small (farm) dams. Some WQ deterioration, associated with these land-uses (irrigation return flows, recreation and upstream towns) is also prevalent.

Ecology (wetlands)

There were no SQs that were highlighted for wetland importance in this IUA.

IUA rationale

The impacts are similar for the Elands, the Ngodwana upstream of the Ngodwana Dam and the Lupelele River. The land use is dominated by forestry and farming with some irrigation.

3.2.15 IUA X2-5 (Elands River downstream of the Ngodwana River)

Water resources: Surface water

This IUA consist of the Eland River commencing at the confluence of the Ngodwana River and ending with the confluence with the Crocodile River. The landscape is similar to that of IUA 5, i.e., a deeply incised wide-bottomed valley. Landuse consists mostly of forestry with grazing and limited irrigation. There are no significant dams in this IUA. The only water use in the IUA is limited irrigation and domestic water supply to the village of Elandshoek.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the outcropping Malmani dolomite and the underlying crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. The alluvial sand deposits of unconsolidated clayey silts forms a primary aquifer of high yielding potential along water courses and valleys (especially along the Elands River). Within the IUA a close inter-dependence exists between groundwater and surface water. Most of the groundwater contribution to surface flow probably comes from springs and seeps along the escarpment, as well as from the dolomitic formation which extends partially across the headwaters of the Crocodile River catchment. Large scale development of groundwater within these aquifer systems is likely to directly impact on the availability of surface water. Groundwater use in these aquifers is expected to be limited to domestic supply and small scale irrigation.

Economy

The main economic activity in the IUA is commercial forestry. There are limited grazing of livestock and irrigation taking place in the IUA.

Ecosystem Services

The upper reaches of the IUA extend from below the Sappi mill and the Ngodwana Township. The remaining extent of the river extends through natural/open terrain. The lower section of the IUA extends through open terrain with limited commercial agriculture/orchards. No settlements noted and Ecosystem Services utilisation is low.

Ecology (rivers)

All of the reaches in this zone are moderately modified (C PES). Impacts are mostly related to potential WQ deterioration associated with industries and irrigation return flows, while non-flow related impacts are associated with forestry, farming, irrigation and the presence of small (farm) dams.

Ecology (wetlands)

There were no SQs that were highlighted for wetland importance in this IUA.

IUA rationale

The rest of the Elands River (and a very short section of the Ngodwana River) is largely impacted on by the Ngodwana Dam and the impacts of the Ngodwana (SAPPI) paper mill. These SQs, although short, are different from the rest of the river and therefore warrants a separate IUA.

3.2.16 IUA X2-6 (Crocodile River to the Nels River confluence)

Water resources: Surface water

This IUA consists of the main stem of the Crocodile River from the confluence with the Elands down to the confluence with the Nels River. The river flows through a wide valley with high mountains on either side. There are no dams on the stretch of river, only a weir just upstream of Nelspruit which diverts water to the Nelspruit water treatment works. The main land use is irrigation. Water use in this IUA consist of irrigation, supplemented with releases from the Kwena Dam, and supply to Nelspruit and surrounding towns for domestic and industrial purposes.

Water resources: Ground water

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. The alluvial sand deposits of unconsolidated clayey silts forms a primary aquifer of high yielding potential along water courses and valleys (especially along the Crocodile River). Within the IUA a close inter-dependence exists between groundwater and surface water. Large scale development of groundwater within these alluvial systems is likely to directly impact on the availability of surface water. Given the relatively good availability of surface water, only limited abstraction of groundwater occurs in the IUA.

Economy

The main economic use in the IUA is the supply of water to irrigators in the region. Water is also diverted to Nelspruit and Rockys Drift for domestic and industrial use.

Ecosystem Services

The upper IUA section is comprised of commercial agriculture on the river banks, and open terrain further beyond the banks. Some tourism/recreational facilities (guest houses) were noted and no settlements were noted in this part. The middle IUA extends through commercial agriculture with some recreational/tourism (lodges). The mid-reaches extend along the outskirts of Nelspruit and the lower IUA section extends along the northern outskirt of Nelspruit. Ecosystem Services utilisation is moderate given population densities but is moderated by the nature of the development.

Ecology (rivers)

This reach consists of the Crocodile River downstream of the Elands River confluence to the Nels River confluence. The upper section (two SQ reaches) is moderately modified (C PES) and it deteriorates further in the lower reach after the inclusion of Nelspruit urban impacts. The primary source of deterioration is flow related due to the Kwena Dam flow modification as well as abstraction for agriculture. WQ deterioration is associated with the Elands River inflow, irrigation return flows while non-flow related impacts are related to agriculture, urban areas and its associated infrastructure.

Ecology (wetlands)

There were no SQs that were highlighted for wetland importance in this IUA.

IUA rationale

The main Crocodile River downstream from the Elands to Nelspruit is influenced largely by the operation of Kwena Dam in conjunction with the Elands River flows. This river is very different to the tributaries which form a separate IUA. Nelspruit with its associated urban impacts results in a set of different impacts; many WQ related and this provides the rationale for ending the IUA at Nelspruit.

3.2.17 IUA X2-7 (Houtbos and Visspruit Rivers)

Water resources: Surface water

This IUA consist of the major tributaries of the Crocodile River flowing within IUA X2-6. This included the Houtbosloop, State and the Visspruit rivers. These tributaries rise on the escarpment and have steep gradients flowing through mountainous areas. There are no significant dams in this IUA. Land use consists of forestry, grazing and irrigation. Water use in this IUA consists of irrigation.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. These weathered and fractured aquifers are generally not of high water bearing capacity and as a result, groundwater use for domestic or irrigation in these aquifers is minimal. However, many rural villages occurring in this region are in all probability dependent on groundwater for domestic water supplies.

Water resources: WQ

There are no hotspots in this IUA.

Economy

The main economic activities are commercial forestry and irrigation of crops. There is also some livestock grazing taking place in the IUA.

Ecosystem Services

The upper portion of the IUA extends through natural forest, in the river valley bottom. Plantation forestry is present on the plateaus. Campsites were noted on the mid reaches and some recreational Ecosystem Services importance is evident. No settlements were noted. The lower section of the IUA is a mosaic of open terrain, plantation forestry and commercial agriculture, however open terrain is dominant. Tourism and recreational facilities were present in the lower section and no settlements were noted.

Ecology (rivers)

The upper reaches of the Houtbosloop, including the Beestekraalspruit and Blystaanspruit, are currently in a slightly modified condition, falling in a PES of B to B/C. This is due to predominantly impact by forestry (non-flow related impact). The lower reaches of the Houtbosloop are slightly more deteriorated falling in a PES of C (Moderately modified), with the primary impacts being non-flow related (forestry and agriculture). The Visspruit is also in a slightly modified condition (PES = B/C) due to primarily non-flow related impacts (forestry and irrigation).

Ecology (wetlands)

There were no SQs that were highlighted for wetland importance in this IUA.

IUA rationale

The two tributaries to the Komati in X2-6 are both dominated by forestry and irrigation. Impacts range from B to a C and are all related to non-flow related impacts.

3.2.18 IUA X2-8 (Nels, Wit, and Gladdespruit rivers)

Water resources: Surface Water

This IUA consists of the major tributaries entering the Crocodile River downstream of IUA X2-6 and IUA X2-7. These tributaries included the Nels, Wit and Gladdespruit rivers. There are several significant dams in this IUA, namely, the Witklip, Klipkopjes, Longmere and Primkop dams. The landscape is undulating and landuse consists mainly of forestry, irrigation as well urban and industrial areas. Water use in this IAU is domestic and industrial as well as irrigation.

Water resources: Surface Water

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. These weathered and fractured aquifers are generally not of high water bearing capacity. But deeply weathered zones and structural fractures form secondary aquifers capable of sustaining small communities with water. Alluvial aquifers are only present in the IUA to a very limited extent. Groundwater use occurs (albeit in limited quantities) throughout the area and is largely for rural domestic supplies.

Economy

The economic activities in the area are forestry, commercial agriculture as well as industrial activities. There is significant irrigation of crops including sugarcane, citrus, macadamia and avocado. There are a lot of industrial users in the IUA which has a significant impact on the local economy and job creation potential. The domestic water usage is also significant in the IUA.

Ecosystem Services

The upper IUA is largely made up of plantation forestry. Mid-reaches comprised of extensive commercial agriculture and some plantation forestry as well as being comprised of open terrain with lesser presence of commercial agriculture. No major settlement or recreational/tourism facilities were noted. The lower IUA section extends into Nelspruit and as such is largely urbanised on the west bank with peri-urban and open terrain on the east bank. Ecosystem Services utilisation is moderate given population densities at the lower end of the IUA but moderated by the nature of the development.

Ecology (rivers)

Six of the upper tributaries (Gladdespruit, Sand and upper Nels Rivers) are mostly influenced by forestry and associated impacts, which place them all in a C PES. Downstream flow becomes more of an problem as abstraction for irrigation deteriorate the Sand, lower Nels and Wit rivers, and with some WQ issues and non-flow impacts such as many dams, the PES deteriorate from a C to a C/D to a D/E respectively.

Ecology (wetlands)

The Gladdespruit (X22C-01004) and Wit (X22H-00836) rivers were highlighted for wetland frequency some of which are classified as NFEPA wetlands. Wetlands on the Gladdespruit are dominated by channelled valley-bottom wetlands and seeps with a PES of C and an integrated EIS of High. Main impacts are afforestation/Invasive plants and vegetation removal. Wetlands on the Wit River are mostly dams or associated with dams but some channelled valley bottom wetlands occur around the town of White River. Most NFEPA wetlands should not be priority wetlands. The wetland PES is an E with severe flow modification and numerous dams. The integrated EIS is High however, due to species diversity and threatened and endemic wetland species (which occur irrespective of whether wetlands are natural or artificial).

IUA rationale

These tributaries warrant their own IUA as they are different to the main Komati River. Impacts are similar (forestry and irrigations, while there are additional impacts in the Wit River (resulting in a D/E PES) from WQ issues, and dams.

3.2.19 IUA X2-9 (Crocodile River to the Kaap confluence (including the Blinkwater tributary))

Water resources: Surface water

This IUA consists of the main stem of the Crocodile River from Nelspruit down to the confluence with the Kaap River, including the Blinkwater River. There are no dams in this IUA. The landscape is undulating flat although the Blinkwater River flows through a mountainous area. Water use in the area consists of irrigations and domestic use. Water is abstracted out of this section of river for supply to the Nsikazi South area.

Water resources: Ground water

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. These weathered and fractured aquifers are generally not of high water bearing capacity. But deeply weathered zones and structural fractures form secondary aquifers capable of sustaining small communities with water. Alluvial aquifers are only present in the IUA to a very limited extent. Groundwater use occurs (albeit in limited quantities) throughout the area and is largely for rural domestic supplies.

Economy

The main economic activity is agriculture with crop irrigation being a major element in the local economy. Domestic water use in the IUA is also high. There are some commercial forestry plantations in the middle reaches of the crocodile.

Ecosystem Services

The upper part of the IUA crosses extensive smallholding and commercial agriculture, and some open terrain it then extends south of two Kanyamazane townships. The IUA also includes plantation forestry in the middle reaches of the Crocodile River. The lower reaches of the Crocodile River portion of the IUA extend through a mosaic of open terrain and commercial agriculture and into the gorge. No settlement were noted other than farm houses. No tourism/recreational elements were noted in the part of the IUA. The river section extends through open/natural terrain. The Mbuzulwane and Blinkwater rivers are made up of smallholdings with some tourism lodges. Ecosystem Services utilisation is moderate although some aesthetic andrecreational aspects are important in limited sections.

Ecology (rivers)

The main stem of the Crocodile River in IUA X2-9 is subject to upstream flow modification all the way to the Kwena Dam, as well as additional abstraction for irrigation as it flows towards the Lowveld. The Blinkwater catchment is reasonably healthy, and most of it is in a B PES, however lower down increased agriculture and alien vegetation push the PES into a C EC.

Ecology (wetlands)

The main stem of the Crocodile River in IUA X2-9 is subject to upstream flow modification all the way to the Kwena Dam, as well as additional abstraction for irrigation as it flows towards the Lowveld. The Blinkwater catchment are reasonably healthy, and most of it is in a B PES, however lower down increased agriculture and alien vegetation push the PES into a C EC.

IUA rationale

The Crocodile River downstream from Nelspruit flows through a gorge (with an offtake and canal systems for various irrigations schemes). The end of the IUA was identified as the Kaap River confluence. A reason for this was the proposed dam in the lower Kaap River which has implications for the downstream Crocodile River. Furthermore, the Crocodile River soon after the Kaap River forms the border of the KNP which result in a different situation from a land use perspective.

3.2.20 IUA X2-10 (Kaap catchment)

Water resources: Surface water

This IUA consists of the Kaap River catchment, a major tributary of the Crocodile River. There are no major dams in the Kaap River catchment but there are several farm dams. The Kaap River rises on the escarpment and drops off steeply to a wide valley floor. Landuse in this IUA consists of forestry, grazing and irrigation. Water use in this IUA consists of irrigation and limited gold mining. The water requirements of Barberton are supplied from the Komati catchment.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Barberton Supergroup and the Kaap Valley Tonalite. These weathered and fractured aquifers are generally not of high water bearing capacity. Alluvial aquifers are present in the IUA along major river tributaries. However, large scale development of groundwater within these alluvial systems is likely to directly impact on the availability of surface water. Groundwater use occurs (albeit in limited quantities) in the upper parts of the catchment and is largely for rural domestic supplies.

Economy

The main economic activities in the IUA are forestry, agriculture and mining. There are significant forestry plantations in the IUA, both pine and gum. The irrigated crops include citrus, sugarcane and banana. There is some gold mining taking place in the IUA which contributes to the economy and employment. Livestock grazing is also taking place in the IUA.

Ecosystem Services

The Noordkaap makes up half of this IUA and extends through plantation forestry, and a mosaic of open terrain and commercial agriculture. Mid-reaches of the Noordkaap extend into a river valley (Barberton Nature Reserve). The lower reaches of the Noordkaap comprised of open terrain, and rural homesteads. The Suidkaap makes up the remainder of the IUA and extends through plantation forestry. The mid and lower reaches of the Suidkaap extend through a mosaic of open terrain and commercial agriculture. No settlement noted other than farm houses. There is some tourism and recreational development on the Kaap proper (X23F 0122).

Ecology (rivers)

The upper Kaap system is covered with forestry which is the main influence on the rivers in the upper catchments. In the lower streams (Kaap and Suidkaap), dams increase and the main influences on these lower reaches are abstraction for irrigation with associated return flows that impact on the WQ of these systems.

Ecology (wetlands)

The Queens River (X23E-01154) was highlighted for wetland frequency although none of these were classified as NFEPA wetlands. Wetlands are predominantly seeps with a PES of C and a Low integrated EIS. Main impacts are forestry and alien woody vegetation.

IUA rationale

The Kaap was included as one IUA as there is no large water resource infrastructure or distinct change in land use that necessitates more than one IUA. Impacts are largely non-flow related linked to forestry, mining and irrigation.

3.2.21 IUA X2-11 (Crocodile River from the Kaap confluence to the Komati River)

Water resources: Surface water

This IUA consists of the Crocodile River (outside of the KNP) from the confluence with the Kaap River down to the confluence with the Komati River. There are few off-channel farm dams in this IUA as well as a small dam, Van Graan se Dam, on the main stem of the river. The landscape in this IUA is very flat and landuse consists of extensive irrigation, grazing and game farming. The water use in this IUA consists of irrigation and limited domestic use from towns such as Malelane, Hectorspruit and Komatipoort.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Barberton Supergroup and the Kaap Valley Tonalite. These weathered and fractured aquifers are generally not of high water bearing capacity. Alluvial aquifers are present in the IUA along the Crocodile River. Groundwater use is minimal and is mainly developed for rural domestic supplies, as well as for game and livestock watering.

Economy

The IUA is characterised by extensive irrigation in the form of citrus, sugarcane, avocado and banana crops. Livestock grazing is also evident along the IUA with game farming activities in the Komatipoort area. Other tourism and recreation activities are evident in the IUA. The TSB Sugar Mill in Malelane has a significant impact on the local economy as well as employment. Limited industrial activities are taking place in the Komatipoort area.

Ecosystem Services

The upper section of the IUA is located on the southern outskirts of the Matsulu Township (north bank). The south bank of the river section comprised of commercial agriculture. Further downstream the north bank of the river section is the KNP while the south bank comprised of commercial agriculture and then made up of Malelane town. Tourism/recreational features associated with the river and the KNP were noted. Downstream of Malelane, the KNP makes up the northern bank with the southern bank made up of intensive agriculture (sugar cane is evident) as well as tourism facilities. Ecosystem Services utilisation is high given mixed use and the tourism and recreational elements allied to higher population densities.

Ecology (rivers)

The entire main stem of the lower Crocodile River is utilised intensively, especially for irrigation. Although most of the northern river banks are situated in the KNP, the southern bank is intensively developed. Flow modification due to abstraction for irrigation and the resultant return flows; have major impacts on water quantity and quality. These factors are exacerbated by many non-flow factors and the outcome of this pressure on the river result in a PES of a C/D to a D.

Ecology (wetlands)

No priority wetlands were highlighted in this IUA.

IUA rationale

The Crocodile River downstream of the Kaap River to the Crocodile River confluence is similar in terms of operation and landuse. The operation of the system is dominated by the irrigation requirements and direct pumping from the river.

3.2.22 IUA X2-12 (Nsikasi River)

Water resources: Surface water

This IUA consists of the Nsikasi River catchment, a tributary of the Crocodile River. There are no significant dams in this IUA although there are few small farm dams. The landscape is undulating and landuse consist mostly of wilderness area (within the KNP) but in the west there are sprawling rural villages and more formal housing developments. There remainder of the area is used for grazing. Water use in the area is for domestic purposes but this is supplied mostly from the

Crocodile River. There is limited supply from run-of-river out of the Nsikasi River and also from groundwater.

Water resources: Ground water

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. These weathered and fractured aquifers are generally not of high water bearing capacity. Given the relatively good availability of surface water, it is expected that only limited abstraction of groundwater occurs in the IUA. The level dependence (solely or largely) of these communities on groundwater is unknown.

Economy

The link between the economy and water supply in this IUA is weak since most of the water is being used by domestic water users located in the settlements spread throughout the IUA. Some grazing of livestock by subsistence farmers is also evident in the IUA.

Ecosystem Services

The western portions of the IUA extend through dense settlement with mosaics of open terrain and subsistence agriculture. The eastern portions of the IUA are largely associated with the KNP. Ecosystem Services utilisation is high given mixed use and the tourism and recreational elements associated with the KNP as well as livelihood dependence allied to higher population densities.

Ecology (rivers)

Most of the Nsikazi catchment is situated in the wilderness area of the KNP, with very little impacts apart from firebreak roads, resulting in a PES between A and B. The B PES results from the moderate influence in the form of upstream flow modifications (small dams). The two streams originating from the west outside of the Park borders (Nsikazi origin and Gutshwa) are mostly influenced by non-flow rural impacts such as agricultural fields, vegetation removal, overgrazing and trampling.

Ecology (wetlands)

No priority wetlands were highlighted in this IUA.

IUA rationale

The Nsikasi catchment is separate from other tributaries to the Komati in X2-11 as it borders mostly the KNP, has two pristine tributaries, and, outside of the KNP, is dominated by dense rural settlements, subsistence agriculture, overgrazing and trampling.

3.2.23 IUA X2-13 (Northern tributaries of the Crocodile River located in the KNP)

This IUA is made up of the rivers within the KNP and are natural or near natural.

3.2.24 IUA X3-1 (Sabie catchment upstream of the Klein Sabie (included) confluence)

Water resources: Surface water

This IUA consists of the headwaters of the Sabie River down to the confluence with the Klein Sabie River. There are no significant dams in the IUA. The Sabie River rises on the escarpment and drops off steeply through mountainous terrain as it flows through this IUA. Landuse in this IUA is mostly forestry with some wilderness areas and urban areas. Water use in the IUA is limited to the urban use of Sabie. There is very little irrigation in this area.

Water resources: Groundwater

The geology underlying the IUA is characterised predominantly by rocks of the Pretoria Group and to the east the outcropping Malmani dolomite. The alluvial sand deposits of unconsolidated clayey silts forms primary aquifer of high yielding potential along watercourses and valleys but may be limited in extent. The fractured Pretoria Group aquifers are generally not of high water bearing capacity and although the groundwater potential of the dolomites is suspected to be high no information concerning utilization and exploration potential is readily available. Within the IUA a close inter-dependence exists between groundwater and surface water. Most of the groundwater contribution to surface flow probably comes from springs and seeps along the escarpment, as well as from the dolomitic formation which extends partially across the headwaters of the Sabie River catchment. Large scale development of groundwater within these alluvial systems is likely to directly impact on the availability of surface water. Groundwater use for domestic or irrigation in these aquifers is minimal. However, groundwater use in the agricultural sector might be underestimated.

Water resources: WQ

There are no hotspots in this IUA.

Economy

The main economic activity in the IUA is commercial forestry. There is domestic water use in the Sabie region with very limited irrigation of crops. Some tourism activities have been noted in the IUA.

Ecosystem Services

The IUA extends through steep land with plantation forestry dominant and with some natural vegetation noted on the river banks. Some tourism/recreational features (waterfalls) were also noted. The southern portion of the IUA is given over to commercial farming of a mixed variety. The town of Sabie is located in the lower portions of the IUA. Ecosystem Services utilisation is moderate with population densities generally low and only aesthetic and recreational aspects elevating the score.

Ecology (rivers)

The rivers in this zone (X31A) range between slightly modified (B to B/CPES) for the unnamed tributary and moderately modified (C PES) for the Sabie main stem and Klein Sabie. The primary impact in this zone is non-flow related associated with forestry, while some WQ deterioration is also evident in the lower Sabie reach due to urban runoff and sawmill industries.

Ecology (wetlands)

There were no priority wetlands highlighted for this IUA.

IUA rationale:

The rivers are dominated by forestry with some WQ issues. Ecological state is similar and the downstream border is dictated by Sabie town with its related WQ problems further downstream.

3.2.25 IUA X3-2 (Sabie River downstream of X3-1 to the Marite confluence including the Goudstroom, MacMac, Motitsi and Marite upstream of Inyaka Dam)

Water resources: Surface water

This IUA consists of the upper reaches of the Marite River down to the Inyaka Dam, the Mac-Mac and Motitsi rivers, and the Sabie River from the X3-2 IUA down to the confluence with the Marite River. The terrain is mostly steep and mountainous. This IUA includes the Inyaka Dam, by far the largest dam in the Sabie catchment, as well as Maritsane dam located upstream of the Inyaka dam. Land use in the IUA consists mostly of forestry although there are significant wilderness areas, area under irrigation and urban/rural development. The towns of Graskop, Hazeyview and parts of Bushbuckridge are located in this IUA. Water use in the IUA consists of irrigation, domestic use and transfers out of the Inyaka Dam to the Sand River catchment (IUA X3-3).

Water resources: Groundwater

The geology underlying the IUA is characterised by the Malamni dolomites (in the east) and the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. Within the IUA a close inter-dependence exists between groundwater and surface water is expected. Most of the groundwater contribution to surface flow probably comes from springs and seeps along the escarpment. The fractured Pretoria Group aquifers are generally not of high water bearing capacity and although the groundwater potential of the dolomites is suspected to be high, no large scale groundwater abstractions occur. As a result, groundwater use for domestic or irrigation is minimal.

Economy

The main economic activities in the IUA are commercial forestry, agriculture (both dry land and irrigation) and tourism activities. There are a number of large settlements in the IUA, including Hazyview, Graskop and Sabie. The irrigated crops include banana, avocado, citrus and macadamia. From an industry perspective it is mostly saw milling that is taking place in the IUA.

Ecosystem Services

The upper part of the IUA has Sabie town located on the headwaters and then extends through a mosaic of plantation forestry and natural vegetation. A number of farm smallholdings were noted as are tourism/recreational features (lodges). The northern part of the IUA extends through plantation forestry and the town of Graskop is present in upper reaches as are parts of Bushbuckridge. Natural vegetation noted in gorges on mid and lower reaches of the northern part of the IUA and some significant tourism aspects are present. Also present is Inyaka Dam. The lower part of the IUA extends through farm smallholdings and again significant tourism and recreational features are present. Hazyview town is located in the lower reaches of the IUA. Ecosystem Services utilisation is moderate to high with population densities generally low but aesthetic and recreational aspects elevating the score.

Ecology (rivers)

The rivers in this zone range between slightly modified (B/C PES) for the Sabie (X31B-00756), Goudstroom (X31B-00792), Mac-Mac (X31C-00683) and the Marite River upstream of Inyaka Dam (X31E-00647a) and moderately modified (C PES) for the Sabie main stem (X31B-00757, X31D-00755 and X31D-00772) and the Motitsi River (X31F-00695). The primary impact in this zone is non-flow related associated with forestry and agricultural fields, while some WQ deterioration is also evident in the some areas due to urban runoff (Graskop in the Motitsi) and sawmill industries.

Ecology (wetlands)

There were no priority wetlands highlighted for this IUA.

IUA rationale

This is a large IUA which includes the Sabie River downstream of Sabie town and tributaries of Sabie and the Marite River. These rivers are grouped into one IUA due to their similar land use dominated by forestry with some farming and recreation and reasonable ecological state (PES of B/C and C).

3.2.26 IUA X3-3 (Marite and Sabie River downstream of Inyaka Dam to the Sand confluence)

Water resources: Surface water

This IUA consists of the main stem of the Marite and Sabie Rivers from the Inyaka Dam to the confluence with the Sand River. There are no dams on the river although there is a significant weir at Hoxane where water is abstracted for domestic use. The terrain is relatively flat and landuse consists of irrigation and grazing.

Water use in this IUA is mostly domestic use. There are large abstractions from the Hoxane weir for domestic use on both sides of the river. There is also a significant amount of irrigation use.

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. Within the IUA a close inter-dependence exists between groundwater and surface water is expected. Groundwater is limited to rural domestic supplies, as well as for game and livestock watering, however, further (large scale) development of groundwater is likely to directly impact on the availability of surface water.

Economy

The main economic activities in the IUA are agriculture in the form of grazing and irrigation. Some of the irrigation crops include; banana, citrus and avocado. There is also a significant amount of domestic water use.

Ecosystem Services

This IUA includes a great many land types and uses. The IUA includes the townships of Hazyview, Belfast and Mkhuhlu and also includes farmland/smallholdings and open terrain as well as patches of land used for small scale but intensive agriculture. The IUA includes the KNP and the main rest camp at Skukuza. As such extensive tourism/recreational features are present. Ecosystem Services utilisation is moderate to high with population densities moderate to high in places and aesthetic and recreational aspects elevating the score.

Ecology (rivers)

The river reaches in the upper section of this zone (Marite Downstream of Inyaka Dam and upper Sabie section) are moderately to largely modified (PES C to C/D), but improving further downstream (main Sabie River) closer to the nature conservation areas (especially on right bank). The primary impacts in the upper reaches of this zone are flow-related due to the Inyaka Dam (Marite River) regulation as well as abstraction for irrigation. The middle and lower section of this zone is impacted more by non-flow related activities (agriculture, rural settlements) and to some extent WQ deterioration (increased nutrients, Hazyview town runoff).

Ecology (wetlands)

There were no priority wetlands highlighted for this IUA.

IUA rationale:

Inyaka Dam results in a change in the operation of the downstream Marite River as well as in the Sabie River. As the operations of these two rivers are therefore different to those of the tributaries, a separate IUA was defined. The confluence of the Sand River forms the end of the IUA because of the changes in the Sabie River associated with the Sand River (e.g. sedimentation).

3.2.27 IUA X3-4 (Sabaan, Noord-Sand, Bejani, Saringwa, Musutlu rivers)

Water resources: Surface water

This IUA consists of the Sabaan River (a highly developed tributary of the Sabie), the Noord-Sand and White Waters Rivers as well as the Saringwa and Musutlu Rivers on the north bank of the Sabie River. The IUA contains the Da Gama Dam and the several farm dams, especially on the Sabaan River. This terrain is undulating and land uses are varied, consisting of forestry, intense irrigation activity, and numerous villages. Water use in this IUA consists of irrigation, supplied out of the Da Gama dams and farm dams on the Sabaan River, as well as large domestic use, supplied from the Sabie River.

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite and the Cunning Moor Tonalites. These Basement aquifers have no primary porosity and have a low groundwater potential. However, deeply weathered and fracture zones may yield boreholes that sustain small scale irrigation and rural domestic supplies. Groundwater use occurs throughout the area and is largely for rural domestic supplies of which many is entirely dependent on groundwater.

Economy

The main economic activities in the IUA are commercial forestry, and intensive irrigation. The forestry plantations include both pine and gum plantations. Irrigated crops include citrus, avocado and banana. There is also a large domestic water use in the IUA.

Ecosystem Services

The western part of the IUA extends through a mosaic of plantation forestry, open/natural terrain and farmland. No settlements were noted. The Da Gama Dam located in the IUA with tourism/recreational features was noted on the dam. Downstream of the dam, the river extends through commercial farmland (orchards) and natural terrain. There are a number of large towns and peri-urban settlements associated with the IUA these include Hazyview, Tsabalala, Legogote, Marongwana, Xanthia Agincourt, Bushbuckridge Cunningmoore-A and part of Belfast. Ecosystem Services utilisation is moderate to high with population densities increasing and some aesthetic and recreational aspects elevating the score.

Ecology (rivers)

This zone consists of various tributaries to the middle reach of the Sabie River. The river reaches in this zone ranged between slightly/moderately modified (B/C) to largely modified (D). The river reaches in slightly/moderately modified condition include those with some of its catchment falling within nature conservation areas (Musutklu and upper Saringwa). The rest of the reaches in moderately modified state include the lower Saringa, Matsavana and White Waters. The reaches on largely modified condition (C/D to DPES) include the Sabani, Noord-Sand and Bejani. The primary impacts in this zone are non-flow related (agriculture, high and low density rural and urban settlements) and to some extent WQ deterioration (increased nutrients).

Ecology (wetlands)

There were no priority wetlands highlighted for this IUA.

IUA rationale

All tributaries of the Sabie outside the KNP which do not form part of the IUAs above have been grouped together in one IUA. Most of the land uses are non-flow related and linked to high and low density settlements, agriculture as well as WQ deterioration. The operation of this IUA will therefore be based on non-flow related aspects rather than management of abstractions and operation of Inyaka Dam.

3.2.28 IUA X3-5 (Sabie River downstream of the Sand confluence to the RSA border)

Water resources: Surface water

This IUA consists of the main stem of the Sabie River downstream of the confluence with Sand River. There are no dams in the IUA. The landscape is flat and is exclusively a wilderness area, contained within the KNP. Water use within this IUA is for game watering and domestic use at the camps within the park.

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite and the volcanic rocks of the Lebombo Group. These weathered and fractured aquifers are generally not of high water bearing capacity. Alluvial aquifers are present in the IUA along the Sabie River. Within the IUA a close inter-dependence exists between groundwater and surface water. Groundwater is limited to rural domestic supplies, as well as for game and livestock watering.

Economy

The IUA is entirely within the KNP and tourism is the only economic activity that takes place.

Ecosystem Services

Entire IUA is located in the KNP. Tourism and recreational aspects elevate the Ecosystem Services.

Ecology (rivers)

The entire main stem of the Sabie River in this IUA is protected in the KNP and only impacted by upstream influences or less significant tourist facility pressure. This places the river in a PES that varies between PES of A/B and B, except for the reach that includes the Lower Sabie Rest Camp where the impacts of the instream dam and associated influences cause the PES to be a lower B/C.

Ecology (wetlands)

There were no priority wetlands highlighted for this IUA.

IUA rationale

Downstream of the Sand confluence the Sabie River flows through the KNP. Landuse is therefore all similar and the only aspect impacting on the Sabie River (apart from small localised impacts due to tourism infrastructure) is the upstream catchment influences in the Sand River and the operation of Inyaka Dam and abstractions in the Sabie River. The main Sabie River therefore warrants an IUA as operation of the Sabie River will be different than its tributaries in this area.

3.2.29 IUA X3-6 (Southern and northern tributaries of the Sabie in the KNP downstream of the Sand confluence including the Phabeni)

Water resources: Surface water

This IUA consists of the tributaries of the Sabie River downstream of the confluence with the Sand River located within the KNP. There are no dams in this IUA. The landscape is very flat and the land is all wilderness area. Water use is for game watering.

Water resources: Ground water

The geology underlying the IUA is characterised predominantly by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite. Alluvial aquifers are only present in the IUA to a very limited extent. The IUA is almost entirely within the KNP and the minimal groundwater use is mainly for domestic supplies, as well as for game watering.

Water resources: WQ

There are no hotspots in this IUA.

Economy

The IUA is entirely within the KNP and tourism is the only economic activity that takes place.

Ecosystem Services

Entire IUA is located in or adjacent to the KNP. Tourism and recreational aspects elevate the Ecosystem Services.

Ecology (rivers)

The Pabeni River flows in the KNP but close to the border, with mostly small non-flow impacts such as grazing and flooding, bank erosion due to the bridge and roads, thus it has a B PES. All the other rivers fall within the KNP and have no or limited impacts, i.e. in an A PES.

Ecology (wetlands)

The Nwatimhiri inside KNP has a few pans and small dams which highlight as priority due to their conservation status.

IUA rationale:

These Sabie tributaries all fall in the KNP in their entirety and are therefore grouped together in one IUA.

3.2.30 IUA X3-7 (Mutlumuvi catchment)

Water resources: Surface water

This IUA consists of the Mutlumuvi River, a major tributary of the Sand River. There are no dams on this river although the failed Zoeknog Dam was located on this river. The Mutlumuvi River rises on escarpment and drops rapidly to the Lowveld plains. Land use consists of forestry on the mountain slopes, numerous villages, grazing, limited irrigation and subsistence dry-land agriculture. Water use in this IUA is domestic water use supplied mostly from the Inyaka Dam but still supplemented from run-of-river abstractions. There is also limited supply to irrigation via the New Forest canal which diverts water out of the river at the New Forest weir.

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite and the Cunning Moor Tonalites. These Basement aquifers have no primary porosity and have a low groundwater potential. However, deeply weathered and fracture zones may yield boreholes that sustain small scale irrigation and rural domestic supplies. Groundwater use occurs throughout the area and is largely for rural domestic supplies of which many is entirely dependent on groundwater (i.e. Bushbuckridge area).

Economy

The main economic activities in the IUA are forestry and agriculture (both commercial and subsistence farming). Forestry includes pine and gum plantations with saw milling activities, while the agriculture includes subsistence dry land agriculture and limited irrigation of crops from the new forest canal. There are a number of settlements in the IUA with a significant demand for domestic water.

Ecosystem Services

Although the IUA includes some areas of low population density and some forestry there are also very dense settlements of Zoeknog, Orinoco, Shatale, Dwarsloop, New Forest, Marijane Thulamahase, Saselani and Arthurstone. Along with subsistence and informal agriculture are pockets of high value greenhouse/tunnel development and commercial agriculture. Resource dependence aspects of Ecosystem Services are high.

Ecology (rivers)

This IUA is situated in an area dominated by rural agriculture and urbanization, and the main influence on the rivers is non-flow issues, such as agricultural fields, vegetation removal, overgrazing and trampling, sedimentation, bed and channel disturbance. However, additional smaller flow and WQ impacts also cause the SQs in the IUA to vary in PES levels between C/D and D/E.

Ecology (wetlands)

The Mutlumuvi (X32D-00605) was highlighted for extensive channelled valley-bottom wetlands with a PES of D and a High integrated EIS. The main impacts are vegetation removal and overgrazing.

IUA rationale

Although not significantly different than the rest of the catchment, the Mutlumuvi and its tributaries were grouped into one IUA. The catchment is characterised by extensive dense settlements and associated impacts. There is also a transfer from Inyaka Dam to this catchment, although nowadays the transfer does not flow directly into the river.

3.2.31 IUA X3-8 (Sand catchment to the Khokhovela (included) confluence)

Water resources: Surface water

This IUA consists of the northern tributaries of the Sand River, i.e. the Klein-sand and Thulandziteka Rivers. There are several small dams in the IUA, namely, the Kasteel, Acornhoek, Orinoco and Edinburgh dams. The terrain is the same as the IUA X3-3 with the rivers rising on the escarpment and falling rapidly to the Lowveld plains. Landuse is forestry, grazing, villages, irrigation and dry-land subsistence agriculture.

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite, the Cunning Moor Tonalites and the Makhutswi gneiss. These Basement aquifers have no primary porosity and have a low groundwater potential. However, deeply weathered and fracture zones may yield boreholes that sustain small scale irrigation and rural domestic supplies. Alluvial aquifers are only present in the IUA to a very limited extent. Groundwater use is largely for rural domestic supplies of which many is dependent on groundwater. Groundwater also sustains some small irrigation schemes.

Economy

The main economic activities in the IUA are forestry and agriculture (both commercial and subsistence farming). Forestry includes pine and gum plantations with saw milling activities, while the agriculture includes subsistence dry land agriculture and grazing with limited irrigation of crops. There are a number of settlements in the IUA with a significant demand for domestic water.

Ecosystem Services

The upper reaches of the IUA extend through the Blyde River Canyon. The IUA then descends onto plains of open terrain and the large townships of Casteel, Craigisburn, and Dingleydale. Some commercial farmland is noted in this part of the IUA as is the Dingleydale Dam. IUA population densities increase with the presence of Edinburgh, Mbumber, Khokovela, Clare, Rolle, and Athole. Cattle grazing and some subsistence agriculture are notable features of this part of the IUA. Some portion of the IUA is given over to Game Park. Resource dependence aspects of Ecosystem Services are high as are the aesthetic features of the Blyde River Canyon and recreational aspects of the Game Park areas.

Ecology (rivers)

Most of the impacts on the rivers in IUA X3-8 are related to rural agriculture and urbanization such as agricultural fields, vegetation removal, overgrazing and trampling, sedimentation, bed and channel disturbance. This put all the SQs in a C PES, except Thulandziteka which is a D PES.

Ecology (wetlands)

Both the Thulandziteka and Motlamogatsana Rivers were highlighted for extensive channelled valley-bottom wetlands with a PES of D and an integrated EIS of High. Many of the wetlands are associated with the tributaries. The main impacts are vegetation removal and overgrazing.

IUA rationale

The similar landuse which is dominated by settlements, overgrazing and sedimentation problems are grouped into one IUA. The downstream border of the IUA is dictated by the change in landuse due to the presence of conservation areas.

3.2.32 IUA X3-9 (Sand catchment downstream of the Khokovela confluence)

Water resources: Surface water

This IUA consists of the Sand River catchment downstream of the Kholovela River, which is approximately at the border with the Sabi Sand Game Reserve. There are no dams in this IUA. The terrain is flat and the area falls entirely within wilderness area, either the Sabi Sand Park or the KNP. Water use is for game watering and camps within these parks.

Water resources: Groundwater

The geology underlying the IUA is characterised by the crystalline igneous and metamorphic basement rocks of the Nelspruit Suite, the Cunning Moor Tonalites and the Makhutswi gneiss. Alluvial aquifers are present in the IUA along the Sabie River. These weathered and fractured aquifers are generally not of high water bearing capacity. Along these alluvial systems a close inter-dependence exists between groundwater and surface water. Groundwater for domestic use or irrigation in this IUA is minimal.

Economy

The area of the IUA falls within the KNP as well as private game reserves along the border of the park. The main economic activity is thus tourism and nature conservation.

Ecosystem Services

Virtually all of the IUA is Game Park but it also includes the settlement of Phungwe and Utlha. Tourism and recreational aspects elevate the Ecosystem Services importance.

Ecology (rivers)

All of these rivers are situated in conservation areas and thus fairly well protected. These rivers are thus without the burden of local impacts, therefore the good PES levels that varies between PES of A and B. However, the Sand which forms the upstream link to the IUA is still under pressure owing to high levels of sedimentation that has washed in from upstream, putting the reach in a PES of a C.

Ecology (wetlands)

There were no priority wetlands highlighted for this IUA.

IUA rationale

The presence of the conservation areas has resulted in the main Sand River and a tributary to form its own IUA.

3.2.33 Description of status quo per IUA in X4 (Nwanedzi and Nwaswitsontso)

There are 24 SQs in this IUA which consists of all the SQs in X4. Of the 24 SQs, 22 are in an A or A/B PES and two in a B PES. Twenty-three of the SQs are situated completely within the KNP. One SQ is situated for 70 % of its length in the KNP. As such, these SQs will not be impacted by any future scenarios and the Water Resource Class will be a Class I.

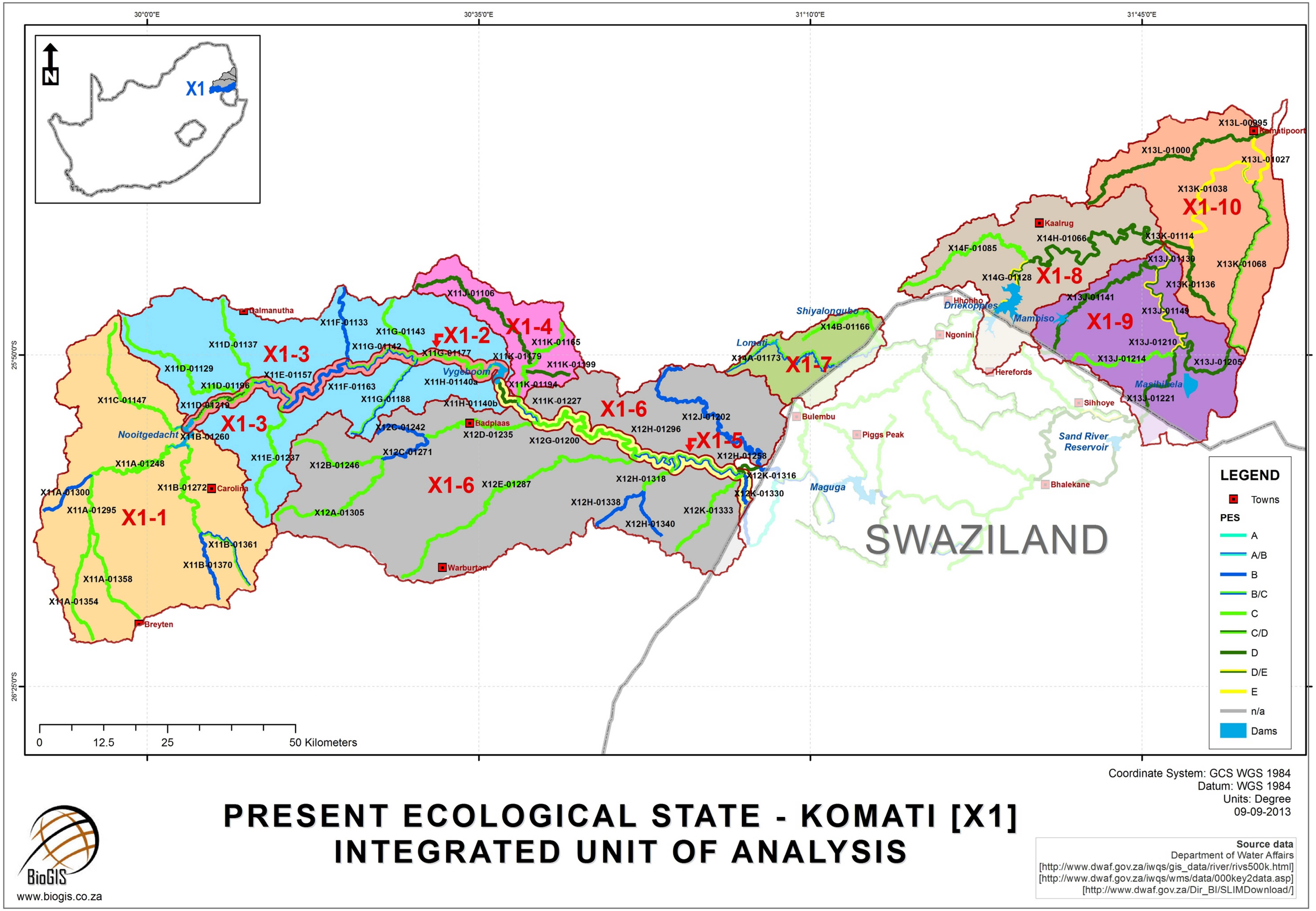


Figure 3.2 IUA and PES in the Komati River system (X1)

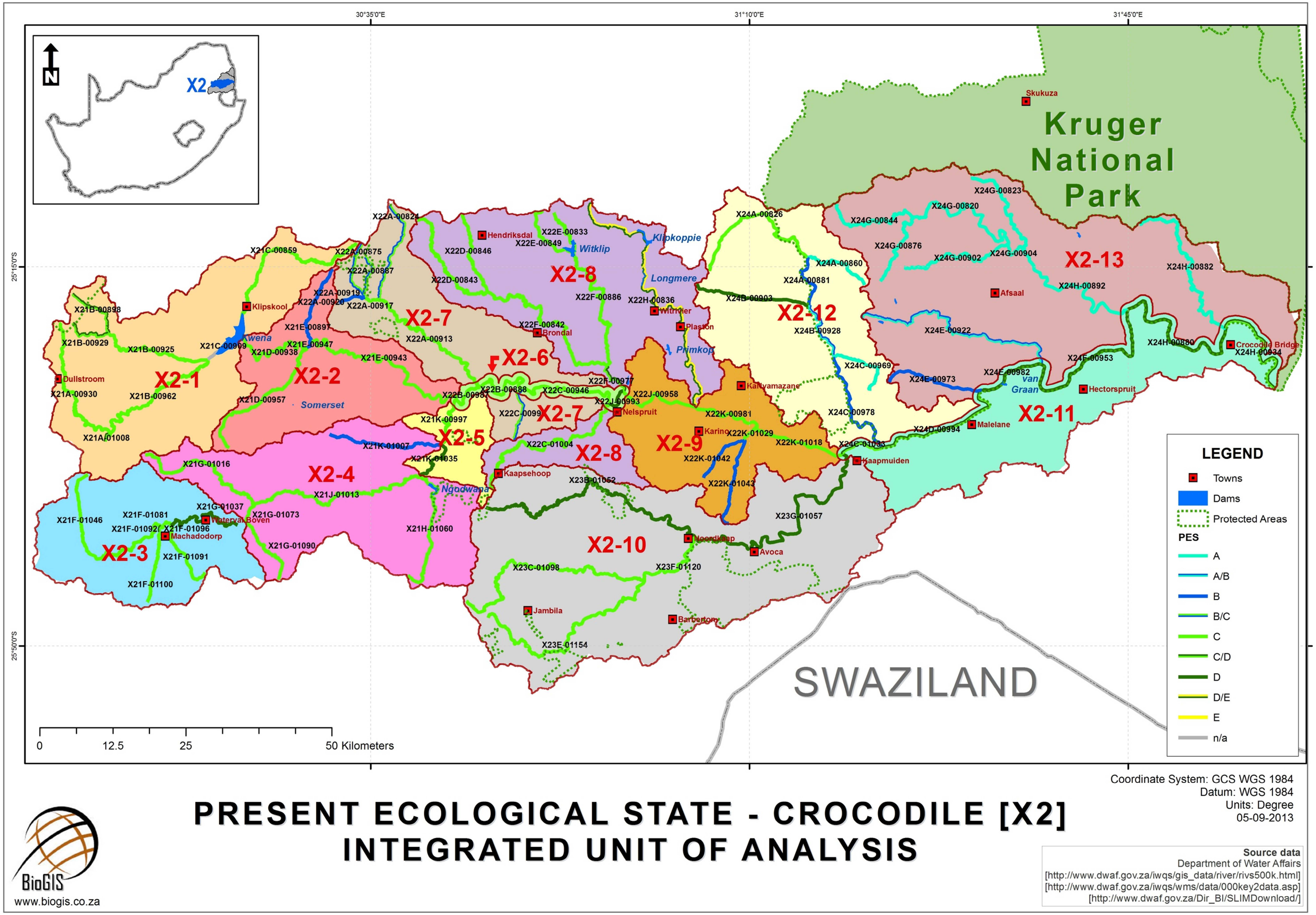


Figure 3.3 IUA and PES in the Crocodile River system (X2)

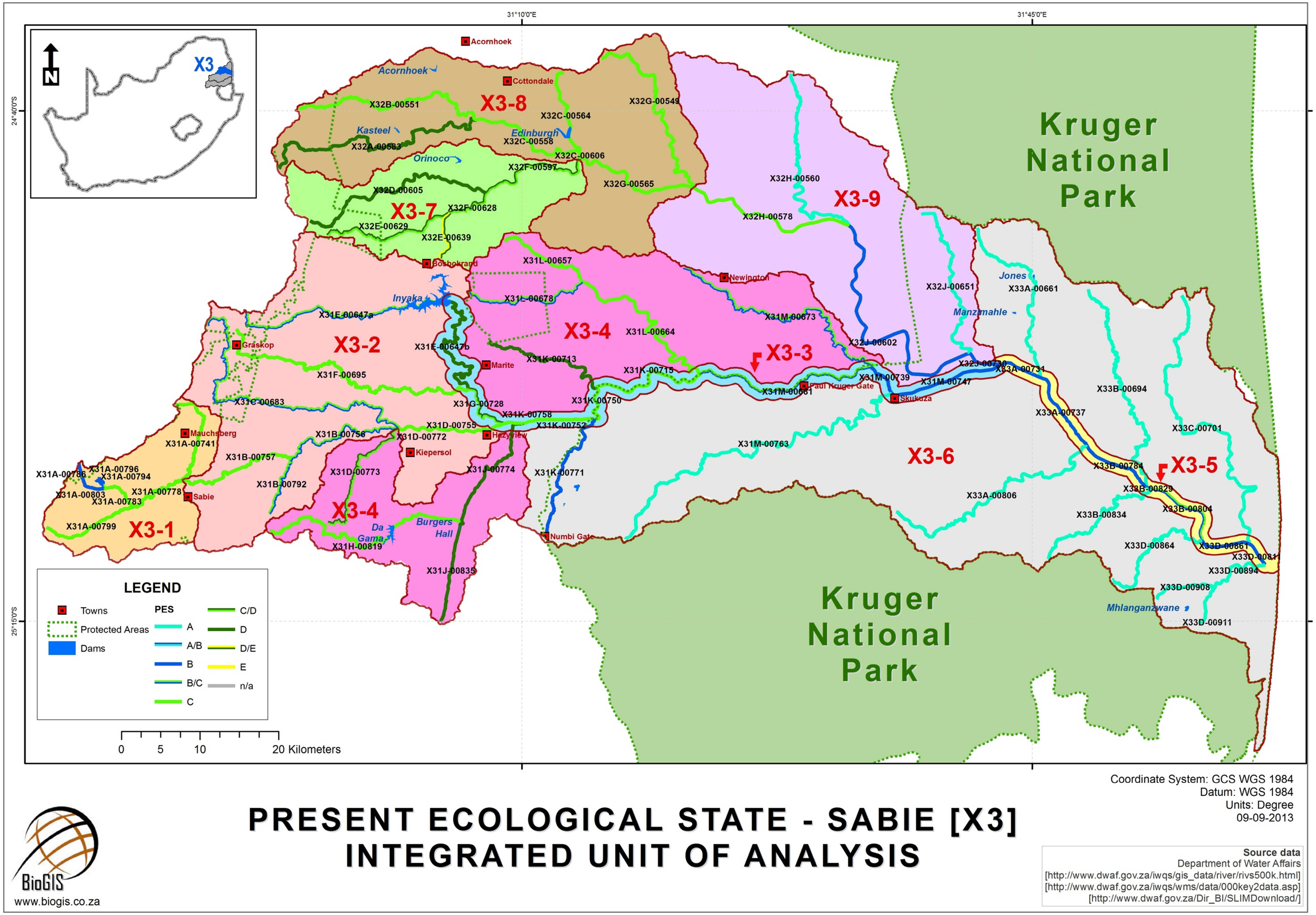


Figure 3.4 IUA and PES in the Sabie-Sand River system (X3)

4 HOTSPOT IDENTIFICATION

This chapter is an extract from report: DWA (2013b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: Status Quo assessment, Integrated Unit of Analysis delineation and biophysical node identification. Prepared by: IWR Water Resources. Authored by: Mallory S, Louw D, Deacon A, Holland, M, Huggins G, Kotze P, Mackenzie J, Scherman P, Van Jaarsveld P,. DWA Report, RDM/WMA05/00/CON/CLA/ 0213. September 2013.

4.1 BACKGROUND

The hotspot represents a river reach with a high Integrated Environmental Importance which could be under threat due to its importance for water resource use. The hotspots are therefore an indication of areas where detailed investigations would be required if development was being considered. These hotspots usually represent areas which are already stressed or will be stressed in future (Louw and Huggins, 2007; Louw *et al.,* 2010).

Hotspots are areas with high Integrated Environmental Importance (IEI) and high Water Resource Use Importance (WRUI). IEI considers PES, Ecological Importance and Sensitivity, FEPAs (Table 4.1) and Socio-Cultural Importance (SCI).

4.2 IMPORTANCE

4.2.1 National Freshwater Ecosystem Priority Areas (NFEPAs)

The SQs with associated NFEPAs (Nel, *et al*., 2011), specifically FEPAs are listed and verified in Table 4.1.

Table4.1 FEPA verification based on PES data and fish information

SQ	River	EI	PES	Veri-fication	FEPA comment
Komati River system(X1)					
X11A-01354		Moderate	C	✗	Unlikely to be in a PES of A or B.
X11A-01358	Vaalwaterspruit	Moderate	C	✗	Unlikely to be in a PESof A or B.
X11A-01295	Vaalwaterspruit	Moderate	C	✗	Unlikely to be in a PESof A or B.
X11B-01361		Moderate	B/C	?	*Barbus anoplus* present in this reach, but this species is not threatened. Uncertainty regarding the justification for use of this species in selecting FEPAs (no rationale provided in FEPA documentation).
X11B-01260	Komati			✗	Entire SQ in Nooitgedacht Dam.
X11C-01147	Witkloofspruit	Moderate	C	✗	Unlikely to be in a PES of A or B.
X11D-01129	Klein-Komati	Moderate	C	✗	Unlikely to be in a PES of A or B.
X11E-01237	Swartspruit	High	B/C	✗	Unlikely to be in a PES of A or B.
X11F-01133	Bankspruit	High	B	?	*B. anoplus* present in this reach, but this species is not threatened. Uncertainty regarding the justification for use of this species in selecting FEPAs (no rationale provided in FEPA documentation).
X12J-01202	Mtsoli	High	B	✓	PES in B and both species expected to be present. *Chiloglanis bifurcus* threatened but uncertain about *B. anoplus* rationale for

SQ	River	EI	PES	Veri-fication	FEPA comment
					inclusion.
X12K-01332	Mhlangampepa	High	B	?	Uncertain about the presence of this species in this SQ (low probability of occurrence).
X12K-01330	Komati			✗	Very short reach completely inundated by downstream weir.
X14A-01173	Lomati	High	B/C	✓	PES probably in low B. All mentioned species except *Barbus brevipinus*, *C. bifurcus* and *Opsaridium peringueyi* expected to be present.
X14B-01166	Ugutugulo	High	C	?	Low probability of a PES still being in A or B. All mentioned species except *B. brevipinus*, *C. bifurcus* and *O. peringueyi* expected to be present.
CrocodileRiver system(X2)					
X21A-01008		Low	C/D	✗	Unlikely to still be in a PES of A or B. Ephemeral system (short drainage line). None of the mentioned species expected in this reach.
X21A-00930	Crocodile	High	C	✗	Unlikely to still be in a PES of A or B. None of the mentioned species expected in this reach.
X21B-00925	Lunsklip	Moderate	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Kneria* spp.and *Opsaridium* spp. likely to be present).
X21B-00962	Crocodile	High	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* spp. likely to be present).
X21C-00859	Alexander-spruit	High	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* spp. likely to be present).
X21D-00957	Buffelskloof-spruit	High	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* spp. likely to be present).
X21G-01090	Weltevrede-spruit	Moderate	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Kneria* spp. and *Opsaridium* spp. likely to be present).
X21H-01060	Ngodwana	Moderate	C	✗	Unlikely to still be in a PES of A or B. (All fish species except *Opsaridium* spp. likely to be present).
X21J-01013	Elands	High	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* spp. likely to be present).
X21K-01035	Elands	Moderate	D	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* spp. likely to be present).
X21K-00997	Elands	Moderate	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* sp. likely to be present).
X22A-00917	Houtbosloop	Moderate	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* sp. likely to be present).
X22A-00913	Houtbosloop	High	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* sp. likely to be present).
X22B-00987	Crocodile	High	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* sp. likely to be present).
X22B-00888	Crocodile	Moderate	C	✗	Unlikely to still be in a PES of A or B (all fish species except *Opsaridium* sp. likely to be

SQ	River	EI	PES	Veri-fication	FEPA comment
					present).
X22D-00843	Nels	Moderate	C	×	Unlikely to still be in a PES of A or B (*C. bifrenatus* and *Opsaridium* sp. unlikely to be present).
X22K-01042	Mbuzulwane	Moderate	B	✓	PES in B. *H. vittatus* highly unlikely to be present, but *O. peringuyi* low probability of occurrence.
X22K-01043	Blinkwater	High	B	✓	PES in B. *H. vittatus* highly unlikely to be present, but *O. peringuyi* low probability of occurrence.
X24E-00973	Matjulu	High	B	×	PES in B (low probability that *H. vittatus* is present and *C. brevis* actually introduced into the Crocodile system).
X24E-00922	Mlambeni	High	A/B	×	PES in A/B (low probability that *H. vittatus* is present and *C. brevis* actually introduced into the Crocodile system).
X24G-00902	Mitomeni	High	A	×	PES in A. Agree based on ecosystem type. Very low probability that *H. vittatus* is present due to ephemeral nature of stream).
X24G-00823	Muhlam-bamadubo	High	A	?	PES in A. Agree based on ecosystem type. Very low probability that *H. vittatus* is present due to ephemeral nature of stream.
X24G-00904	Mbyamiti	High	A	?	PES in A. Agree based on ecosystem type and low probability that *H. vittatus* is present at times in lower reaches.
X24H-00882	Vurhami	High	A	×	PES in A. Agree based on ecosystem type. Very low probability that *H. vittatus* is present due to ephemeral nature of stream.
X24H-00892	Mbyamiti	High	A	?	PES in A. Agree based on ecosystem type and moderate probability that *H. vittatus* is present at times in lower reaches.
Sabie-SandRiver system (X3)					
X31A-00778	Sabie	Moderate	C	×	Unlikely to be in present ecological status of A or B. All mentioned species except *Serranochromis meridianus* and *O. peringueyi* expected to be present.
X31A-00783		Moderate	C	×	Unlikely to be in present ecological status of A or B. All mentioned species except *S. meridianus* and *O. peringueyi* expected to be present.
X31A-00786		High	B	✓	PES estimated to still fall in B. *A. natalensis* most probably only of listed fish species present in this reach.
X31A-00799	Sabie	Moderate	C	×	Unlikely to be in a PES of A or B. All mentioned species except *S. meridianus* and *O. peringueyi* expected to be present.
X31B-00756	Sabie	Moderate	B/C	×	Unlikely to be in a PES of A or B. All mentioned species except *S. meridianus* and *O. peringueyi* expected to be present.
X31B-00757	Sabie	Moderate	C	×	Unlikely to be in a PES of A or B. All mentioned species except S. *meridianus, O. peringueyi* and *H. vittatus* expected to be present.
X31B-00792	Goudstroom	Moderate	B/C	✓	PES estimated to fall in a low B. All mentioned species except *S. meridianus and O. peringueyi* expected to be present.
X31C-00683	Mac-Mac	High	B/C	×	Unlikely to be in a PES of A or B. All mentioned species except *S. meridianus*

SQ	River	EI	PES	Veri-fication	FEPA comment
					expected to be present.
X31D-00755	Sabie	Moderate	C	✗	Unlikely to be in a PES of A or B. All mentioned species except S. *meridianus* and *H. vittatus* expected to be present.
X31F-00695	Motitsi	High	C	✗	Unlikely to be in present ecological status of A or B. All mentioned species except S. *meridianus* expected to be present.
X31K-00715	Sabie	High	C	✗	Unlikely to be in a PES of A or B. All mentioned species expected to be present.
X31K-00750	Sabie	Moderate	C	✗	Unlikely to be in a PES of A or B. All mentioned species expected to be present.
X31K-00752	Sabie	Moderate	C	✗	Unlikely to be in a PES of A or B. All mentioned species expected to be present.
X31K-00758	Sabie	High	C	✗	Unlikely to be in a PES of A or B. All mentioned species expected to be present.
X31M-00681	Sabie	High	B/C	✓	PES estimated to still fall in low B. All mentioned species expected to be present.
X31M-00739	Sabie	High	B	✓	PES estimated to still fall in B. All mentioned species expected to be present.
X31M-00747	Sabie	High	B	✓	PES estimated to still fall in B. All mentioned species expected to be present.
X31M-00763	Nwaswitshaka	High	A	✓	PES estimated to still fall in A. All mentioned species expected to be present.
X32A-00583	Thulandziteka	High	D	✗	Highly unlikely to be in a PES of A or B. All mentioned species expected to be present.
X32B-00551	Motlamogat-sana	High	C	✗	Unlikely to be in a PES of A or B. All mentioned species expected to be present.
X32H-00560	Phungwe	High	A	✓	PES estimated to still fall in A. Low probability of S *meridianus* to be present.
X32J-00602	Sand	High	B	✓	PES estimated to still fall in A or B. All mentioned species expected to be present.
X32J-00651	Mutlumuvi	High	A	✗	PES estimated to still fall in A or B. Low probability of *H. vittatus* being present due to ephemeral nature of reach.
X32J-00730	Sand	High	B	✓	PES estimated to still fall in A or B. All mentioned species expected to be present.
X33A-00661	Nwatindlopfu	High	A	✗	PES estimated to still fall in A or B. Low probability of *H. vittatus* being present due to ephemeral nature of reach.
X33A-00731	Sabie	High	B	✓	PES estimated to still fall in B. All mentioned species expected to be present.
X33A-00737	Sabie	High	B	✓	PES estimated to still fall in B. All mentioned species expected to be present.
X33A-00806	Nwatimhiri	High	A	✗	PES estimated to still fall in A or B. Low probability of *H. vittatus* being present due to ephemeral nature of reach.
X33B-00694	Salitje	High	A	✗	PES estimated to still fall in A or B. Low probability of *H. vittatus* being present due to ephemeral nature of reach.
X33B-00784	Sabie	High	B	✓	PES estimated to still fall in B. All mentioned species expected to be present.
X33B-00804	Sabie	High	B/C	✓	PES estimated to still fall in low B. All mentioned species expected to be present.
X33B-00829	Sabie	High	A/B	✓	PES estimated to still fall in A or B. All mentioned species expected to be present.

SQ	River	EI	PES	Veri-fication	FEPA comment
X33C-00701	Mnondozi	High	A	✗	PES estimated to still fall in A or B. Low probability of *H. vittatus* being present due to ephemeral nature of reach.
X33D-00811	Sabie	High	B	✓	PES estimated to still fall in A or B. All mentioned species expected to be present.
Nwanedzi and Nwaswitsontso River system (X4)					
X40D-00594	Metsimetsi	High	A	✓	PES estimated to still fall in A. Agree based on river ecosystem type.
X40D-00660	Nwaswitsontso	High	A	✓	PES estimated to still fall in A. Agree based on river ecosystem type.

4.2.2 River Ecological Importance and Sensitivity results

The results are available from the PESEIS study (DWS, 2014a). No review or adjustments have been made to these results during this study and they have been taken as is. The number of areas with a HIGH or VERY HIGH (>3) Ecological Importance (EI) rating is provided per IUA (Table 4.2). The green shading shows any IUA with 70% or higher HIGH EI SQs.

Table 4.2 Number of High EI SQs per IUA

IUA	Number of SQs	Number of HIGH (>3) SQs	% of HIGH (>3) SQs
X1-1	9	0	0
X1-2	6	3	50
X1-3	7	2	29
X1-4	5	0	0
X1-5	5	4	80
X1-6	12	9	75
X1-7	2	2	100
X1-8	3	2	67
X1-9	7	0	0
X1-10	7	0	0
X2-1	7	4	57
X2-2	5	3	60
X2-3	7	0	0
X2-4	6	2	33
X2-5	2	0	0
X2-6	4	1	25
X2-7	8	3	38
X2-8	9	2	22
X2-9	6	3	50
X2-10	5	4	80
X2-11	6	4	67
X2-12	7	5	72
X2-13	10	10	100
X3-1	8	1	13
X3-2	8	3	38
X3-3	9	6	67

IUA	Number of SQs	Number of HIGH (>3) SQs	% of HIGH (>3) SQs
X3-4	9	1	11
X3-5	7	7	100
X3-6	11	9	82
X3-7	5	0	0
X3-8	7	2	29
X3-9	5	5	100
X4	24	20	83

4.2.3 Socio Cultural Importance results

The following SQs, as set out in Table 4.3 below, scored "High".There were no scores in the "Very High" range. The bulk of those scoring HIGH did so either because of the recreation and aesthetic value associated with the Drakensberg or the high dependence on resources associated with poor and vulnerable communities located within the SQ.

Table 4.3 SCI that cored HIGH

SQ number	River	Comment
Komati River system (X1)		
X13B-01347		River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive so social value is considered to be high.
X13B-01348		River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive so social value is considered to be high.
X14C-01212	Phophonyane	Upper reaches (upper 50%) comprised solely of commercial agriculture (sugar cane) with no presence of human habitation. River extends past the Piggs peak area so elevated tourism/recreational value. Lower reaches (lower 50%) extends into the Komati township which has extensive rural homestead and informal agriculture along the river. High social value.
X14C-01203	Phophonyane	River section extends into the Lomati township which has extensive rural homesteads and informal agriculture along the river. High social value.
X14D-01174	Lomati	River section extends into the Lomati township which has extensive rural homesteads and informal agriculture along the river. High social value.
X14E-01172	Mlilambi	The upper reaches of the river section is located in Swaziland, and an area comprised of scattered rural homesteads, informal agricultural plots and open terrain. The lower reaches of the river extends into an area of higher population density (linked to the Hlohlo township) and extensive informal subsistence farm plots. Social value is high.
X13B-01270	Umlambongweny a	Upper reaches of the river section extends through plantation forestry, and a large farm dam. The river then passes the rural village of Ndzingeni (which contains both households and industrial features). The lower half of the river section extends through a mosaic of rural homesteads with informal agriculture, open terrain. Social value is moderate to high.
X13C-01364	Mbuyane	The river section headwaters are located in Malolotja Nature Reserve in Swaziland. Much of the river extent is, however, a mosaic of rural homesteads, informal agriculture and open terrain. Social value is considered to be high.
X13D-01323	Komati	Much of the river extent is a mosaic of rural homesteads, informal agriculture and open terrain. Formal small-holdings noted. Social value is considered to be moderate to high.
X13E-01389	Nyonyane	River section extends largely through a mosaic of open terrain and formal smallholdings (small-scale agriculture). Rural homesteads noted but not extensive. Social value is moderate.

SQ number	River	Comment
X13E-01346	Komati	Upper reaches of the river section comprised of open terrain. Mid-reaches extend north of a large rural settlement of Bhalekane and extensive informal agricultural fields. Commercial agriculture also present on the lower reaches. Social value is high.
X13F-01252	Mzimnene	Upper portions of the river section comprised of plantation forestry. Upper and mid-section of the river extend through a mosaic of open terrain, and rural homestead with extensive informal agriculture. Lower reaches extend into moderate density township (Bhalekane) with commercial agriculture on the river banks. Social value is considered to be high.
X13G-01261	Mphofu	Upper reaches of the river extends through a mosaic of plantation forestry and natural forests. Lower reaches extend through rural settlement (low density homesteads) with extensive informal agricultural plots.
X13G-01216	Mbulatana	River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive along much of the river extent so social value is considered to be high. Social value is considered to be moderate to high.
X13G-01259	Mphofu	River section extends through a mosaic of open terrain, rural homesteads and informal agriculture. The latter two are extensive along much of the river extent so social value is considered to be high. Social value is considered to be moderate to high.
X13G-01282	Komati	River section is flanked on both banks by extensive commercial agriculture. Beyond the agricultural fields, is extensive rural settlement (low-density homestead) which flanks the river on certain sections. Social value is considered to be moderate to high.
X13H-01197	Mhlangatane	River section extends through a mosaic of low-density, rural homesteads with extensive informal agricultural plots present and open terrain. Commercial agriculture is present on the lower reaches of the river. Social value is considered to be high.
X13H-01226		River section extends through a mosaic of low-density, rural homesteads with extensive informal agricultural plots present and open terrain. Commercial agriculture is present on the lower reaches of the river. Social value is considered to be high.
X13H-01299		Upper reaches of the river section extends through rural settlements (rural homesteads) and extensive informal agricultural fields. Mid-reaches of the river section extend into open terrain/natural terrain with no human presence before discharging into the Sand River Reservoir. Lower reaches extend below the dam wall and cross commercial agricultural land. Social value is considered to be high.
X13H-01281	Komati	Small section of river which extends through commercial agricultural land, with rural homesteads found on the north bank. Social value is considered high.
X13J-01214	Mgobode	River section extends through open terrain and informal agricultural plots, of which the plots are linked to the Mgodobe Township located further down the river. The mid-reaches of the river extend through open terrain. The lower reaches of the river extend through the Madadeni Township, with some informal agricultural plots noted. Social value is considered to be moderate to high.
X13J-01141	Mzinti	River section is extends through extensive informal agricultural plots on it upper reaches, which are linked to the large Magogeni township located further down the river. The river extends through two additional large townships (Skoonplaas and Boschfontein). The lower reaches of the river include open terrain and an additional township (Mzinti). Social value is considered to be moderate to high.
X13K-01068	Nkwakwa	River section extends through a mosaic of open terrain, rural townships and limited informal agricultural plots. Lower-reaches of the river extend through commercial agriculture. Social value is considered to be moderate to high
X14E-01151	Lomati	The river section is located in Swaziland and extends through extensive commercial agriculture (sugar cane). The river extends into the Hlohlo

SQ number	River	Comment
		township before discharging into the Driekoppies Dam in South Africa. Social value is considered to be high.
Crocodile River system (X2)		
X24A-00826	Nsikazi	Upper reaches of the river section extends through Legogote Township and Manzini. Mid-reaches are comprised of open terrain and passes the Makoko Township.
X24C-00978	Nsikazi	Upper reaches of the river section passes the Ehlanzeni township, and then extends through open/natural terrain, associated with a nature reserve. Lower reaches of the river passes the Matsulu township.
Sabie-Sand River system (X3)		
X31K-00713	Bejani	River extends through open terrain. Marongwana township located on the north bank on the upper reaches of the river. Much of the mid and lower-reaches extend through extensive rural townships.
X31M-00673	Musutlu	River extends through open terrain. Three large townships located on the banks of the river.
X32E-00629	Nwarhele	Upper section low population density some forestry then very dense settlement of Shatale and Dwarsloop.
X32E-00639	Ndlobesuthu	Short river section with very dense settlement of Marijane and Dwarsloop.

4.2.4 Integrated Environmental Importance results

These results are similar to the Ecological Importance results provided in Table 4.2.

4.3 WATER RESOURCE USE IMPORTANCE

The WRUI was assessed by assigning a qualitative score to a river reach for four variables that represent the status of the in-stream flow. The detailed Excel spreadsheet will be made available on the CD with all data provided with the main report. The HIGH importance evaluation and the associated metric resulting in the evaluation are provided in Table 4.4.

Table 4.4 High Importance WRUI SQs

SQ	River	Comment
Komati River system (X1)		
X11A-01300	Unnamed	Acid Mine Drainage (AMD) from coal mines.
X11A-01354	Unnamed	AMD from coal mines.
X11A-01358	Vaalwaterspruit	AMD from coal mines.
X11A-01295	Vaalwaterspruit	AMD from coal mines.
X11A-01248	Vaalwaterspruit	AMD from coal mines.
X11B-01370	Boesmanspruit	AMD from coal mines.
X11B-01361	Unnamed	AMD from coal mines.
X11B-01272	Boesmanspruit	AMD from coal mines.
X11B-01260	Komati	AMD from coal mines.
X11K-01179	Gladdespruit	High water use and transfers.
X11K-01194	Gladdespruit	High water use and transfers.
X11K-01227	Komati	High water use and transfers.
X12G-01200	Komati	High water use and transfers.
X13G-01282	Komati	High water use.
X13H-01299		High water use.

SQ	River	Comment
X13H-01281	Komati	High water use.
X13H-01277	Komati	High water use.
X13H-01280	Komati	High water use.
X13J-01221	Komati	High water use.
X13J-01210	Komati	High water use.
X13J-01149	Komati	High water use.
X13J-01130	Komati	High water use.
X13K-01114	Komati	High water use.
X13K-01038	Komati	High water use.
X13L-01000	Ngweti	High water use.
X13L-01027	Komati	High water use.
X13L-0995	Komati	High water use.
X14G-01128	Lomati	High water use.
Crocodile River system (X2)		
X22H-00836	Wit	High water use.
X22J-00993	Crocodile	High water use.
X22J-00958	Crocodile	High water use.
X22K-00981	Crocodile	High water use.
X22K-01018	Crocodile	High water use.
X23G-01057	Kaap	High water use.
X24C-01033	Crocodile	High water use.
X24D-00994	Crocodile	High water use.
X24E-00982	Crocodile	High water use.
X24F-00953	Crocodile	High water use.
X24H-00880	Crocodile	High water use.
X24H-00934	Crocodile	High water use.
Sabie-Sand River system (X3)		
X31D-00755	Sabie	High water use.
X31D-00773	Sabani	High water use.
X31E-00647	Marite	High water use.

4.4 PRIORITY AREAS – HOTSPOTS

The identified hotspots are illustrated in Table 4.5 and the maps in Figure 4.1 to Figure 4.3. Only hotspots with the maximum evaluation, i.e. a 4 scoring, has been provided.

Table 4.5 Hotspot results

SQ	River	IEI (0 - 5)	WRUI (0 - 4)	Hotspot
Komati River system (X1)				
X11A-01300	Unnamed	4	4	4
X11A-01354	Unnamed	3	4	4
X11A-01358	Vaalwaterspruit	3	4	4
X11A-01295	Vaalwaterspruit	3	4	4
X11A-01248	Vaalwaterspruit	3	4	4
X11B-01370	Boesmanspruit	4	4	4
X11B-01361	Unnamed	3	4	4
X11B-01272	Boesmanspruit	3	4	4
X11F-01163	Komati	5	3	4
X11G-01142	Komati	4	3	4
X11K-01179	Gladdespruit	3	4	4
X11K-01194	Gladdespruit	3	4	4
X11K-01227	Komati	4	4	4
X12G-01200	Komati	3	4	4
X12H-01296	Komati	4	3	4
X12H-01258	Komati	4	3	4
X14H-01066	Lomati	3	4	4
Crocodile River system (X2)				
X22J-00993	Crocodile	3	4	4
X22J-00958	Crocodile	3	4	4
X22K-00981	Crocodile	3	4	4
X22K-01018	Crocodile	3	4	4
X23G-01057	Kaap	3	4	4
X24C-01033	Crocodile	3	4	4
X24D-00994	Crocodile	3	4	4
X24E-00982	Crocodile	3	4	4
X24F-00953	Crocodile	3	4	4
X24H-00880	Crocodile	3	4	4
X24H-00934	Crocodile	3	4	4
Sabie-Sand River system (X3)				
X31D-00755	Sabie	3	4	4
X31E-00647	Marite (US of dam)	4	4	4
X31M-00681	Sabie	4	3	4
X31M-00739	Sabie	5	3	4
X32J-00602	Sand	5	3	4
X32J-00730	Sand	5	3	4
X33A-00731	Sabie	5	3	4
X33A-00737	Sabie	5	3	4
X33B-00784	Sabie	5	3	4
X33B-00804	Sabie	4	3	4
X33B-00829	Sabie	5	3	4
X33D-00811	Sabie	5	3	4
X33D-00861	Sabie	5	3	4
X31E-00647	Marite (DS of Inyaka Dam)	3	4	4

The rivers where hotspots dominate are mostly on the main stems of the rivers. This can largely be attributed to the cumulative impact of water use and reducing WQ relating to industrial and urban development as well as mining.

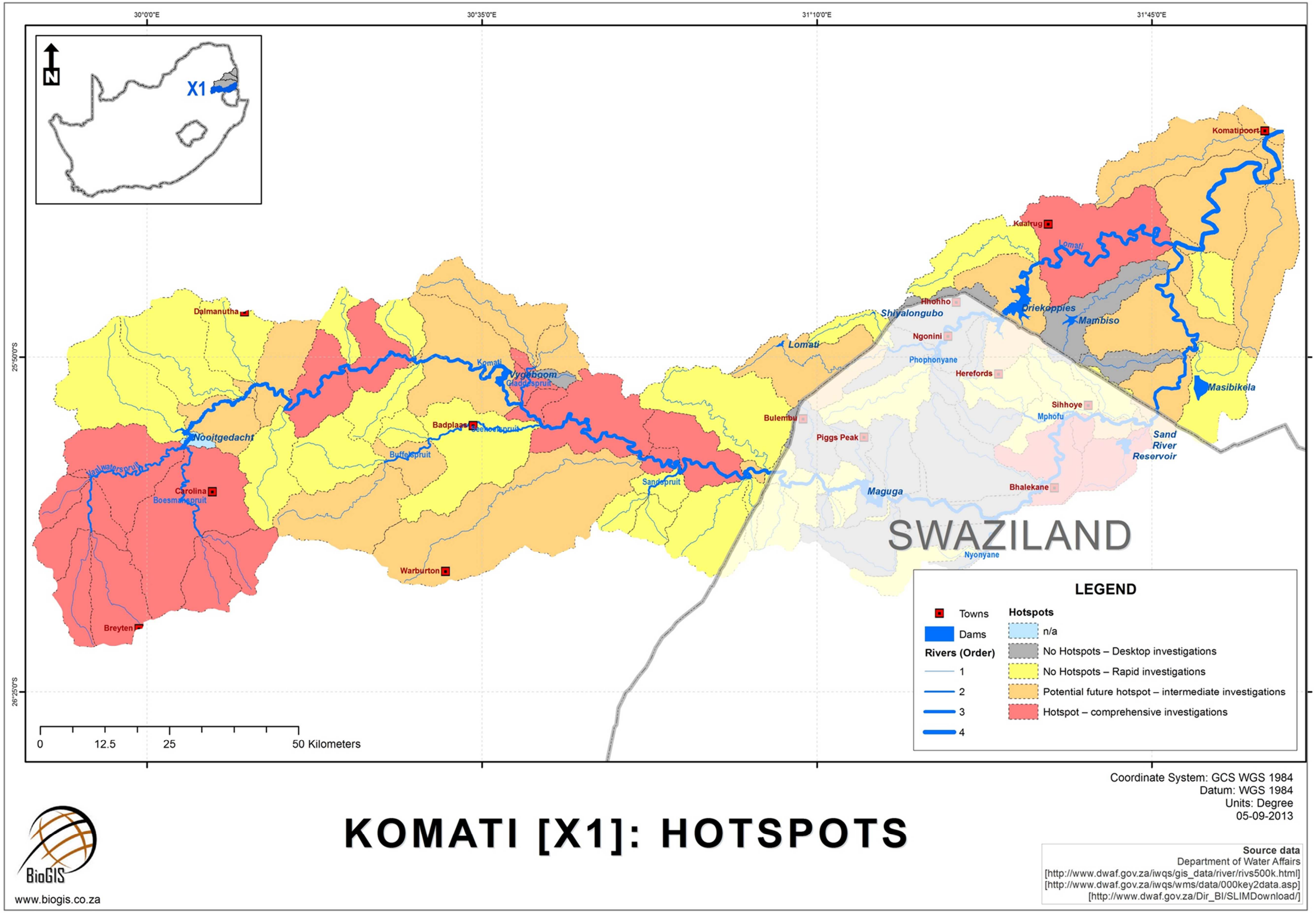


Figure 4.1 Hotspots in the Komati River system (X1)

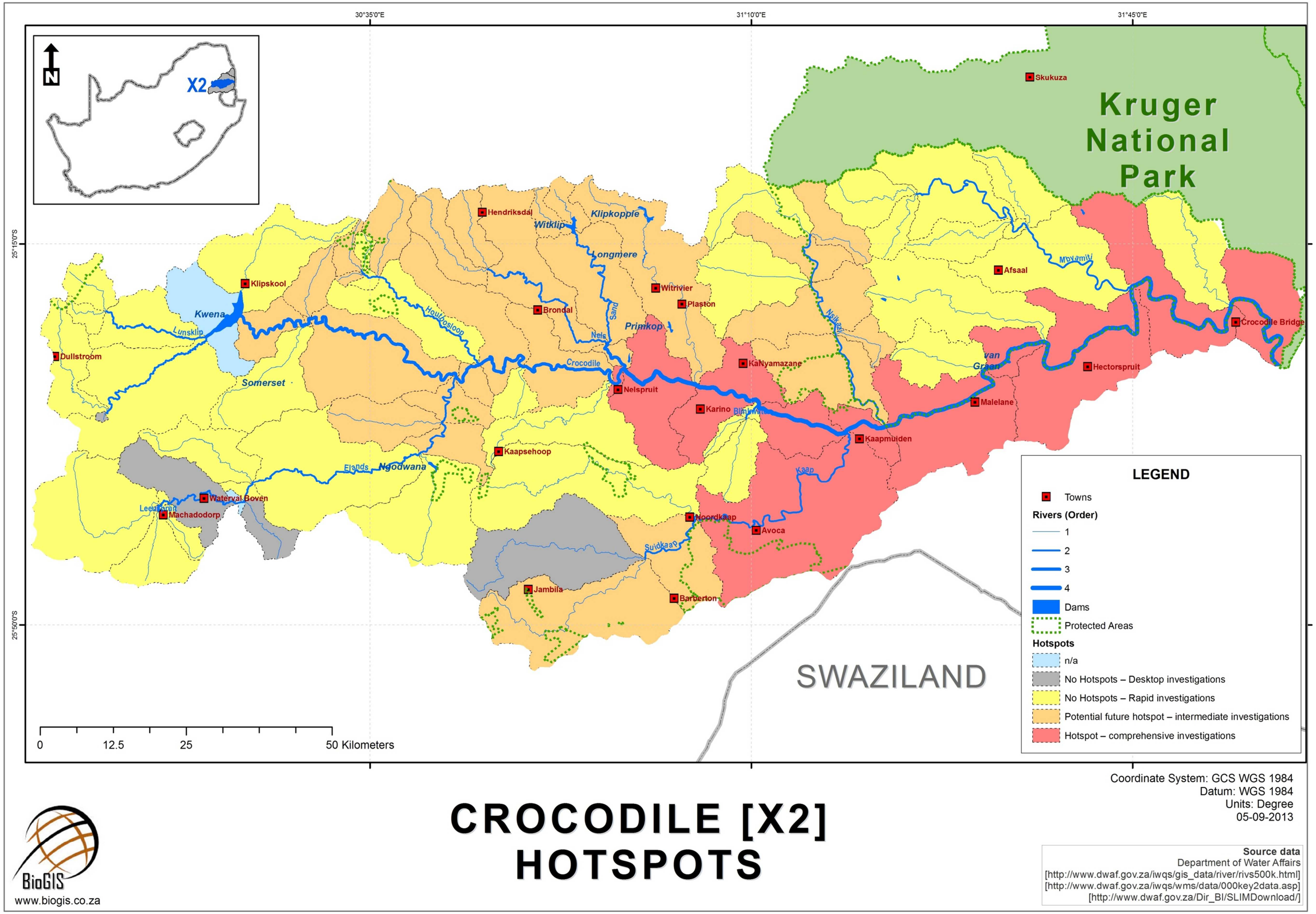


Figure 4.2 Hotspots in the Crocodile River system (X2)

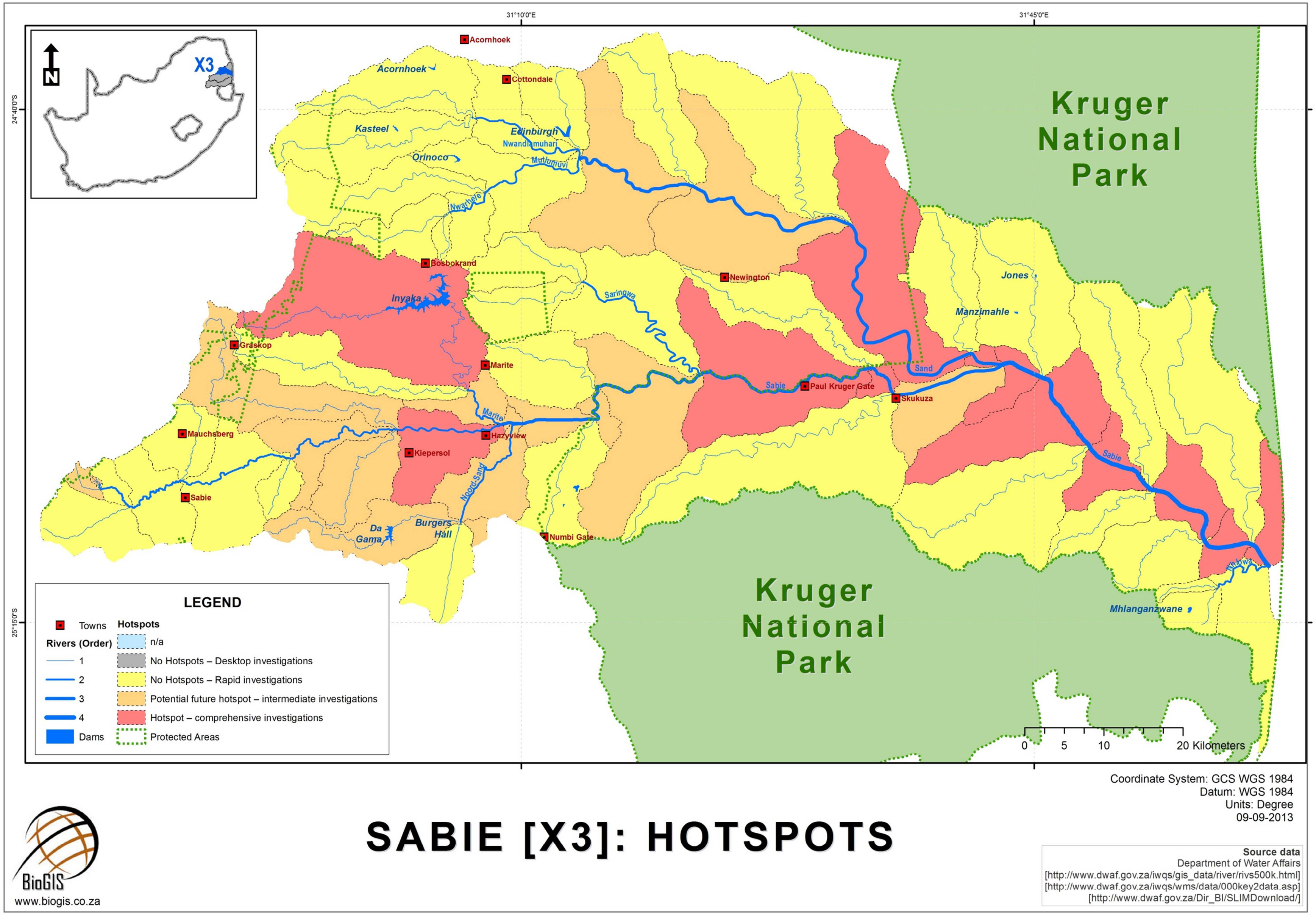


Figure 4.3 Hotspots in the Sabie-SandRiver system (X3)

5 ECOLOGICAL WATER REQUIREMENTS

This chapter is an extract from report: DWA (2014) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Ecological Water Requirements. Authored by Birkhead AL, Koekemoer S, Louw D. DWA Report, RDM/WMA05/00/CON/CLA/0114. March 2014.

5.1 BACKGROUND

Within the integrated water resource management process outlined in Table 5.1, integrated step 3refers to: Quantify EWRs and changes in non-WQecosystem services. The main aspect of thisChapter is the EcoClassification and EWR determination at various biophysical nodes in the study area. This document summarises the EcoClassification and EWR results of the following Reserve studies undertaken in the study area between 2004 and 2010:

- 2003 – 2005 Elands River Reserve Study (Hill, 2005).
- 2004 – 2006 Komati Reserve Study (AfriDev, 2006a).
- 2007 - 2010 Inkomati Reserve Study (DWA, 2010a).

Table 5.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and Resource Units, and describe the status quo of the water resource(s)
2	Initiation of stakeholder process and catchment visioning.
3	**Quantify the Ecological Water Requirements and changes in non-water quality ecosystem goods, services and attributes.**
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

5.2 RESOURCE UNITS

RUs as determined during the comprehensive EWR studies were accepted.

5.3 EWR SITES

A total of 24 EWR sites as determined during the various comprehensive EWR studies was accepted and tabled below:

- In the Crocodile River system (X2) and Sabie-Sand River system (X3), 15 EWR sites were selected (DWA, 2008a).
- Two EWR sites were selected on the Elands River in the Crocodile River system (X2) (Hill, 2003).
- Seven EWR sites were selected in the Komati River system (X1) (AfriDev, 2005a).

Table 5.2 Details of the EWR sites selected during the EWR studies conducted during 2003 - 2010

EWR Site number	EWR Site name	River	Co-ordinates		Management Resource Unit
			Latitude	Longitude	
Komati River system (X1)					
EWR K1	Gevonden	Upper Komati	-23.91769	30.05083	B
EWR K2	Kromdraai	Upper Komati	-23.88806	30.36125	C
EWR M1	Silingani	Lomati	-23.64939	30.66064	Maguga
EWR K3	Tonga	Lower Komati	-23.67753	31.09864	D
EWR G1	Vaalkop	Gladdespruit	-23.25081	30.49572	G
EWR T1	Teespruit	Teespruit	-23.75264	31.40731	T
EWR L1	Kleindoringkop	Lomati	-23.80983	31.59081	M
Crocodile River system (X2)					
EWR C1	Valeyspruit	Crocodile	25 29.647	30 08.656	Croc A
EWR C2	Goedenhoop	Crocodile	25 24.555	30 18.955	Croc A
EWR C3	Poplar Creek	Crocodile	25 27.127	30 40.865	Croc B
EWR C4	KaNyamazane	Crocodile	25 30.146	31 10.919	Croc D (RUA Croc D.1)
EWR C5	Malelane	Crocodile	25 28.972	31 30.464	Croc E
EWR C6	Nkongoma	Crocodile	25 23.430	31 58.467	Croc E
EWR C7	Honeybird	Kaap	25 38.968	31 14.572	Kaap A
ER 1		Elands	25.631000	30.326250	RU 1
ER 2		Elands	25.567972	30.666694	RU 2
Sabie-Sand River system (X3)					
EWR S1	Upper Sabie	Sabie	25 04.424	30 50.924	Sabie A
EWR S2	Aan de Vliet	Sabie	25 01.675	31 03.099	Sabie A
EWR S3	Kidney	Sabie	24 59.256	31 17.572	Sabie B.1
EWR S4	MacMac	Mac Mac	25 00.800	31 00.243	Mac A
EWR S5	Marite	Marite	25 01.077	31 07.997	Mar A
EWR S6	Mutlumuvi	Mutlumuvi	24 45.352	31 07.923	Mut A
EWR S7	Thulandziteka	Thulandziteka	24 40.829	31 05.188	Sand A
EWR S8	Sand	Sand	24 58.045	31 37.641	Sand B, RAU B.1

5.4 ECOCLASSIFICATION RESULTS (LEVEL IV)

The Komati River system EcoClassification results were updated using the EcoClassification models as well as additional information that has become available since the 2006 study. These results are included in the table below which provides a summary of the EcoClassification results of the three Reserve studies undertaken in the study area.

Table 5.3 Summary of the EcoClassification results

EWR C1 Valeyspruit (Crocodile River)

EIS: Moderate
Highest scoring metric were diversity of sensitive habitat types present e.g. wetlands (including floodplains containing various oxbows).
PES: A/B
Minor impacts, mainly due to farming, exotic vegetation species and trout. Impacts are mostly non-flow related
REC[1]: A/B
Maintain the PES as only moderate EIS.
AEC down: B/C
Scenario includes decreased low flows due to e.g. increased golf estates, trout farms and increased abstractions for Dullstroom. Growth of Dullstroom will also result in increased sewage. Increased grazing causing trampling and destabilisation of banks.

Driver Components	PES & REC Category	Trend	AEC↓
HYDROLOGY	A/B		B
WATER QUALITY	A		B
GEOMORPHOLOGY	B	Stable	C
Response Components	**PES & REC Category**	**Trend**	**AEC↓**
FISH	A	Stable	B/C
MACRO INVERTEBRATES	B	Stable	B/C
INSTREAM	A/B		B/C
RIPARIAN VEGETATION	A	Stable	B
ECOSTATUS	A/B		B/C

EWR C2 Goedehoop (Crocodile River)

EIS: High
Rare and endangered fish spp. which are sensitive to flow and quality changes. High species diversity.
PES: B
Impacts as for EWR 1 with increased agricultural activities and decreased flows. However, impacts mostly still non-flow related.
REC: B
Although the EIS is high, the PES is already a B and as the impacts are mostly non-flow related, it would not be realistic to improve the PES through flow related interventions.
AEC down: C
See EWR 1. Possible zero flow situations and additional impacts on moderate events.

Driver Components	PES & REC Category	Trend	AEC↓
HYDROLOGY	B		C
WATER QUALITY	B		C
GEOMORPHOLOGY	B	Stable	B/C
Response Components	**PES & REC Category**	**Trend**	**AEC↓**
FISH	B	Stable	C
MACRO INVERTEBRATES	B	Negative	C
INSTREAM	B		C
RIPARIAN VEGETATION	A/B	Negative	B
ECOSTATUS	B		C

EWR C3 Poplar Creek (Crocodile River)

EIS: High
Rare and endangered fish, vegetation and bird spp., some of which are sensitive to flow and quality changes.
PES: B/C
Major problems related to upstream Kwena Dam and its operation, e.g. migration, sedimentation, changed flow regime. The changed flow regime consists of higher than natural flows in the dry season and much lower low flows in the wet season.
REC: B
The EIS is high; therefore the REC is an improvement of the PES. This can be achieved by improving the flow regime (low flows) and removal of exotic vegetation species.
AEC down: C/D
Lower flows than natural in both the dry and wet season. Associated increase in temperature and oxygen.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C		B	D
WATER QUALITY	C		B/C	C/D
GEOMORPHOLOGY	C	Negative	C	C
Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
FISH	B	Stable	B	C
MACRO INVERTEBRATES	C	Negative	B	C/D
INSTREAM	B/C		B	C
RIPARIAN VEGETATION	C	Negative	B	D
ECOSTATUS	B/C		B	C/D

EWR C4 KaNyamazane (Crocodile River)

EIS: High
Rare and endangered species that are sensitive to flow and quality changes are present. There is also a high species taxon richness and a diversity of habitat types
PES: C
Combination of flow and non-flow related impacts. Changes mostly related to changes in flow regime due to upstream Kwena Dam and the operation of upstream system. Abstractions return flows, landuse mismanagement, WQ issues, and sedimentation.
REC: B
The EIS is high; therefore the REC is an improvement of the PES. Improvements to flow regime will be required. Only successful if combined with removal of exotic vegetation and if there are some improvement in grazing and browsing.
AEC down: C/D
Montrose Dam with decreased floods. Pools will fill in, bars will appear, riffles will be clogged and covered with sediment, reed growth will increase, the marginal zone will expand and vegetation will encroach.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C			
WATER QUALITY	C		B	C
GEOMORPHOLOGY	B/C	Stable	B	C
Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
FISH	B	Stable	B	C
MACRO INVERTEBRATES	C	Stable	B	D
INSTREAM	B/C		B	C
RIPARIAN VEGETATION	C	Negative	B	D
ECOSTATUS	C		B	C/D

1 Recommended Ecological Category

EWR C5 Malelane (Crocodile River)

EIS: Very High
Rare and endangered spp. sensitive to flow and quality changes. High species taxon richness and diversity of habitat types, KNP on LB.
PES: C
Change in low flows, specifically in the dry season. Change in flooding regime. All impacts associated with sugarcane activities.
REC: B
The EIS is very high; therefore the REC is an improvement of the PES. Changes mostly focussing on improving the low flow regime and some land use management.
AEC down: D
Decreased low flows and periods of zero flows in some stretches of the river which will result in increased algal growth, temperature and nutrient problems, loss of deeper channel sections, increased reed and vegetation growth.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C		B	D
WATER QUALITY	C		B	D
GEOMORPHOLOGY	C/D	Negative	C	D
Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
FISH	C	Stable	B	D
MACRO INVERTEBRATES	C	Stable	B	D
INSTREAM	C		B	D
RIPARIAN VEGETATION	C	Negative	B	D
ECOSTATUS	C		B	D

EWR C6 Nkongoma (Crocodile River)

EIS: Very High
Rare and endangered spp. sensitive to flow and quality changes. High species taxon richness and diversity of habitat types, KNP on left bank.
PES: C
Change in low flows, even zero flows present, specifically in the dry season. Change in flooding regime. All impacts associated with sugarcane activities.
REC: B
The EIS is very high; therefore the REC is an improvement of the PES. Changes mostly focussing on improving the low flow regime and some land use management.
AEC down: D
Decreased low flows and periods of zero flows in some stretches of the river which will result in increased algal growth, temperature and nutrient problems, loss of deeper channel sections, increased reed and vegetation growth.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	D		B	D
WATER QUALITY	C		B	D
GEOMORPHOLOGY	C	Negative	C	C/D
Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
FISH	C	Stable	B	D
MACRO INVERTEBRATES	C	Stable	B	C/D
INSTREAM	C		B	D
RIPARIAN VEGETATION	C	Negative	B	D
ECOSTATUS	C		B	D

EWR C7 Kaap (Kaap River)

EIS: High
Rare and endangered spp. sensitive to flow and quality changes. High species taxon richness and habitat types sensitive to flow and quality changes.
PES: C
Changes are flow and non-flow related. Low to zero flows present due to upstream abstractions. Land-use activities related to agriculture and mining. Extensive exotic vegetation present.
REC B:
The EIS is high; therefore the REC is an improvement of the PES. No zero flows, increased low flows, more moderate floods. This must happen in conjunction with exotic vegetation removal.
AEC D:
Mountain View Dam will be present which will result in much lower flows than present and decreased floods. The channel will be narrower, some riffles will be sandier and smaller in general which will result in more reeds and a narrower marginal zone.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	D		C	D
WATER QUALITY	B		B	C
GEOMORPHOLOGY	B	Negative	B	C
Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
FISH	C	Stable	B	D
MACRO INVERTEBRATES	B	Stable	B	C
INSTREAM	B/C		B	C
RIPARIAN VEGETATION	C/D	Negative	B/C	D
ECOSTATUS	C		B	D

EWR S1: Upper Sabie (Sabie River)

EIS: High
Rare and endangered fish and vegetation species. Fish species present that are intolerant to flow and flow related WQ changes. .
PES: B/C
Impacts due to forestry, exotic vegetation species, and abstraction. Impacts largely non-flow related.
REC: B
The EIS is high; therefore the REC is an improvement of the PES. Inactivity of picnic site and removal of aliens is required. Improved fish EC dependent on improved vegetation cover.
AEC down: C/D
Decreased low flows resulting in increased sediment with increased nutrients, turbidity, temperature, additional toxics. Increased vegetation exotics and reeds on bars.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	A/B		A/B	B/C
WATER QUALITY	A/B		A/B	B/C
GEOMORPHOLOGY	B	Stable	B	C
Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
FISH	B/C	Stable	B	C/D
MACRO INVERTEBRATES	B	Stable	A/B	C
INSTREAM	B/C		B	C
RIPARIAN VEGETATION	B/C	Negative	B	C/D
ECOSTATUS	B/C		B	C/D

EWR S2: Aan de Vliet (Sabie River)

EIS: High
Rare and endangered fish and vegetation species. Species present intolerant to flow and flow related WQ changes.
PES: C
Forestry and landuse activities, mostly non-flow related.
REC: B
Changes in flow are not required to improve the state.
Remove exotic vegetation and cease mowing in the riparian zone. Reduce recreational disturbances. The nutrient status must also be improved.
AEC down: C/D
Increased abstraction could lead to increased return flows that will cause problems due to pesticides, nutrient loading etc. Mismanagement of land use in terms of forestry and agriculture

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C		B/C	D
WATER QUALITY	B		A/B	C
GEOMORPHOLOGY	B	Negative	B	C
Response Components	PES Category	Trend	REC	AEC↓
FISH	B/C	Stable	B	C/D
MACRO INVERTEBRATES	B/C	Stable	B	C
INSTREAM	B/C		B	C
RIPARIAN VEGETATION	C	Negative	B	D
ECOSTATUS	C		B	C/D

EWR S3 Kidney (Sabie River)

EIS: Very High
Rare and endangered species, taxon richness and species intolerant to flow and flow related WQ changes. Refuge area for biota and an important migration corridor for birds and fish. Within KNP.
PES: A/B
Forestry, abstraction, Inyaka Dam and landuse activities. (Flow and non-flow related)
REC: A/B
As the PES is already an A/B, the REC = the PES.
AEC Down: B/C
Increased abstractions, no Reserve implementation, less floods. Increased nutrients, changes in temperature, oxygen etc. Riffles lost due to sedimentation, channel shallower and sandier. Vegetation exotics will increase.
More reeds will be present in sandier areas.

Driver Components	PES & REC Category	Trend	AEC↓
HYDROLOGY	C		C/D
WATER QUALITY	B		C
GEOMORPHOLOGY	B	Negative	C
Response Components	PES & REC Category	Trend	AEC↓
FISH	B	Stable	C
MACRO INVERTEBRATES	B	Stable	C
INSTREAM	B		C
RIPARIAN VEGETATION	A/B	Stable	B/C
ECOSTATUS	A/B		B/C

EWR S4 Mac Mac (Mac Mac River)

EIS: High
Rare and endangered fish and vegetation species. Species present intolerant to flow and flow related WQ changes.
PES: B
Forestry, exotic vegetation and wastewater input. Impacts are flow and non-flow related.
REC: A/B
The EIS is high and the REC is therefore to improve the PES by improving the fish. Improved WQ required.
AEC down: C
Decreased low flows due to e.g. a weir or small dam in the upper catchment. This will result in embedded cobbles. Nutrients and temperature will increase. Increased exotic vegetation in the riparian zone.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C		C	C
WATER QUALITY	A/B		A	B/C
GEOMORPHOLOGY	A	Stable	A	B
Response Components	PES Category	Trend	REC	AEC↓
FISH	B/C	Stable	B	C/D
MACRO INVERTEBRATES	A/B	Stable	A/B	B/C
INSTREAM	B		B	C
RIPARIAN VEGETATION	A/B	Negative	A/B	B/C
ECOSTATUS	B		A/B	C

EWR S5 Marite (Marite River)

EIS: High.
Rare, endangered and unique biota. Species richness high and species intolerant to flow and flow related WQ changes present.
PES: B/C
Increased low flows and landuse activities. Impacts mostly flow related
REC: B
The EIS is high; therefore the REC is an improvement of the PES. More natural distribution of flows required. Reduce grazing and trampling, remove exotic vegetation.
AEC down: C/D
No flow releases for the EWR, less dilution and less floods due to e.g. direct abstraction from the dam. More nutrients and toxics present. Sandier river, some riffles and bedrock areas in the reach will be lost, vegetation encroachment on bars and banks and embedded cobbles. Increased aliens, removal, grazing, and trampling.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C			D
WATER QUALITY	B		B	C
GEOMORPHOLOGY	C	Negative	C	D
Response Components	PES Category	Trend	REC	AEC↓
FISH	B/C	Negative	B	C/D
MACRO INVERTEBRATES	B/C	Stable	B	C
INSTREAM	B/C		B	C/D
RIPARIAN VEGETATION	B/C	Negative	B	C/D
ECOSTATUS	B/C		B	C/D

EWR S6 Mutlumuvi (Mutlumuvi River)

EIS: High
Rare, endangered and unique biota. Taxon species richness high and species intolerant to flow and flow related WQ changes present.
PES: C
Abstraction, forestry, informal settlements and landuse activities. Impacts flow and non-flow related.
REC: B
The EIS is high and improvement requires improved system operation which improves the low flow regime.
AEC down: C/D
Decreased low flows and longer periods of zero flows. Increased algal growth. Less moderate floods will cause some impact on sedimentation. The reedbeds will become less dense and Matumi will disappear.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C			
WATER QUALITY	B/C		B	C/D
GEOMORPHOLOGY	C	Stable	C	D
Response Components	**PES Category**	**Trend**	**AEC ↑**	**AEC↓**
FISH	C	Stable	B	D
MACRO INVERTEBRATES	B/C	Negative	B	C
INSTREAM	C		B	C/D
RIPARIAN VEGETATION	C	Negative	B	D
ECOSTATUS	C		B	C/D

EWR S7 Thulandziteka (Thulandziteka River)

EIS: Moderate
Rare and endangered species, high taxon richness, species intolerant to flow and flow related WQ changes.
PES: C
Forestry, abstraction, flow modification and poor landuse management. Impacts flow and non-flow related.
REC: C
Due to the moderate EIS, the REC = the PES.
AEC Up: B
Improved flows through fixing of canals, rehabilitation of forestry areas and improved management of canal system and landuse. Remove exotic vegetation, minimise agricultural disturbance and remove unused orchards.
AEC Down: D
Increased use of the dam with less spills, i.e. less floods. More abstraction and forestry. Nutrients, temperature, oxygen, and turbidity levels will change. Increase in bed height, more subsurface flows and sediment with resulting decrease in riffles and shallower pools. More reeds, alien vegetation and more removal.

Driver Components	PES & REC Category	Trend	AEC ↑	AEC↓
HYDROLOGY	A?			D
WATER QUALITY	C		B	D
GEOMORPHOLOGY	C/D	Stable	C	D
Response Components	**PES &REC Category**	**Trend**	**AEC ↑**	**AEC↓**
FISH	C	Stable	B	D
MACRO INVERTEBRATES	B/C	Negative	B	C/D
INSTREAM	C		B	D
RIPARIAN VEGETATION	C	Negative	B	D
ECOSTATUS	C		B	D

EWR S8 Lower Sand (Sand River)

EIS: High
Rare and endangered species, high taxon richness and species intolerant to flow and flow related WQ changes. Situated in KNP
PES: B
Abstraction, dams, weirs, poor landuse management. Impacts are flow and non-flow related.
REC: B
Although the EIS is high, the PES is already in a B therefore the REC = PES. Improve the macroinvertebrate EC by increasing low flows.
AEC down: C
More decreased low flows and longer periods of no flow.

Driver Components	PES Category	Trend	REC	AEC↓
HYDROLOGY	C?		C	D?
WATER QUALITY	B		B	C
GEOMORPHOLOGY	C	Negative	C	Lower C
Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
FISH	B	Stable	B	C
MACRO INVERTEBRATES	C	Negative	B	C/D
INSTREAM	B/C		B	C
RIPARIAN VEGETATION	B	Stable	B	B/C
ECOSTATUS	B	Negative	B	C

EWR ER1 (Elands River)

EIS: Moderate
The EIS (present) was rated as Moderate, and there were no endangered species are associated with the river.
PES: B
Related to afforestation and some abstractions for irrigation. Impacts are flow and non-flow related.
REC: B
Due to the moderate EIS, the REC = the PES.

Component	PES and REC
Hydrology	B
Physico chemical	A
Geomorphology	B/C (B)
Fish	A/B
Invertebrates	B
Riparian vegetation	B
EcoStatus	B

EWR ER 2 (Elands River)

EIS: High
Endangered species, viz *C. bifurcus* occurs in the reach. Other flow and WQ sensitive species of particular importance include *A. uranoscopus*, *B. argenteus*, *C. pretoriae* and *B. polylepis*. The *B. polylepis* population in the Elands River is of particular importance due to it being isolated from *L. marequensis* in the Crocodile River. As a consequence, *B. polylepis* has developed particular variations in mouth morphology, which do not occur when *L. marequensis* is present.
PES: B
Reduced flows, afforestation of the floodplain and some possible engineering (straightening) of the active channel. Impacts are flow and non-flow related.
REC: B
Although the EIS is High, the PES is already in a B therefore the REC = PES.

Component	PES and REC
Hydrology	B
Physico chemical	A
Geomorphology	C
Fish	A/B (B)
Invertebrates	B
Riparian vegetation	D
EcoStatus	B

EWR K1 Gevonden (Upper Komati River)

EIS: High
Presence of the endangered fish, mammal, reptile and bird species. Presence of endemic fish and frog species. The high importance of the area for conservation (Songimvelo Reserve, Nkomazi Wilderness Area and Transboundary Park).
PES: B/C
Major flow related impacts due to Nooitgedacht Dam – reduced low flows and floods. Forestry also impacts low flows and WQ deterioration due to trout dams and tourist developments.
REC: B/C
The EIS is high, indicating that an improvement is required. However, due to the strategic importance and scarcity of water it was considered unrealistic to recommend a higher category. Maintaining the river as a Category B/C would be adequate from an ecological point of view.

Component	PES and REC
Hydrology	C
Physico chemical	B
Geomorphology	C
Fish	C
Invertebrates	B/C
Riparian vegetation	C
EcoStatus	B/C

EWR K2 Kromdraai (Upper Komati River)

EIS: High
Presence of the endangered fish, mammal, reptile and bird species. Presence of endemic fish and frog species. The high importance of the area for conservation (Songimvelo Reserve, Nkomazi Wilderness Area and Transboundary Park).
PES: C
Major impacts are flow related – low flows and floods are impacted by Vygeboom Dam. Deteriorated WQ also impacts the site.
REC: B
The EIS is high; therefore the REC is an improvement of the PES. Improvement can be achieved by non-flow related measures.

Component	PES	REC
Hydrology	C/D	B
Physico chemical	B/C	B
Geomorphology	C/D	C
Fish	C	B
Invertebrates	C	B
Riparian vegetation	C	B
EcoStatus	C	B

EWR K3 Tonga (Lower Komati River)

EIS: Moderate
Diversity of habitats, the presence of rare, vulnerable and endangered fish, mammal, reptile and bird species. Presence of endemic macro-invertebrate taxa and fish species intolerant to flow. Species richness and the importance as a migration corridor for eels, *Macrobracium* and local breeding migrations of fish and birds.
PES: E?
Major problems during 2006 were related to frequent and extended periods of flow cessation, caused primarily by diversion of water at Tonga Weir; vegetation clearing and sand mining as well as deteriorated WQ. Conditions may have improved in recent years however, which may be attributed to more constant baseflow releases from Maguga Dam to meet irrigation demand in the lower Komati River and international (Mozambique) obligations. The latest information therefore indicates an improvement in the period 2006 to 2013. Revision of results is still in progress and the PES needs validation.
REC: D
Due to the moderate EIS, the REC = the PES.

Component	PES	REC
Hydrology	E	D
Physico chemical	D	C
Geomorphology	D/E	D
Fish	C/D	C/D
Invertebrates	D	D
Riparian vegetation	D/E	D
EcoStatus	E?	D

EWR G1 Vaalkop (Gladdespruit)

EIS: Low
Presence of two flow-dependent fish species, the sensitivity to flow changes and flow related WQ changes.
PES: D
Combination of flow and non-flow related impacts. The main impacts are related to reduced low flows due to forestry, WQ problems due to acid mine drainage from old gold mines, sulphates and raw sewerage, erosion and sedimentation, alien invasives and trout dams.
REC: D
Due to the low EIS, the REC = the PES.

Component	PES and REC
Hydrology	B
Physico chemical	C
Geomorphology	D
Fish	D
Invertebrates	D
Riparian vegetation	D
EcoStatus	D

EWR T1 Teespruit (Teespruit)

EIS: Moderate
Presence of endangered fish species and the presence of two flow-dependent fish species.
PES: C
Small-scale abstractions impact low flows. Deteriorated WQ in the lower reaches of the river and encroachment of alien vegetation are the main non-flow related impacts.
REC: C
Due to the moderate EIS, the REC = the PES.

Component	PES and REC
Hydrology	B
Physico chemical	C
Geomorphology	C
Fish	C
Invertebrates	C
Riparian vegetation	C
EcoStatus	C

EWR L1 Kleindoringkop (Lomati River)	
EIS: High Diversity of habitats, the presence of the endangered fish, mammal, reptile and bird species. Presence of flow-dependent fish species, the high number of fish species and the importance of the area for conservation at a national scale. **PES: C** Change in low flows, due to Schoemans Dam. The dam has impacted on the geomorphology of the river. Altered fish community and vegetation has occurred. Recent data indicates that impacts on flow are ongoing, and vegetation removal, cultivation of the riparian zone and agricultural return flows impact the site. **REC: C** The EIS is high, indicating that an improvement is required. However a REC cannot be achieved by improving flows because it is probably neither feasible nor possible to improve present conditions significantly.	

Component	PES and REC
Hydrology	D
Physico chemical	B/C
Geomorphology	D
Fish	C
Invertebrates	C
Riparian vegetation	B/C
EcoStatus	C

5.5 EWR RESULTS AT EWR SITES (KEY BIOPHYSICAL NODES)

The 2006 Komati EWR results (AfriDev, 2006a) were updated using the updated natural and present day hydrology (pMAR). The PES results are summarised below as percentage of the natural Mean Annual Runoff (nMAR). The EWR results of the other studies are also provided.

Table 5.4 EWR results for the EWR sites in the Inkomati Catchment

EWR site	nMAR	PMAR	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM	MCM	MCM		MCM[1]	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)
Crocodile River system												
C1	15.19	14.90	98%	A/B PES, REC	3.8	24.8	1.54	10.13	0.93	6.14	4.69	30.9
				B/C AEC	2.56	16.84	1.54	10.13	0.93	6.14	3.71	24.4
C2	47.11	44.80	95%	B PES, REC	23.53	49.95	9.23	19.58	3.50	7.43	26.85	57
				C AEC	11.39	24.18	9.23	19.58	3.03	6.44	17.43	37
C3	169.9	1515.2	892%	B/C PES	74.76	44	30.75	18.1	16.7	9.8	93.78	55.2
				B REC		A time series of requirements could not be generated as improvement of the PES required flows higher than the reference time series (present day), during the wet season.						
C4	754.1	528.3	70%	B PES, REC	216.4	28.7	74.66	9.9	46.8	6.2	260.16	34.5
				C/D AEC	99.54	13.2	74.66	9.9	38.7	5.1	160.62	21.3
C5	1006.2	637.9	63%	C PES	214.3	21.3	121.8	12.1	53.3	5.3	301.87	30
				B REC	349.2	34.7	121.8	12.1	74.5	7.4	404.50	40.2
				D AEC	121.8	12.1	121.8	12.1	29.2	2.9	214.33	21.3
C6	1063.1	525.2	49%	C PES	147.8	13.9	112.7	10.6	78.7	7.4	264.72	24.9
				B REC	323.2	30.4	112.7	10.6	140.3	13.2	466.71	43.9
				D AEC	123	11.6	47.84	4.5	48.9	4.6	152.03	14.3
C7	169	86.6	51%	C PES	25.2	14.9	11.16	6.6	10.82	6.4	38.87	23
				B REC	50	29.6	11.16	6.6	12.51	7.4	62.20	36.8
				D AEC	10.14	6	11.16	6.6	8.96	5.3	27.72	16.4
Sabie-Sand River system												
S1	140.18	109	78%	B/C PES	46.54	33.2	17	12.1	7.43	5.3	52.99	37.8
				B REC	61.82	44.1	17	12.1	8.55	6.1	64.90	46.3
				C/D AEC	29.02	20.7	17	12.1	6.31	4.5	43.46	31
S2	262.1	199.5	76%	B/C PES	51.90	19.8	29.1	11.1	11.5	4.4	73.39	28
				B REC	81.52	31.1	29.1	11.1	13.1	5	93.57	35.7
				C/D AEC	32.76	12.5	29.1	11.1	9.44	3.6	57.93	22.1
S3	495.86	322.1	65%	A/B	155.2	31.3	48.1	9.7	31.7	6.4	183.5	37

EWR site	nMAR	PMAR	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM	MCM	MCM		MCM[1]	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)
				PES/REC								
				B/C AEC	101.2	20.4	48.1	9.7	26.8	5.4	134.4	27.1
S4	65.78	51.8	79%	A/B PES/REC	20.59	31.3	6.38	9.7	4.21	6.4	24.34	37
				B/C AEC	13.42	20.4	6.38	9.7	3.55	5.4	17.83	27.1
S5	157.09	89.7	57%	B/C PES	32.67	20.8	12.6	8	10.2	6.5	44.30	28.2
				B REC	47.44	30.2	12.6	8	11.2	7.1	57.02	36.3
				C/D AEC	15.39	9.8	12.6	8	8.48	5.4	31.10	19.8
S6	44.99	29.9	66%	C PES	9.99	22.2	4.63	10.3	2.83	6.3	14.58	32.4
				B AEC	14.49	32.2	6.03	13.4	2.83	6.3	17.37	38.6
				C/D AEC	6.21	13.8	4.63	10.3	2.56	5.7	11.56	25.7
S7	28.88	17.3	60%	C PES	5.11	17.7	2.05	7.1	3.18	11	9.15	31.7
				B REC	7.65	26.5	3.23	11.2	3.81	13.2	11.38	39.4
				D AEC	2.71	9.4	2.05	7.1	2.95	10.2	7.77	26.9
S8	133.61	88.5	66%	B PES/REC	22.85	17.1	4.54	3.4	9.75	7.3	33.80	25.3
				C AEC	12.69	9.5	4.54	3.4	8.82	6.6	24.58	18.4
Elands												
ER 1	50.1			B PES, REC	18.45	36.82	4.9	9.79	6.01	12	24.46	48.82
ER 2	50.1			B PES, REC	68.46	33.98	21.77	10.8	22.23	11.03	90.7	45.02
Komati River system												
K1	158.6	108.5	68.38	B/C PES, REC	27.38	17.30			16.30	10.20	43.68	27.50
K2	545.6	318.6	58.41	C PES	50.87	9.30			49.00	9.00	99.87	18.30
K3	1022	489.8	47.95	D REC	101.1	9.90			74.46	7.30	175.55	17.20
G1	29.52	21.18	71.75	D PES, REC	5.89	19.90			2.05	7.00	7.94	26.90
T1	56.36	45.13	80.07	C PES, REC	12.75	22.60			7.15	12.70	19.89	35.30
L1	294.3	229.5	77.99	C PES, REC	34.46	11.70			16.50	5.60	50.96	17.30

1 Million Cubic Metres

5.6 ECOCLASSIFICATION RESULTS AT THE DESKTOP BIOPHYSICAL NODES

The PES and Ecological Importance (EI) - Ecological Sensitivity (ES) (PESEIS; DWS, 2014a)) study results were used to determine the PES and REC. These results are summarised below.

Table 5.5 Komati River system (X1): Desktop biophysical nodes results summary

SQ number	River	PES	EIS	REC
X11A-01300		B	Moderate	B
X11A-01354		C	Moderate	C
X11A-01358	Vaalwaterspruit	C	Moderate	C
X11A-01295	Vaalwaterspruit	C	Moderate	C
X11A-01248	Vaalwaterspruit	C	Moderate	C
X11B-01370	Boesmanspruit	B	Moderate	B
X11B-01361		B/C	Moderate	B/C
X11B-01272	Boesmanspruit	C	High	B/C
X11C-01147	Witkloofspruit	C	High	C
X11D-01129	Klein-Komati	C	Moderate	C
X11D-01137	Waarkraalloop	C	Moderate	C
X11D-01219	Komati	C/D	Moderate	C/D

SQ number	River	PES	EIS	REC
X11D-01196	Komati	C	Moderate	C
X11E-01237	Swartspruit	C	High	B
X11E-01157	Komati	B/C	Moderate	B/C
X11F-01133	Bankspruit	B	High	B
X11G-01188	Ndubazi	B/C	Moderate	B
X11G-01143	Gemakstroom	C	Moderate	C
X11K-01165	Poponyane	C	Moderate	C
X11K-01199		D	Moderate	D
X11K-01179	Gladdespruit	C	Moderate	C
X11K-01194	Gladdespruit	C	Moderate	C
X12A-01305	Buffelspruit	C	High	B
X12B-01246	Hlatjiwe	C	Moderate	C
X12C-01242	Phophenyane	B	High	B
X12C-01271	Buffelspruit	B	Moderate	B
X12D-01235	Seekoeispruit	C	High	B/C
X12E-01287	Teespruit	C	High	B
X12H-01338	Sandspruit	B	High	B
X12H-01340		B	Moderate	B
X12H-01318	Sandspruit	C	Moderate	C
X12J-01202	Mtsoli	B	High	B
X12K-01333	Mlondozi	C	High	B/C
X12K-01332	Mhlangampepa	B	High	B
X12K-01316	Komati	D	Moderate	D
X13A-01337	Maloloja	A	High	A
X13J-01141	Mzinti	D	High	D
X13J-01205	Mbiteni	D	Moderate	D
X13J-01221	Komati	D	Moderate	D
X13K-01136	Mambane	D	Moderate	D
X13K-01068	Nkwakwa	C/D	High	C/D
X13K-01114	Komati	D	Moderate	D
X13L-01000	Ngweti	D	Moderate	D
X13L-0995	Komati	D	Moderate	D
X14B-01166	Ugutugulo	C	High	B/C

Table 5.6 Crocodile River system (X2): Desktop biophysical nodes results summary

SQ number	River	PES	EIS	REC
X21A-01008		C/D	Moderate	C
X21B-00929	Gemsbokspruit	C/D	Very High	C
X21B-00898	Lunsklip	C/D	Very High	C
X21B-00925	Lunsklip	C	Moderate	C
X21C-00859	Alexanderspruit	C	High	C
X21D-00957	Buffelskloofspruit	C	High	B/C
X21D-00938	Crocodile	C	Moderate	C
X21E-00897	Buffelskloofspruit	B	High	B
X21E-00947	Crocodile	B	Moderate	B
X21F-01046	Elands	C	High	C
X21F-01100	Leeuspruit	C	Moderate	C
X21F-01096	Dawsonsspruit	A	Low	A
X21F-01091	Rietvleispruit	C	Moderate	C

SQ number	River	PES	EIS	REC
X21F-01092	Leeuspruit	C/D	Moderate	C/D
X21F-01081	Elands	C	Moderate	C
X21G-01090	Weltevredespruit	C	Moderate	C
X21G-01016	Swartkoppiespruit	C	High	C
X21H-01060	Ngodwana	C	High	B
X21J-01013	Elands	C	High	B/C
X21K-01007	Lupelule	B	High	B
X21K-00997	Elands	C	Moderate	C
X22A-00875	Houtbosloop	B/C	High	B
X22A-00887	Beestekraalspruit	B/C	Moderate	B/C
X22A-00824	Blystaanspruit	B/C	High	B
X22A-00920		B	Moderate	B
X22A-00919	Houtbosloop	B/C	Moderate	B/C
X22A-00917	Houtbosloop	C	Moderate	C
X22A-00913	Houtbosloop	C	High	B
X22C-00990	Visspruit	B/C	Moderate	B/C
X22C-01004	Gladdespruit	C	High	B/C
X22D-00843	Nels	C	Moderate	C
X22D-00846		C	Moderate	C
X22E-00849	Sand	C	Moderate	C
X22E-00833	Kruisfonteinspruit	C	Moderate	C
X22F-00842	Nels	C	High	B/C
X22F-00886	Sand	C	Moderate	C
X22F-00977	Nels	C/D	High	C/D
X22H-00836	Wit	D/E	High	D
X22K-01042	Mbuzulwane	B	Moderate	B
X22K-01043	Blinkwater	B	High	B
X22K-01029	Blinkwater	C	Moderate	C
X23B-01052	Noordkaap	D	High	C
X23C-01098	Suidkaap	C	High	B/C
X23E-01154	Queens	C	High	B/C
X23F-01120	Suidkaap	C	Moderate	C
X24A-00826	Nsikazi	C	High	C
X24A-00860	Sithungwane	A	High	A
X24A-00881	Nsikazi	B	High	B
X24B-00903	Gutshwa	D	High	D
X24B-00928	Nsikazi	A/B	High	A/B/
X24C-00978	Nsikazi	B	High	B

Table 5.7 Sabie-Sand River system (X3): Desktop biophysical nodes results summary

SQ number	River	PES	EIS	REC
X31A-00741	Klein Sabie	C	Moderate	B/C
X31A-00783		C	Moderate	C
X31A-00786		B	High	B
X31A-00794		B	Moderate	B
X31A-00796		B	Moderate	B
X31A-00803		B/C	Moderate	B/C
X31B-00792	Goudstroom	B/C	Moderate	B/C
X31D-00773	Sabani	C/D	Moderate	C/D

SQ number	River	PES	EIS	REC
X31E-00647	Marite (US of dam)	B/C	High	B
X31F-00695	Motitsi	C	High	B
X31H-00819	White Waters	C	High	B/C
X31J-00774	Noord-Sand	D	Moderate	D
X31J-00835	Noord-Sand	D	Moderate	D
X31K-00713	Bejani	D	High	D
X31K-00771	Phabeni	B	Moderate	B
X31L-00657	Matsavana	C	Moderate	C
X31L-00664	Saringwa	C	Moderate	C
X31L-00678	Saringwa	B/C	High	B/C
X31M-00673	Musutlu	B/C	High	B/C
X32B-00551	Motlamogatsana	C	High	C
X32C-00558	Nwandlamuhari	C	Moderate	C
X32C-00564	Mphyanyana	C	Moderate	C
X32C-00606	Nwandlamuhari	C	Moderate	C
X32E-00629	Nwarhele	C/D	High	C
X32F-00628	Nwarhele	C/D	Moderate	C/D
X32G-00549	Khokhovela	C	High	C
X32H-00560	Phungwe	A	High	A

5.7 EWR RESULTS AT THE DESKTOP BIOPHYSICAL NODES

The Revised Desktop Reserve Model (RDRM) (Hughes *et al*., 2012) was used to estimate EWRs at all desktop biophysical nodes, excluding those that fall in its totality in conservation areas. The results are summarised in the table below.

Table 5.8 Summary of Desktop EWRs for the biophysical nodes in the Inkomati Catchment (Komati, Crocodile and Sabie Rivers)

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
			Natural	PD		Low flows		Total flows	
						10^6 m^3	MAR	10^6 m^3	MAR
Komati River system (X1)									
X1-1	X11A-01248	Vaalwaterspruit	26.3	22.4	C	3.73	14.2%	6.19	23.5%
X1-1	X11A-01295	Vaalwaterspruit	15.4	12.9	C	2.81	18.2%	4.20	27.2%
X1-1	X11A-01300		1.7	1.4	B	0.31	18.1%	0.48	28.1%
X1-1	X11A-01354		3.9	3.1	C	0.59	15.1%	0.96	24.5%
X1-1	X11A-01358	Vaalwaterspruit	6.6	5.7	C	1.13	17.3%	1.76	26.8%
X1-1	X11B-01272	Boesmanspruit	51.2	41.9	C	7.76	15.1%	12.38	24.2%
X1-1	X11B-01361		4.2	3.6	B/C	0.68	16.0%	1.14	27.0%
X1-1	X11B-01370	Boesmanspruit	4.8	3.5	B	0.91	19.0%	1.39	28.8%
X1-1	X11C-01147	Witkloofspruit	11.4	9.9	C	1.54	13.5%	2.51	22.1%
X1-2	X11D-01129	Klein-Komati	21.0	17.8	C	4.04	19.2%	5.76	27.4%
X1-2	X11D-01137	Waarkraalloop	11.7	10.9	C	2.18	18.6%	3.19	27.3%
X1-2	X11E-01237	Swartspruit	14.8	13.8	C	2.85	19.3%	4.13	27.9%
X1-2	X11F-01133	Bankspruit	6.5	5.8	B	1.32	20.3%	2.00	30.8%
X1-2	X11G-01143	Gemakstroom	10.4	7.9	C	1.82	17.5%	2.72	26.1%
X1-2	X11G-01188	Ndubazi	17.4	14.2	B	4.33	24.9%	6.07	34.9%
X1-3	X11D-01196	Komati	95.4	51.1	C	13.39	14.0%	19.17	20.1%
X1-3	X11D-01219	Komati	73.6	33.0	C/D	6.78	9.2%	9.04	12.3%
X1-3	X11E-01157	Komati	118.3	72.4	B/C	20.99	17.7%	30.31	25.6%
X1-4	X11K-01165	Poponyane	13.7	10.8	C	2.01	14.7%	3.12	22.7%

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
						Low flows		Total flows	
			Natural	PD		10^6 m^3	MAR	10^6 m^3	MAR
X1-4	X11K-01179	Gladdespruit	64.4	30.8	C	8.68	13.5%	13.04	20.2%
X1-4	X11K-01194	Gladdespruit	71.2	36.8	C	7.86	11.0%	13.59	19.1%
X1-4	X11K-01199		2.4	1.5	D	0.36	15.1%	0.53	22.3%
X1-5	X12K-01316	Komati	577.0	348.9	D	79.99	13.9%	122.33	21.2%
X1-6	X12A-01305	Buffelspruit	32.0	24.2	C	7.26	22.7%	9.69	30.3%
X1-6	X12B-01246	Hlatjiwe	22.1	17.1	C	5.04	22.8%	6.75	30.5%
X1-6	X12C-01242	Phophenyane	6.3	5.9	B	1.80	28.7%	2.35	37.5%
X1-6	X12C-01271	Buffelspruit	71.1	56.4	B	22.53	31.7%	28.76	40.5%
X1-6	X12D-01235	Seekoeispruit	97.0	80.0	C	22.54	23.2%	29.58	30.5%
X1-6	X12H-01318	Sandspruit	13.9	13.3	C	3.36	24.1%	4.43	31.7%
X1-6	X12H-01338	Sandspruit	4.4	4.3	B	1.24	27.9%	1.64	36.7%
X1-6	X12H-01340		4.8	4.3	B	1.48	30.6%	1.92	39.5%
X1-6	X12J-01202	Mtsoli	66.5	58.6	B	15.92	23.9%	22.26	33.5%
X1-6	X12K-01332	Mhlangampepa	3.4	3.4	B	1.06	30.7%	1.38	40.0%
X1-6	X12K-01333	Mlondozi	22.4	22.3	C	4.56	20.3%	6.34	28.2%
X1-7	X14A-01173	Lomati	84.4	72.0	B	23.24	27.5%	30.65	36.3%
X1-7	X14B-01166	Ugutugulo	20.9	14.3	B/C	4.88	23.4%	6.61	31.7%
X1-9	X13J-01141	Mzinti	6.3	4.2	D	0.66	10.5%	1.21	19.1%
X1-9	X13J-01205	Mbiteni	5.9	5.1	D	0.50	8.6%	1.04	17.6%
X1-9	X13J-01221	Komati	1000.3	535.0	D	137.12	13.7%	197.35	19.7%
X1-10	X13K-01068	Nkwakwa	5.4	5.4	C/D	0.61	11.2%	1.23	22.7%
X1-10	X13K-01114	Komati	1341.4	645.6	D	172.51	12.9%	242.23	18.1%
X1-10	X13K-01136	Mambane	1.8	1.8	D	0.24	13.1%	0.41	22.4%
X1-10	X13L-00995	Komati	1356.6	504.8	D	97.40	7.2%	150.08	11.1%
X1-10	X13L-01000	Ngweti	4.6	2.5	D	0.35	7.5%	0.67	14.5%
Crocodile River system (X2)									
X2-1	X21A-01008		na[2]	na	C/D	na	na	na	na
X2-1	X21B-00898	Lunsklip	9.6	8.4	C/D	1.78	18.4%	2.49	25.8%
X2-1	X21B-00925	Lunsklip	25.8	22.2	C	6.01	23.3%	8.07	31.3%
X2-1	X21B-00929	Gemsbokspruit	3.8	3.3	C/D	0.71	18.9%	0.99	26.3%
X2-1	X21C-00859	Alexanderspruit	28.8	26.2	C	6.81	23.6%	9.09	31.5%
X2-2	X21D-00938	Crocodile	124.8	104.5	C	24.51	19.6%	29.99	24.0%
X2-2	X21D-00957	Buffelskloofspruit	16.9	12.9	C	4.22	25.0%	5.50	32.6%
X2-2	X21E-00897	Buffelskloofspruit	8.4	6.6	B	2.15	25.6%	2.96	35.3%
X2-2	X21E-00947	Crocodile	125.1	104.7	B	30.35	24.3%	36.11	28.9%
X2-3	X21F-01046	Elands	35.1	31.6	C	9.49	27.1%	12.35	35.2%
X2-3	X21F-01081	Elands	50.8	46.8	C	13.90	27.4%	18.02	35.5%
X2-3	X21F-01091	Rietvleispruit	3.3	3.1	C	0.90	27.1%	1.17	35.4%
X2-3	X21F-01092	Leeuspruit	11.9	11.2	C/D	2.81	23.6%	3.70	31.2%
X2-3	X21F-01096	Dawsonsspruit	na	na	A	na	na	na	na
X2-3	X21F-01100	Leeuspruit	11.9	11.2	C	3.21	27.0%	4.17	35.1%
X2-4	X21G-01016	Swartkoppiespruit	11.4	9.7	C	2.77	24.4%	3.70	32.5%
X2-4	X21G-01090	Weltevredespruit	5.5	4.7	C	1.31	23.6%	1.77	32.0%
X2-4	X21H-01060	Ngodwana	59.6	36.2	B	7.61	12.8%	13.20	22.1%
X2-4	X21J-01013	Elands	151.5	124.1	C	33.97	22.4%	46.15	30.5%
X2-4	X21K-01007	Lupelule	29.4	22.9	B	6.59	22.4%	9.43	32.1%
X2-7	X22A-00824	Blystaanspruit	21.0	15.0	B/C	5.76	27.4%	7.42	35.3%
X2-7	X22A-00875	Houtbosloop	6.9	5.0	B/C	1.82	26.2%	2.36	34.2%
X2-7	X22A-00887	Beestekraalspruit	3.7	2.7	B/C	0.96	25.9%	1.26	33.9%
X2-7	X22A-00913	Houtbosloop	75.3	53.9	B	24.84	33.0%	31.11	41.3%

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
						Low flows		Total flows	
			Natural	PD		10^6 m^3	MAR	10^6 m^3	MAR
X2-7	X22A-00917	Houtbosloop	14.8	10.6	C	3.31	22.3%	4.40	29.7%
X2-7	X22A-00919	Houtbosloop	10.6	7.6	B/C	2.85	26.8%	3.69	34.7%
X2-7	X22A-00920		1.7	1.2	B	0.52	30.8%	0.67	39.4%
X2-7	X22C-00990	Visspruit	3.4	3.0	B/C	0.67	20.0%	1.05	31.1%
X2-8	X22C-01004	Gladdespruit	16.3	10.7	C	1.80	11.1%	3.39	20.9%
X2-8	X22D-00843	Nels	20.6	14.9	C	4.51	21.9%	6.09	29.6%
X2-8	X22D-00846		13.8	10.0	C	3.32	24.1%	4.39	31.9%
X2-8	X22E-00833	Kruisfonteinspruit	11.1	8.2	C	2.08	18.7%	2.96	26.6%
X2-8	X22E-00849	Sand	8.7	6.4	C	1.71	19.8%	2.40	27.7%
X2-8	X22F-00842	Nels	74.9	45.1	C	8.37	11.2%	14.21	19.0%
X2-8	X22F-00886	Sand	48.9	37.3	C	9.48	19.4%	13.41	27.4%
X2-8	X22F-00977	Nels	125.4	84.9	C/D	21.08	16.8%	30.24	24.1%
X2-8	X22H-00836	Wit	43.0	20.0	D	3.41	7.9%	6.39	14.9%
X2-9	X22K-01029	Blinkwater	7.6	6.8	C	1.44	19.0%	2.05	27.2%
X2-9	X22K-01042	Mbuzulwane	1.2	1.1	B	0.34	28.7%	0.46	38.5%
X2-9	X22K-01043	Blinkwater	5.9	5.4	B	1.43	24.2%	2.07	34.9%
X2-10	X23B-01052	Noordkaap	50.9	33.5	D	8.66	17.0%	11.96	23.5%
X2-10	X23C-01098	Suidkaap	61.8	37.8	C	20.12	32.6%	24.40	39.5%
X2-10	X23E-01154	Queens	39.5	25.0	C	7.26	18.4%	10.71	27.1%
X2-10	X23F-01120	Suidkaap	109.8	57.1	C	26.51	24.1%	34.04	31.0%
X2-12	X24A-00826	Nsikazi	2.0	1.9	C	0.48	24.2%	0.67	34.0%
X2-12	X24A-00881	Nsikazi	11.7	11.3	B	3.44	29.5%	4.75	40.6%
X2-12	X24B-00903	Gutshwa	25.4	24.8	D	4.11	16.2%	6.21	24.4%
X2-12	X24B-00928	Nsikazi	42.4	41.4	A/B	13.46	31.8%	18.65	44.0%
X2-12	X24C-00978	Nsikazi	52.3	42.0	B	16.06	30.7%	21.15	40.5%
Sabie-Sand River system (X3)									
X3-1	X31A-00741	Klein Sabie	14.6	11.8	C	2.15	14.7%	3.37	23.0%
X3-1	X31A-00783		12.1	9.5	C	3.17	26.1%	4.09	33.8%
X3-1	X31A-00786		4.7	3.6	B	1.82	39.1%	2.22	47.8%
X3-1	X31A-00794		na	na	B	na	na	na	na
X3-1	X31A-00796		na	na	B	na	na	na	na
X3-1	X31A-00803		na	na	B/C	na	na	na	na
X3-2	X31B-00792	Goudstroom	12.2	9.8	B/C	3.79	31.0%	4.75	38.9%
X3-2	X31E-00647a	Marite	79.9	62.8	B/C	20.58	25.8%	27.74	34.7%
X3-2	X31F-00695	Motitsi	43.9	35.8	C	7.82	17.8%	11.62	26.5%
X3-4	X31D-00773	Sabani	19.2	7.6	C/D	3.13	16.3%	3.75	19.5%
X3-4	X31H-00819	White Waters	28.9	16.2	C	7.51	25.9%	9.09	31.4%
X3-4	X31J-00774	Noord-Sand	45.1	20.2	D	4.21	9.3%	7.22	16.0%
X3-4	X31J-00835	Noord-Sand	12.0	11.0	D	2.91	24.2%	3.76	31.3%
X3-4	X31K-00713	Bejani	2.4	2.4	D	0.40	16.9%	0.61	25.7%
X3-4	X31L-00657	Matsavana	3.8	2.6	C	0.17	4.3%	0.65	16.8%
X3-4	X31L-00664	Saringwa	10.9	9.5	C	1.47	13.5%	2.67	24.5%
X3-4	X31L-00678	Saringwa	3.2	3.2	B/C	0.59	18.2%	1.00	30.8%
X3-4	X31M-00673	Musutlu	1.8	1.8	B/C	0.19	10.6%	0.34	19.0%
X3-6	X31K-00771	Phabeni	2.5	2.5	B	0.70	27.8%	0.97	39.0%
X3-7	32E-00629	Nwarhele	10.6	9.9	C/D	1.93	18.2%	2.76	26.1%
X3-7	X32F-00628	Nwarhele	14.8	14.0	C/D	3.44	23.3%	4.63	31.3%
X3-8	X32B-00551	Motlamogatsana	15.4	10.4	C	2.75	17.9%	3.95	25.7%
X3-8	X32C-00558	Nwandlamuhari	49.7	25.0	C	7.64	15.4%	10.02	20.2%
X3-8	X32C-00564	Mphyanyana	3.1	2.0	C	0.05	1.6%	0.33	10.5%

IUA	SQ node	River name	MAR[1] (10^6 m^3)		REC	Long-term requirements			
			Natural	PD		Low flows		Total flows	
						10^6 m^3	MAR	10^6 m^3	MAR
X3-8	X32C-00606	Nwandlamuhari	53.2	33.7	C	8.77	16.5%	12.54	23.6%
X3-8	X32G-00549	Khokhovela	3.9	3.8	C	0.41	10.4%	0.67	17.0%
X3-9	X32H-00560	Phungwe	7.6	7.3	A	1.19	15.7%	1.98	26.1%

1 Mean Annual Runoff
2 Small SQ catchment areas (less than 3 km^2) and hence no hydrology modelled (small flows and inaccurate at this resolution).

6 DESCRIPTION OF SCENARIOS

This chapter is an extract from report: DWS (2014b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Operational Scenarios and recommended Water Resource Classes.Authored by Huggins G, Louw MD, Mallory S,Scherman S, Van Jaarsveld P and Van Rooyen P. DWS Report, RDM/WMA05/00/CON/CLA/0214. September 2014.

6.1 INTRODUCTION

The Inkomati, consisting of the Komati, Crocodile and Sabie Rivers, is highly a stressed system with water use equal to or exceeding the available resource in most areas. The system is institutionally well developed in that there is a catchment management agency (referred to as the Inkomati-Usuthu Catchment Management Agency or IUCMA); several well managed irrigation boards as well as the Komati Basin Water Authority (KOBWA). The Department of Water and Sanitation also has a regional office located in Nelspruit.

6.2 WATER MANAGEMENT SCENARIOS

In terms of physical infrastructure the Inkomati is not fully developed and there is scope for several new dams in the study area. The scenarios considered as part of this study therefore includes several infrastructure development options. While a workshop was held with stakeholders to identify scenarios, the development options were already well established as part of several previous studies, as listed below.

- Mbombela Reconciliation Strategy (DWA, 2013c).
- Progressive Realisation of the IncMaputo Water Use Agreement (TPTC, 2012).
- Sabie Feasibility Study (Chunnet Fourie and Partners, 1990).

These scenarios derived from these previous studies broadly consist of options to reduce the water requirements and options to increase the water supply. The water conservation and demand management options are incorporated into the water demand growth scenarios:

- **Komati River system**
  - Water Conservation & Water Demand Management.
  - Construction of the Silingane.
- **Crocodile River system**
  - Water Conservation & Water Demand Management.
  - Construction of the Mountain View Dam.
  - Construction of the Boschjeskop Dam.
- **Sabie River system**
  - Water Conservation & Water Demand Management.
  - Construction of the New Forest Dam.

A complicating factor in the Inkomati is the fact that all the major rivers within the study area form part of the larger Incomati River Basin which is shared with Swaziland and Mozambique. Two international agreements have relevance to the cross border flow into Mozambique. These are the Piggs Peak Agreement (TPTC, 1990) and the IncoMaputo Water Use Agreement (TPTC, 2002). The Piggs Peak agreement specifies a minimum flow in from the Crocodile and Komati rivers into Mozambique of 2 m^3/s. The arrangement within South Africa is that the Crocodile River will contribute 0.9 m^3/s while the Komati River contributes 1.1 m^3/s.

While the Piggs Peak agreement has been superseded by the IncoMaputo Water Agreement (TPTC, 2002), this agreement has yet to be implemented in practice, at least in terms of the cross border flow which has been increased from the Piggs Peak agreement from 2 m^3/s to 2.6 m^3/s.

6.3 ECOLOGICAL WATER REQUIREMENT OPTIONS

With respect to the EWR, the following three options were considered in each major river system (Komati, Crocodile and Sabie-Sand):

- No EWR.
- PES.
- REC.

In the Crocodile River system a further scenario referred to as the 'Present Day EWR' was also considered. This scenario stems from the Ecological Reserve study (DWA, 2010a,b) in which the recommendation was to maintain the present day flow.

6.4 CONSOLIDATED DEFINITION OF THE SCENARIOS

Table 6.1 - 6.4 summarise the scenario definition in the form of a matrix, where each row represents a scenario and the columns indicate each of the variables applicable to each scenario. The scenarios are grouped into four sub-catchments, the Komati, the Crocodile, the Sabie and the Sand River. The reason that the Sand River was separated from the Sabie is that it was found that many of the scenarios were applicable to either the Sabie (X31) or the Sand catchment, but not both.

Details of the modelling assumptions for each scenario analysed are presented in Appendix A - Chapter 10 (DWS, 2014b), along with the description of the network configuration and the data applied in the model for the simulations.

6.4.1 Komati River system

The proposed scenarios for the Komati River system are summarised in Table 6.1 and the associated variables associates with the scenarios are described below.

Table 6.1 Komati River system (X1): Scenario summary

Scenario	Scenario variables					
	Update water demands	Domestic growth and increase irrigation (plus restrictions so system does not fail)	IIMA[1] Flows	DARDLA[2]	Silingane Dam (DSMaguga)	EWR
K1	Yes	No	No	No	No	No
K2	Yes	No	No	No	No	Yes
K31	Yes	Yes	Yes	No	No	Yes
K32	Yes	Yes	Yes	No	No	No
K41	Yes	Yes	Yes	Yes	No	Yes
K42	Yes	Yes	Yes	Yes	No	No
K43	Yes	No	Yes	Yes	No	No
K5	WQ scenario (not for ecological assessment), includes mining aspects)					
K6	Yes	Yes	Yes	Yes	Yes	Yes

1 Interim IncoMaputo Agreement 2 Department of Agriculture, Rural Development and Administration

Update water demands

The existing yield model, which was set up as part of the Inkomati Water Availability Assessment Study (IWAAS) (DWA, 2009b), was updated with more recent water use information. In the Komati River system this included improved estimates of water use obtained from the All Towns Reconciliation Strategies (DWA, 2011a).

Growth in domestic and irrigation water requirements

The All Towns Reconciliation Strategies (DWA, 2011a) were used as data source of information on likely growth in domestic water requirements up to and including 2030. While no growth in irrigation is anticipated in the South African part of the catchment, Swaziland has yet taken up their full allocation. This scenario assumed that Swaziland would take up their full irrigation allocation.

Increased cross-border flows as stipulated in the Interim IncoMaputo Agreement

The current operating rule allows for the Komati River to contribute 1.1 m^3/s to the 2.0 m^3/s minimum flow into Mozambique as stipulated in the Piggs Peak agreement (TPTC, 1990). The more recent IIMA (TPTC, 2002) allows for a minimum cross border flow of 2.6 m^3/s of which 1.43 m^3/s will be provided from the Komati River.

Uptake of unutilised irrigation allocations through the intervention of the DARDLA

There is an estimated 14.6 million m^3/annum of water allocated to irrigators in the Upper Komati that is not being used. The DARDLA plan to reinstate 6.6 million m^3/annum of this irrigation at the original location and apply to DWS to transfer the remaining 8.8 million m^3/annum to downstream of Swaziland. Since the operating rule of the Vygeboom Dam includes the release of 0.6 m^3/s for these irrigators, the inclusion of this irrigation requirement does not impact on the transfers to Eskom since no additional release is required.

Impact of mining operations on the WQ in the upper Komati

The coal mines in the upper reaches of the Komati catchment pose a serious risk to the WQ in the Nooitgedacht and Vygeboom dams as well as the rivers feeding into these dams. There have already been incidences of spills which had dire consequences to the water supply to the town of Carolina. This scenario considered the impact of uncontrolled mining development with eventual acid mine drainage. This was modelled with and without transfers of water from the Usuthu catchment. This scenario has no ecological consequences, only a cost implication. The cost of treating AMD must be subtracted from the economic benefit of the mining.

Inclusion of the Silingane Dam on the Komati River

The study referred to as the Progressive Realisation of the IncoMaputo Agreement (TPTC, 2012) identified the Silingane Dam on the Komati River in Swaziland (at the downstream end of the X13D catchment) as a potential development option to increase the utilisable water within the Komati Basin. Although this development is probably a long way off, it was considered as a scenario and evaluated. The assumed parameters for this dam are as follows:

- Full supply capacity: 590 million m^3
- Full supply area:17.4 km^2
- Dead storage:5.0 million m^3

The assumed operating rule is that water will first be drawn from Silingane Dam and water released from Maguga Dam to Silingane Dam when the storage in the Silingane Dam drops below 10% of its full supply capacity.

Ecological Water Requirements

The EWR in the Komati River system was determined in 2005 (AfriDev, 2005b). The management class of the PES and REC is the same at all EWR sites hence it was not necessary to distinguish between PES and REC in the scenarios. An important point to note with regard to the EWR in the Komati River system is that there is no EWR requirement downstream of the confluence of the Komati and Lomati Rivers. The reason for this is the numerous weirs constructed on this stretch of river in the late 80's which effectively transformed this reach of river into a reservoir and not deemed appropriate for Reserve assessments.

6.4.2 Crocodile River system

The proposed scenarios for the Crocodile River system are summarised in Table 6.2. The variables associated with the scenarios are described below.

Table 6.2 Crocodile River system (X2): Scenario summary

Scenario	Scenario Variables						
	Update water demands with revised PES EWR	Updated water demands	Domestic growth	IIMA Flows	Mountain View Dam (Kaap)	Boschjeskop Dam (Nels)	EWR
C1	Yes	No	No	No	No	No	No
C2	No	Yes	No	No	No	No	REC
C3	No	Yes	Yes	Yes	No	No	PES
C4	No	Yes	Yes	Yes	No	No	REC
C5	No	Yes	Yes	Yes	Yes	No	No
C61	No	Yes	Yes	Yes	Yes	No	REC
C62	No	Yes	Yes	Yes	Yes	No	PES
C71	No	Yes	Yes	Yes	No	Yes	REC
C72	No	Yes	Yes	Yes	No	Yes	No
C81	No	Yes	Yes	Yes	Yes	Yes	REC
C82	No	Yes	Yes	Yes	Yes	Yes	PES

Updated water demands

The yield model used as part of the Ecological Reserve Study (DWA, 2010b) was based on the validation study carried out in 2006. New information on water use is now available from various sources, such as the Mbombela Reconciliation Strategy (DWA, 2013c), the All Towns Strategies (DWA, 2011a) and the Validation and Verification study being undertaken by the Inkomati-Usuthu Catchment Management Agency (ICMA, in progress).

Revised PES EWR

The de-facto EWR, as implemented by the IUCMA through their Crocodile Operations Committee is included in this scenario. This EWR was based on the minimum of the 'Present Day' flow and a EWR related to a C EC at EWR C6. See example from the month of October in Figure 6.1 below.

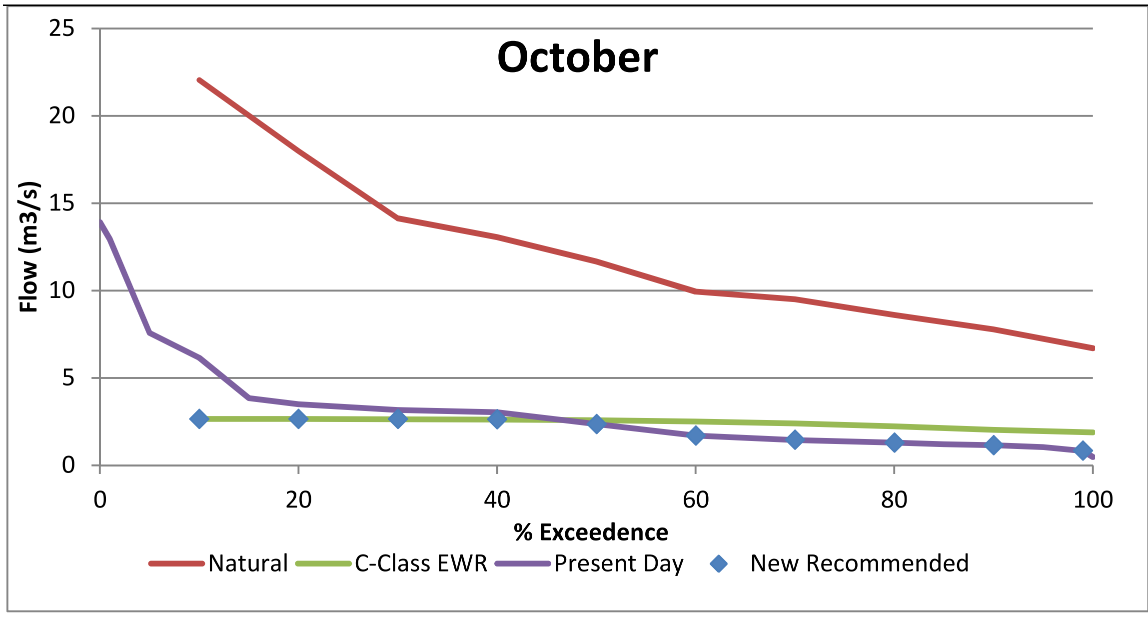


Figure 6.1 Derivation of the EWR as implemented by the IUCMA

Growth in Domestic water requirements

The Mbombela Reconciliation Strategy (DWA, 2013c) and the All Towns Reconciliation Strategies (DWA, 2011a) were used as a data source of information on likely growth in domestic water requirements up to and including 2030. No growth in irrigation is anticipated in Crocodile River system without the development of new dams.

Increased cross-border flows as stipulated in the Interim IncoMaputo Agreement

The current operating rule allows for the Crocodile River to contribute 0.9 m^3/s to the 2.0 m^3/s minimum flow into Mozambique as stipulated in the Piggs Peak agreement (TPTC, 1990). The more recent IIMA (TPTC, 2002) allows for a minimum cross border flow of 2.6 m^3/s of which 1.17 m^3/s will be provided from the Crocodile River.

Mountain View Dam

One of the infrastructure interventions considered during the Mbombela Reconciliation Strategy study (DWA, 2013c) was the construction of a dam on the Kaap River near the confluence with the Crocodile Dam at a site referred to as Mountain View. The construction of this dam could meet the growing domestic requirements or contribute to the EWR (PES or REC). The parameters for this dam used in the scenario analyses are as follows:

- Full supply capacity: 75 million m^3.
- Full supply area: 3.6 km^2.
- Dead storage: 2.0 million m^3.

Boschjeskop Dam

Another possible infrastructure intervention considered during the Mbombela Reconciliation Strategy study (DWA, 2013c) was the construction of a dam on the Nels River at the farm Boschjeskop. As with the Mountain View Dam, this dam could meet the growing domestic requirements of Mbombela or contribute to the EWR (PES or REC). The parameters for this dam used in the scenario analyses are as follows:

- Full supply capacity: 120 million m^3.
- Full supply area:6.0 km^2.
- Dead storage: 2.0 million m^3.

Ecological Water Requirements

Four scenarios were considered with regard to the EWR. These are:

- The *de facto* EWR as applied by the IUCMA; secondly
- No EWR.
- PES.
- REC.

It was identified during the Inkomati Reserve study (DWA, 2010a,b) that EWRC6 (at the downstream end of the Crocodile River) is the so-called driver station in that if the EWR at this point is met then the EWR is met at all the other six EWR sites. The possible exception to this is the EWR on the Kaap River (EWRC7) which is located just upstream of the site of the proposed Mountain View Dam. Hence the construction of the Mountain View Dam will not be able to contribute to the EWR of the Kaap River.

6.4.3 Sabie and Sand River system

While the yield model of the Sabie catchment (of which the Sand River is a major tributary) considers the Sabie and Sand as one system, the scenarios relate to either the Sabie River system (X31) or the Sand River system (X32). For clarity, the scenarios have therefore been presented in two tables. The scenarios for the Sabie River system are summarised in Table 6.3 (Sabie) and Table 6.4 (Sand).

Table 6.3 Sabie River system (X31): Scenario summary

Scenario	Update water demands	Growth in water demands	EWR
S1	Yes	No	No
S2	Yes	No	Yes (REC)
S31	Yes	Yes	Yes (REC)
S32	Yes	Yes	No
S6	Yes	Minimised to meet REC	Yes (REC)

Table 6.4 Sand River system (X32): Scenario summary

Scenario	Scenario Variables				
	Update water demands	Growth in water demands	Reinstate Sand Forestry	New Forest Dam (Mutlumuvi River)	EWR
S1	Yes	Yes, with no return flows	No	No	No
S4	Yes	Yes, with 50% return flows	Yes	No	No
S51	Yes	Yes, with 50% return flows	Yes	Yes	Yes REC
S52	Yes	Yes, with 50% return flows	Yes	Yes	No
S53	Yes	Yes, with 50% return flows	Yes	Yes	Yes PES
S71	Yes	Yes, with 25% return flows	Yes	Yes	Yes REC
S72	Yes	Yes, with 25% return flows	Yes	Yes	No
S73	Yes	Yes, with 25% return flows	Yes	Yes	Yes PES

Updated present day

The water demand applied within the water resources model (as used during the Ecological Reserve study – DWA, 2010a,b) were based on the validation study carried out in 2006. New information on water use is now available from various sources and the model was updated to provide a more accurate representation of present day (ICMA, in progress) water use in the Sabie River system.

Specific updates include:

- Improved estimates of irrigation areas through a validation process.
- Improved understanding of the operation of the Sabie Irrigation Board.
- Reduced irrigation in the Sand River due to the collapse of several irrigation schemes.
- Increased abstraction from the Sabie River at Hoxani.

Growth in Water Demands

The growth in domestic water demands was sourced from the All Towns Strategies and Mbombela Reconciliation Strategy (DWA, 2011a; DWA, 2013c). There are plans to expand the irrigation activities upstream of the Inyaka Dam to leverage on recent successful land claims. The exact details of this expansion are not known but an increased abstraction of 10 million m^3/annum was assumed.

Reinstate forestry in the Sand River

Early in the millennium most of the forestry was removed from the Sand River in order to preserve the riverine ecology. The intention was that job lost from the forestry industry would be taken up through increased eco-tourism. However, this did not happen. The Department of Agriculture and Forestry have announced their intention to reinstate some of the forestry. Exact details of their intentions could not be obtained but based on areas previously removed the area to be reinstated was assumed to be 3 000 ha.

New Forest Dam

A dam site was identified on the Mutlumuvi River, a tributary of the Sand River (Chunnet, Fourie and Partners, 1990), approximately at EWRS6. This dam is a likely source of water to meet the rapidly increasing domestic requirements which will soon exceed the yield available from the Inyaka Dam. The parameters of this dam are as follows:

- Full supply capacity: 50 million m^3.
- Full supply area:5.0 km^2.
- Dead storage: 0.0 million m^3.

Return flows

Currently, approximately 18 million m^3/annum is transferred into the Sand River system from the Inyaka Dam. However, there is very limited waste water treatment capacity in the catchment. As a result, return flows are negligible. As a general rule of thumb, return flow of about 50% of the domestic use can be expected and this is allowed for in most water resources analyses. Initially the assumption was made that by 2030 (the future water use scenario), there will be full treatment of all domestic effluent resulting in 50% return flow. As an alternative scenario, return flow was reduced to 25% of domestic use. The reasoning behind this is that it could take a lot longer to fully develop waste water treatment capacity in the Sand River than the 15 years initially assumed.

Ecological Water requirements

Three scenarios were considered with regard to the EWR. These are:

- No EWR.
- PES.
- REC.

7 ECOLOGICAL SCENARIO CONSEQUENCES

This chapter is an extract from report: DWS (2014b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Operational Scenarios and recommended Water Resource Classes. Authored by Huggins G, Louw MD, Mallory S,Scherman S, Van Jaarsveld P and Van Rooyen P. DWS Report, RDM/WMA05/00/CON/CLA/0214. September 2014.

7.1 BACKGROUND

This Chapter focuses on the results of the evaluation of the various scenarios (Sc). The integration into a single ecological ranking for the Komati, Crocodile, Sabie, and Sand River systems are provided in Section 7.2 – 7.5, respectively. Detailed consequences are provided in the supporting document, Report 4.2 (DWS, 2014c).

7.2 KOMATI RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS AT THE EWR SITES

The scenarios are described in Table 6.1. The scenarios applicable to the Komati River system only impact on EWR K3 (Komati River at Tonga Rapids) and EWR L1 (Lomati River downstream of Driekoppies Dam).

Recent changes in the lower Komati operating rule from Maguga Dam have resulted in improvement in the system since the 2004 – 2006 EWR study (AfriDev, 2006a). The results illustrate that all the scenarios meet the ecological objectives at EWR K3.

The Lomati River at EWR L1 is largely impacted on by the unseasonal releases for irrigation from Driekoppies Dam. The scenario results illustrate that Sc K2, K31 and K41 are similar to the present day flows (i.e. maintain the PES) whereas the other scenarios are in a worse state due to the impacts on riparian vegetation which in turn impacts on the instream components. This results in a change from a C to a C/D EcoStatus.

7.3 CROCODILE RIVER SYSTEM ECOLOGICAL CONSEQUENCES OF SCENARIOS

7.3.1 Crocodile River system: Ecological consequences of scenarios at the EWR sites

The scenarios are described in Table 6.2. The ecological consequences are summarised in Table 7.1. The first column provides the ECs for each component at the EWR site. The second column provides the ranking of the scenarios. The third column includes a short explanation of the consequences and ranking.

The scenarios only impact on EWR C3, C4, C5 and C6 in the Crocodile River and EWR C7 in the Kaap River.

EWR C3: The results illustrate that none of the scenarios meet the ecological objectives of the REC. Only Sc C61 maintains the EcoStatus PES although there is deterioration in geomorphology. The major issue is that EWR C3 is downstream of Kwena Dam and that current and scenario releases are unseasonal resulting in too high flows in winter and too little flows in summer.

EWR C4: The results illustrate that all the scenarios meet the ecological objectives of the PES and of these scenarios Sc C62 and C72 result in an improvement in the PES, although the REC requirements are not met. This site is upstream of the major off-takes into canals for irrigation further downstream and the problems (current and with scenarios) are the constraints on the operation for irrigation resulting in an unseasonal distribution of flows.

EWR C5: The results illustrate that all the scenarios meet the ecological objectives of the PES and of these scenarios Sc C2, C4. C61, C71, C81 and C82 result in an improvement in the PES, although the REC requirements are not met.

Table 7.1 Crocodile River system: Summary of ecological consequences at the EWR sites

Ecological consequences as ECs	Ecological consequences	Ranked scenarios	Ranking rationale

EWR C3 (Crocodile River)

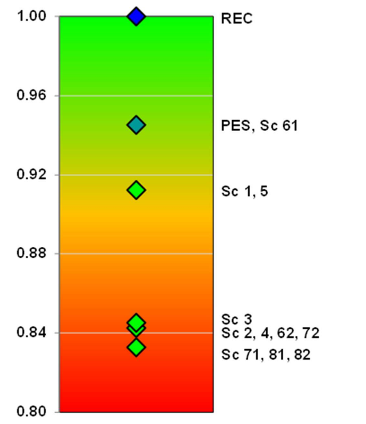
Ecological consequences as ECs

Component	PES	REC	Sc 1	Sc 2, 3, 4, 62, 72	Sc 5	Sc 61	Sc 71, 81, 82
Physico chemical	C	B/C	B	B	B	B	B
Geomorphology	C	C	C/D	C/D	C/D	C/D	C/D
Fish	B	B	B	C	B	B	C/D
Invertebrates	C	B	C	C	C	C	C
Riparian vegetation	C	B	C	C	C	C	C
EcoStatus	B/C	B	C	C	C	B/C	C

Ecological consequences

Reduced flood peaks and reduced summer season baseflows all result in smaller, less frequent floods. This reduces scour of the bed, pools and lower banks and also promotes vegetation encroachment and channel width reduction (narrowing). These impacts and the increased high flows early in the dry season may result in flushing juvenile fish downstream.

Ranked scenarios



Ranking rationale

The results illustrate that none of the scenarios meet the ecological objectives of the REC. Only Sc C61 maintains the EcoStatus PES although there is deterioration in geomorphology. The major issue is that EWR C3 is downstream of Kwena Dam and that current and scenario releases are unseasonal resulting in too high flows in winter and too little flows in summer.

EWR C4 (Crocodile River)

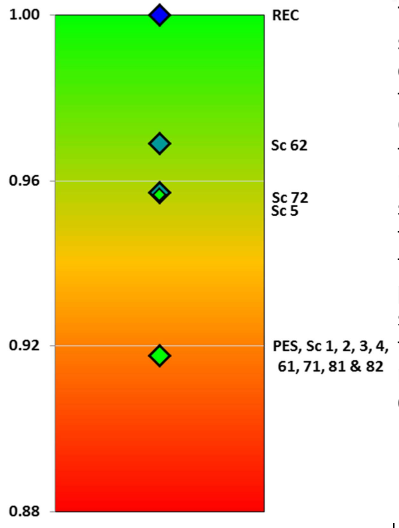
Ecological consequences as ECs

Component	PES	REC	Sc 1,2.3,4, 61, 71, 81, 82	Sc 5	Sc 62, 72
Physico chemical	C	B	C	B	B
Geomorphology	B/C	B	B/C	B/C	B/C
Fish	B	B	B	A/B	A
Invertebrates	C	B	C	B	A/B
Riparian vegetation	C	B	C	C	C
EcoStatus	C	B	C	C	B/C

Ecological consequences

As there are no large dams which can inhibit the provision of flood flows this far down the catchment (the impact of altered spills from the upstream Kwena Dam will not have a measureable impact on geomorphology at this site due to amelioration from numerous tributary inputs), moderate and large floods necessary for channel maintenance will still occur. Instream biota remains in the PES or improves due to improved low flow conditions

Ranked scenarios



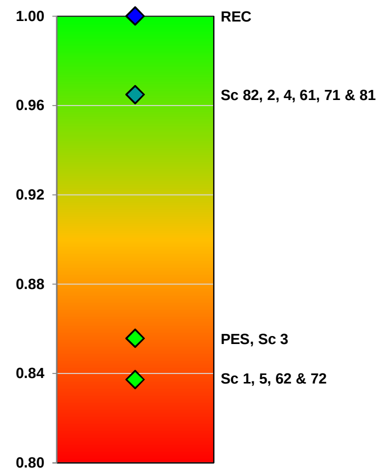
Ranking rationale

The results illustrate that all the scenarios meet the ecological objectives of the PES and of these scenarios; Sc C62 and C72 result in an improvement in the PES, although the REC requirements are not met. This site is upstream of the major off-takes into canals for irrigation further downstream and the problems (current and with scenarios) are the constraints on the operation for irrigation resulting in an unseasonal distribution of flows.

EWR C5 (Crocodile River)

Component	PES	REC	Sc 3	Sc 1, 5 62, 72	Sc 2, 4, 61, 71, 81, 82
Physico chemical	C	B	C	C	B/C
Geomorphology	C/D	C	C/D	C/D	C/D
Fish	C	B	C	C	B/C
Invertebrates	C	B	C	C	B
Riparian vegetation	C	B	C	C	B/C
EcoStatus	C	B	C	C	B/C

As there are no large dams which can supply floods this far down the catchment, the scenario will not have a measureable impact on geomorphology at this site due to amelioration from numerous tributary inputs. Instream biota remains in the PES or improves due to improved wet season volumes for downstream irrigation.

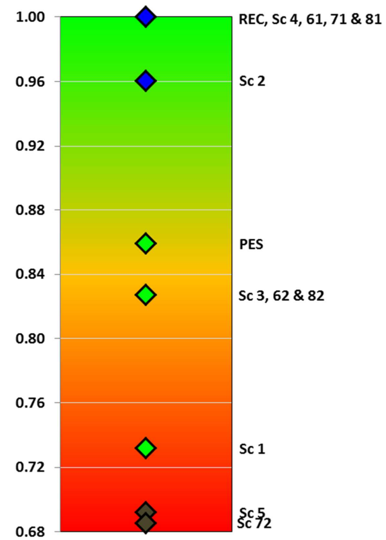


Most of the scenarios meet the ecological objectives of the PES and of these scenarios; ScC2, C4,C61, C71, C81 and C82 result in an improvement in the PES, although the REC requirements are not met. Scenario C1, C5, C62 and C72 result in the PES EcoStatus although low flows is lower than the PES requirement.

EWR C6 (Crocodile River)

Component	PES	REC	Sc 1	Sc 2	Sc 3, 62, 82	Sc 4	Sc 5	Sc 61, 71	Sc 72	Sc 81
Physico chemical	C	B	C	B	C	B	C/D	B	C/D	B
Geom	C	C	C	C	C	C	C/D	C	D	C
Fish	C	B	D	C	C/D	B	D	B	D	B
Invert	C	B	D	B/C	C	B	D	B	B	B
Riparian vegetation	C	B	B/C	B	B	B	C	B	C	B
EcoStatus	C	B	C	B	C	B	C/D	B	C/D	B

Scenario 5 and 72 impacts on the WQ and geomorphology due to reduced wet season flows below the PES. Fish will respond with possible impacts on fish functions such as spawning, breeding, nursery and migration. Although the situation is improved under Sc C62 and C82, the PES is still not achieved for all components although the EcoStatus is a C.

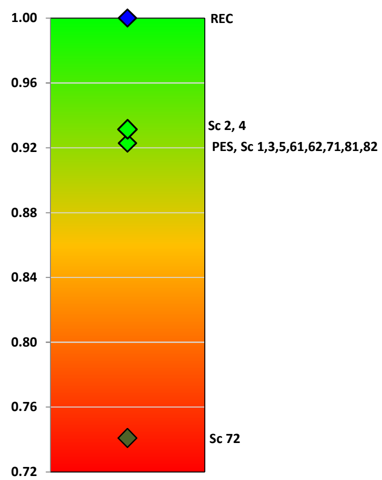


This site is the key site in the system, both from an operational and ecological importance viewpoint. The results illustrate that Sc C5 and Sc C72 do not meet the ecological objectives of the PES or the REC and are the worst case scenarios. ScenarioC4, C61, C71 and Sc C81 meet the REC requirements. ScenarioC2 also meets the REC requirements although the ecological objectives for invertebrates are not fully met. Scenario C1, C3, C62 and C82 meet the PES requirements however the instream biota are impacted to a greater extent under these scenarios and ecological objectives are not fully met for fish and macro-invertebrates.

EWR K7 (Kaap River)

Component	PES	REC	Sc72,	Sc 2, 4	Sc 1,3,5, 61,62,71, 81,82
Physico chemical	B	B	C	B	B
Geomorphology	B	B	B	B	B
Fish	C	B	D	B	C
Invertebrates	B	B	C/D	B/C	B
Riparian vegetation	C/D	B/C	C/D	C/D	C/D
EcoStatus	C	B	C/D	C	C

The evaluation against EWR was made based on the assumption that the EWR should not be higher than PD flows during the dry season. All scenarios meet the PES or marginally improve the PES (Sc C2 and C4) except for Sc C72 results in a drop in most categories and results in a C/D EcoStatus. The reason for the lower EC is due to lower flows than the EWR and the PD during the dry months which impacts on the WQ and instream biota.



ScenarioC72 does not meet the ecological objectives of the PES or the REC. The rest of the scenarios meet the PES EcoStatus requirements although and all component requirements. Of these scenarios, Sc C2 and C4 are the best scenarios as the fish improves a category.

EWR C6: This site is the key site in the system, both from an operational and ecological importance viewpoint. The results illustrate that Sc C5 and Sc C72 do not meet the ecological objectives of the PES or the REC and are the worst case scenarios. ScenarioC4, C61, C71 and Sc C81 meet the REC requirements. ScenarioC2 also meets the REC requirements although the ecological objectives for macro-invertebrates are not fully met. Scenario C1, C3, C62 and Sc C82 meet the PES requirements however the instream biota are impacted to a greater extent under these scenarios and ecological objectives are not fully met for fish and macro-invertebrates. Scenario C1 is the worst scenario in this group for the fish, macro-invertebrate and riparian vegetation components. This will mean that if Sc C1 is implemented, there is a high risk that the EcoStatus will drop to a lower category.

EWR C7: The results illustrate that Sc C72 does not meet the ecological objectives of the PES or the REC. The rest of the scenarios meet the PESEcoStatus requirements although there is deterioration in macro-invertebrates. Of these scenarios, Sc C2 and C4 are the best scenarios as there is a small improvement in the PES.

The individual site rankings are illustrated in Figure 7.1.

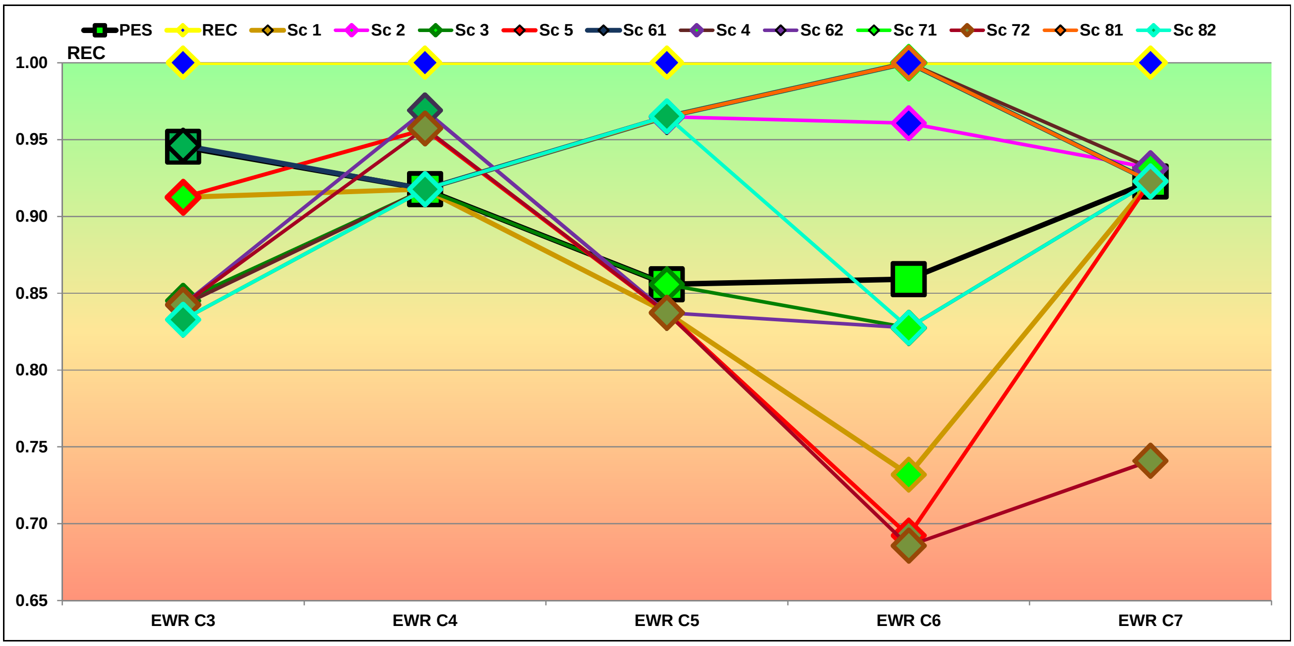


Figure 7.1 Crocodile River system: Ranking of scenarios

7.3.2 Crocodile River system: Integrated ecological consequences

The process to determine an integrated ranking of the different scenarios is described below. The first step was to determine the relative importance of the different EWR sites. The site weight (Table 7.2) indicates thatEWR 6 carries the highest weight due to its high ecological importance and as it represents the KNP. Furthermore it is situated at the most downstream reach of the Crocodile River system and therefore plays an important role in the operation of the system.

The weights are provided in the Table 7.2. The weight is based on the conversion of the PES and EIS to numerical values to determine the normalised weight.

Table 7.2 Crocodile River system: Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas (0 - 5)	Confidence	Normalised Weight
EWR C1	A/B	Moderate	1	3.75	0.14
EWR C2	B	High	1	3.5	0.14
EWR C3	B/C	High	1	2.5	0.12
EWR C4	C	High	2	2.5	0.13
EWR C5	C	Very High	5	3.4	0.18
EWR C6	C	Very High	5	4	0.20
EWR C7	C	High	1	1	0.10

The weight is applied to the ranking value for each scenario at each EWR site and this provides an integrated score and ranking for the operational scenarios of the Crocodile River system. The ranking of '1' refers to the REC and the rest of the ranking illustrate the degree to which the scenarios meet the REC. The results are provided in Table 7.3 after the weights have been taken into account.

Table 7.3 Crocodile River system: Ranking value for each scenario resulting in an integrated score and ranking

EWR site	PES	REC	Sc C1	Sc C2	Sc C3	Sc C4	Sc C5	Sc C61	Sc C62	Sc C71	Sc C72	Sc C81	Sc C82
EWR C1	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
EWR C2	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
EWR C3	0.11	0.12	0.11	0.10	0.10	0.10	0.11	0.11	0.10	0.10	0.10	0.10	0.10
EWR C4	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
EWR C5	0.16	0.18	0.15	0.18	0.16	0.18	0.15	0.18	0.15	0.18	0.15	0.18	0.18
EWR C6	0.17	0.20	0.15	0.19	0.17	0.20	0.14	0.20	0.17	0.20	0.14	0.20	0.17
EWR C7	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.07	0.09	0.09
Score	**0.92**	**1**	**0.89**	**0.95**	**0.903**	**0.96**	**0.89**	**0.97**	**0.91**	**0.96**	**0.86**	**0.96**	**0.92**

The above results are plotted on a traffic diagram (Figure 7.2) to illustrate the integrated ecological ranking.

7.3.3 Crocodile River system: Conclusions

The integrated ecological ranking for the Crocodile River system that will be taken forward in the decision-making process on scenarios and Water Resource Class determination is summarised in Figure 7.2.

The worst case scenarios are Sc C72 and C5 which both include new dam options but with no EWR releases. Scenario C1 which represents the current operating rule also has the potential to degrade the river although it will still maintain the EcoStatus of a C at EWR C6. The best options are those options that include the REC. It is however known that these have serious potential economic consequences. Scenario C3 (with no new dams) and Scenario C82 (that includes new dams) are potentially the best compromise options to explore further.

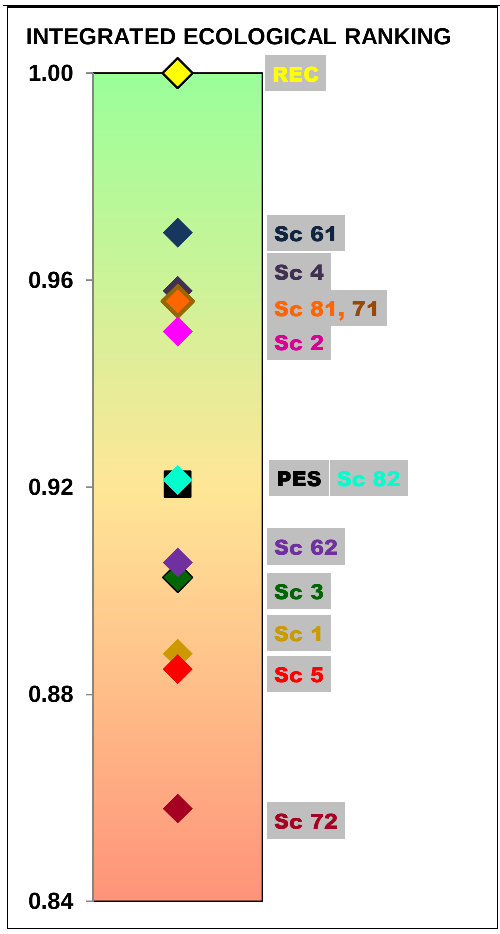


Figure 7.2 Crocodile River system: Integrated ecological ranking of the scenarios

7.4 SABIE RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS

7.4.1 Sabie River system: Ecological consequences of scenarios at the EWR sites

The scenarios are described in Table 6.3. The ecological consequences are summarised in Table 7.4. The first column provides the ECs for each component at the EWR site. The second column provides the ranking of the scenarios. The third column includes a short explanation of the consequences and ranking.

The scenarios only impact on EWR S3 (Sabie River) and EWR S5 (Marite River). At all the other EWR sites, the status quo is therefore maintained.

Table 7.4 Sabie River system: Summary of ecological consequences at the EWR sites

Ecological consequences as ECs	Ecological consequences	Ranked scenarios	Ranking rationale

EWR S3 (Sabie River)

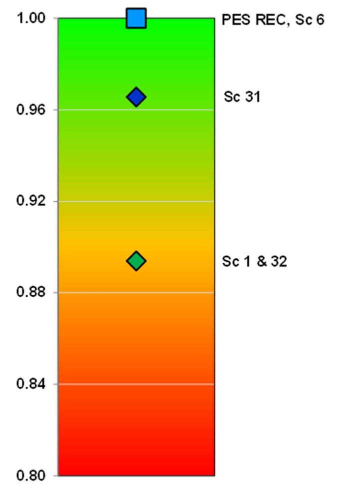
Ecological consequences as ECs

Component	PES & REC	Sc 1	Sc 31	Sc 32	Sc 6
Physico chemical	B	C	B	C	B
Geomorphology	B	B	B	B	B
Fish	B	C	B/C	C	B
Invertebrates	B	C	B	C	B
Riparian vegetation	A/B	B	B	B	A/B
EcoStatus	A/B	B/C	B	B/C	A/B

Ecological consequences

Increased stress during the dry season results in WQ and instream biota degradation. Reduced base flows also impact on the marginal vegetation zone.

Ranked scenarios



Ranking rationale

Sc S1 and S32 do not meet the ecological objectives of the PES and REC and degrade the EcoStatus to a B/C from the current A/B EC. Scenario S31 is an improvement of these scenarios but the fish and riparian vegetation REC are not met. Scenario S6 maintains the REC and is ecologically the most acceptable scenario for EWR S3 and the KNP.

EWR S5 (Marite River)

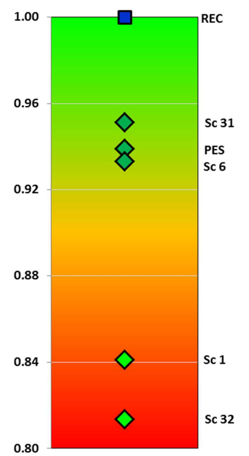
Ecological consequences as ECs

Component	PES	REC	Sc 1	Sc 31	Sc 32	Sc 6
Physico chemical	B	B	C	A/B	C	A/B
Geomorphology	C	C	C	C/D	C/D	C/D
Fish	B/C	B	C	B/C	C	B/C
Invertebrates	B/C	B	C	B	C	B/C
Riparian vegetation	B/C	B	B/C	B/C	B/C	B/C
EcoStatus	B/C	B	C	B/C	C	B/C

Ecological consequences

Geomorphological impacts (Sc S6, S31 and S32) are small and largely related to the dam and the changes in sediment regime. These changes, as well as the WQ changes, result in a decrease in the fish status under Sc S1, and S32 due to the unseasonal high flows released from Inyaka Dam. Sc S31 is however an improvement from Sc S6 as flows are generally lower. Scenario S32 flows are lower than the EWR requirement which results in increased stress.

Ranked scenarios



Ranking rationale

Inyaka Dam is situated in the Marite River upstream of EWR S5. Operation of the Sabie River is dependant on releases from Inyaka Dam, whether it is for the EWR and/or the users. As is currently the case, the impacts of this operating rule on the Marite River result in releases that do not mimic the natural seasonal distribution and often results in too much flows (i.e. flows higher than natural). None of the scenarios therefore achieve the REC. ScenarioS31 is marginally better than the PES whereas Sc S1 and S32 result in in an EcoStatus below the PES.

The ranking of the scenarios at each site in terms of how successful the scenarios are in meeting the REC is provided in Figure 7.3. The ranking order is quite different between EWR S3 and EWR S5 due to the operation of the system. Inyaka Dam is situated in the Marite River upstream of EWR S5. Operation of the Sabie River is dependant on releases from Inyaka Dam, whether it is for the EWR and/or the users. In essence, as is currently the case, the impacts of this operating rule on the Marite River result in releases that do not mimic the natural seasonal distribution and often results in too much flows (i.e. flows higher than natural). None of the scenarios therefore achieve the REC in the Marite River which would require smaller releases at times. Scenario S31 is marginally better than the PES whereas Sc S1 and S32 result in an EcoStatus below the PES. The ranking shows that Sc S1 and S32 are the lowest in the ranking and significantly lower than the other scenarios.

The ranking in the Sabie River follows a similar order to the Marite River except for Sc 6 which is at opposite ends of the ranking. Scenario S6 was designed as an optimised scenario to ensure that the EWR is met in the Sabie River. To meet the EWR, additional releases from Inyaka Dam is required and that is why Sc S6 results in ecological degradation in the Marite River. Scenario S32 is the worst scenario in the Sabie River as well as in the Marite River.

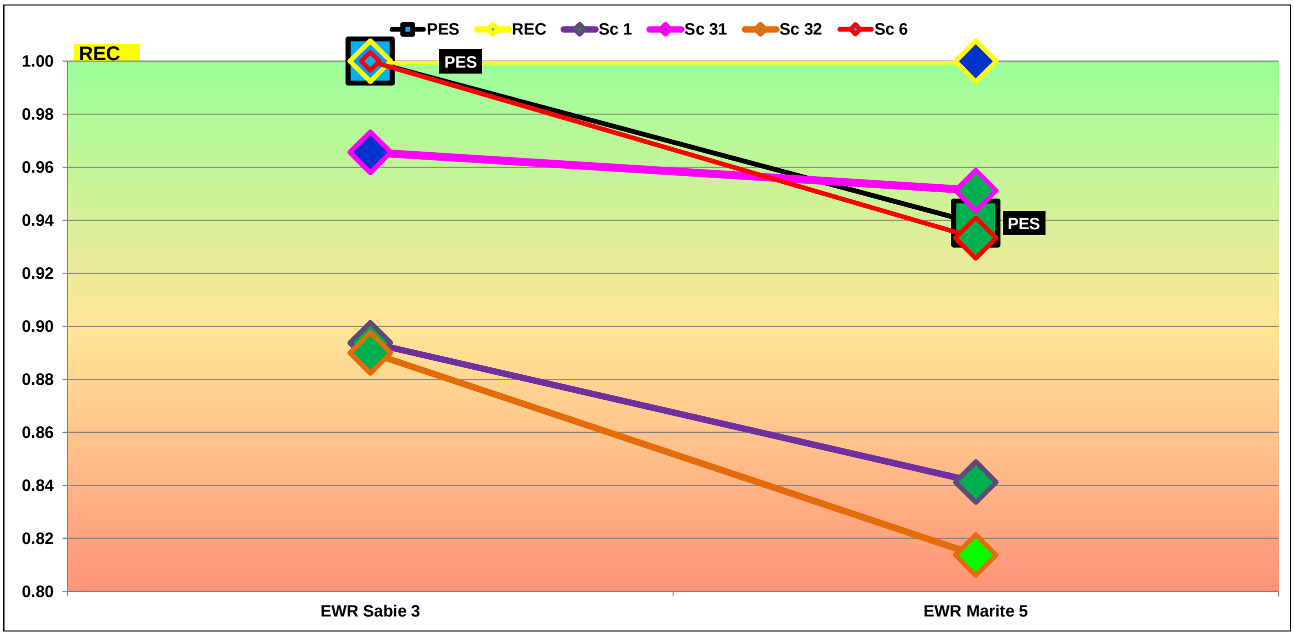


Figure 7.3 Sabie River system: Ranking of scenarios at EWR S3 and EWR S5

7.4.2 Sabie River system: Integrated ecological consequences

The process to determine an integrated ranking of the different scenarios is described below. The first step was to determine the relative importance of the different EWR sites. The site weight (Table 7.5) indicates that EWR S3 carries the highest weight due to its high ecological importance and as it represents the KNP.

The weights are provided in the Table 7.5. The weight is based on the conversion of the PES and EIS to numerical values to determine the normalised weight.

Table 7.5 Sabie River system: Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas (0 - 5)	Confidence	Normalised Weight
EWR S1	B/C	High	1	3.25	0.17
EWR S2	C	High	2	3.25	0.19
EWR S3	A/B	Very High	5	3.75	0.26
EWR S4	B	High	3	3.15	0.21
EWR S5	B/C	High	1	3.25	0.17

The weight is applied to the ranking value for each scenario at each EWR site and this provides an integrated score and ranking for the operational scenarios of the Sabie River system. The ranking of '1' refers to the REC and the rest of the ranking illustrate the degree to which the scenarios meet the REC. The results are provided in Table 7.6 after the weights have been taken into account. Values for EWR sites S3 and S5 only have been provided as the scenarios do not impact on the other EWR sites.

Table 7.6 Sabie River system: Ranking value for each scenario resulting in an integrated score and ranking

EWR site	PES	REC	Sc S1	Sc S31	Sc S32	Sc S6
EWR S3	0.26	0.26	0.24	0.26	0.24	0.26
EWR S5	0.16	0.17	0.15	0.17	0.14	0.15
Score	**0.97**	**1**	**0.92**	**0.96**	**0.92**	**0.95**

The above results are plotted on a traffic diagram (Figure 7.4) to illustrate the integrated ecological ranking.

7.4.3 Sabie River system: Conclusions

Scenario S31 and S6 are the best options as they are the closest to meeting the ecological objectives. If one however considers that the Sabie River has always been seen as the flagship river in the KNP as well as one of the few rivers left in South Africa in excellent condition, then the ranking order of the Sabie River should (from an ecological view point) override the integrated ranking. As Sc S6 is the only scenario that maintains the PES (and REC) in the Sabie River, this scenario is the ecological recommendation.

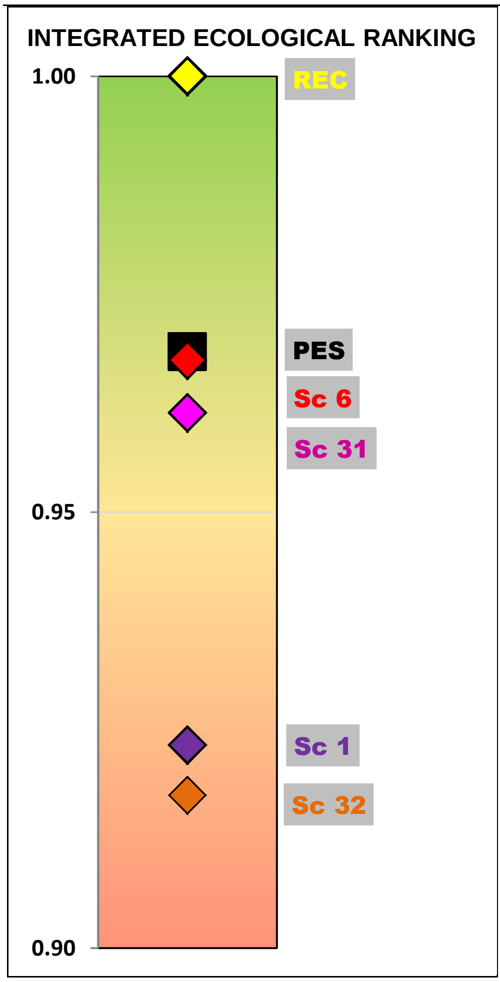


Figure 7.4 Sabie River system: Integrated ecological ranking of the scenarios

7.5 SAND RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS

7.5.1 Sand River system: Ecological consequences of scenarios at the EWR sites

The scenarios are described in Table 6.4. The ecological consequences are summarised in Table 7.7. The first column provides the ECs for each component at the EWR site. The second column provides the ranking of the scenarios. The third column includes a short explanation of the consequences and ranking.

The scenarios largely impact on EWR S6 (Mutlumuvi River) and EWR S8 (Sand River). Due to the lower confidence at EWR S7 (Thulandziteka (Sand) River) and as it is situated upstream of the impact of the New Forest Dam, this site was not considered during the scenario evaluation.

The results at EWR S6 (Mutlumuvi River) illustrate that none of the scenarios meet the ecological objectives of the REC. Scenario S4 meets the ecological objectives of the PES and has the least impact of all the scenarios. Scenario S51 and S71 result in the PES EcoStatus although geomorphology and fish are impacted. Scenario S53 and S73 result in a deterioration in the PES while Sc S52 and S72 have serious impacts as the EWR site will receive zero flows except when the dam spills.

Although affected by the proposed New Forest Dam under Sc S51, S52 and S53, the impacts of these scenarios are ameliorated by the return flows from the lower catchment. Scenario S72 is marginally lower than the EWR during some months but does maintain the REC for all components and the EcoStatus.

Table 7.7 Sand River system: Summary of ecological consequences at the EWR sites

EWR S6 (Mutlumuvi River)

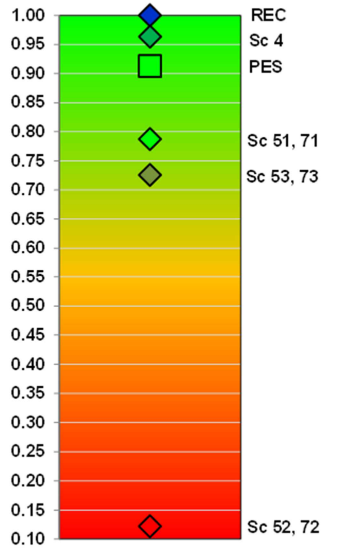
Ecological consequences as ECs

Component	PES	REC	Sc 4	Sc 51, 71	Sc 52, 72	Sc 53, 73
Physico chemical	B/C	B/C	B/C	C	F	C
Geomorphology	C	C	C	D	F	D
Fish	C	B	B/C	C/D	F	D
Invertebrates	B/C	B	B	C	F	C/D
Riparian vegetation	C	B	B/C	C	F	C/D
EcoStatus	C	B	B/C	C	F	C/D

Ecological consequences

Scenario S52 and S72 are the worst case scenario as the river will barely ever flow and the EC of all components will decrease significantly. Low flows and floods also decrease under Sc S51, S53, S71 and S73 with the resulting degradation of most of the components linked to the geomorphological and WQ deterioration. Scenario S4 is the best option (as it does not include a dam) and improves the PES although not achieving the REC.

Ranked scenarios



Ranking rationale

None of the scenarios meet the ecological objectives of the REC. Scenario S4 meets the ecological objectives of the PES and has the least impact of all the scenarios. Scenario S51 and S71 result in the PES EcoStatus although geomorphology and fish are impacted. Scenario S53 and S73 result in a deterioration in the PES while Sc S52 and S72 have serious impacts as the EWR site will receive zero flows except when the dam spills.

EWR S8 (Sand River)

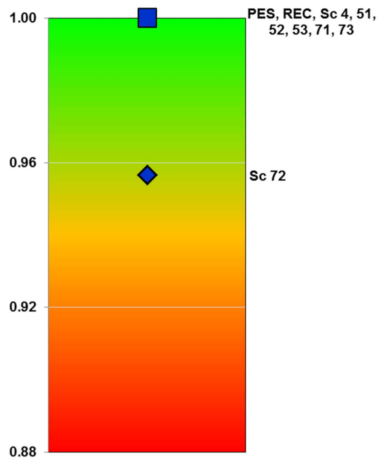
Ecological consequences as ECs

Component	PES	REC	Sc 4, 51, 52, 53, 71, 73	Sc 72
Physico chemical	B	B	B	B/C
Geomorphology	C	C	C	C
Fish	B	B	B	B
Invertebrates	B	B	B	B/C
Riparian vegetation	B	B	B	B
EcoStatus	B	B	B	B

Ecological consequences

The REC flows are met under all scenarios apart from Sc S72. Scenario S72 has marginally less base flows than the EWR resulting in invertebrates and WQ degrading by half a category.

Ranked scenarios



Ranking rationale

All the scenarios include return flows that are of such a scale that they ameliorate the impact of the proposed New Forest Dam and the reinstatement of forestry.

The ranking order is the same for both sites with Sc S72 being the worst case at both sites (Figure 7.5).

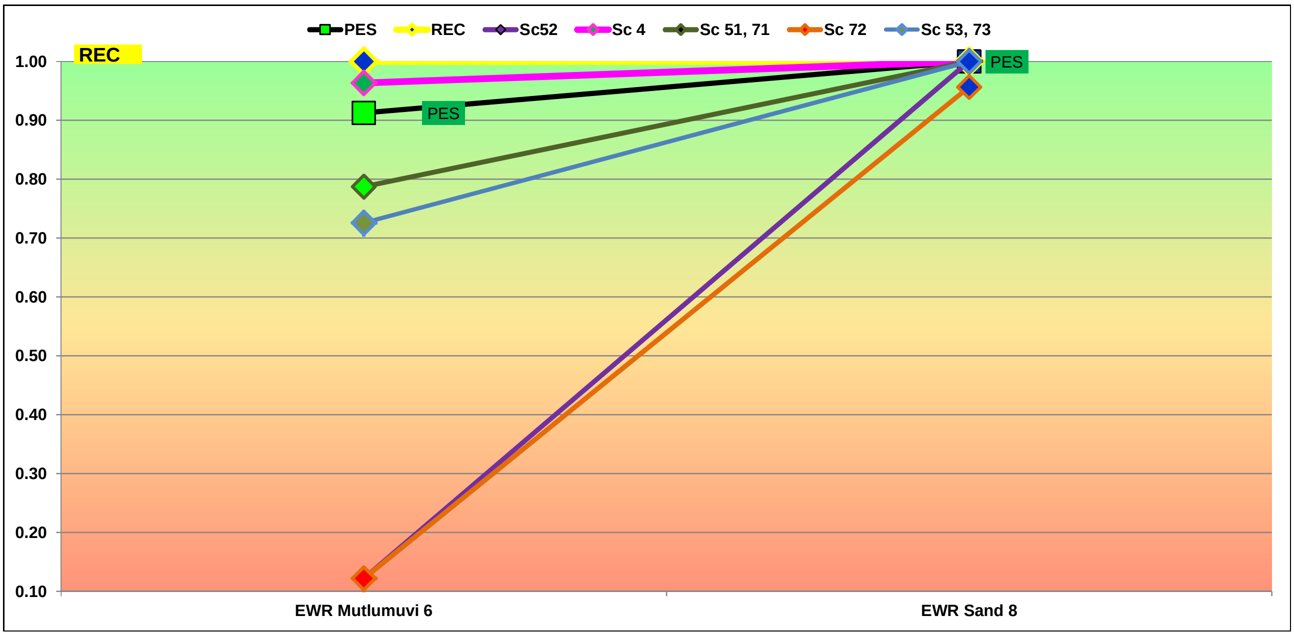


Figure 7.5 Sand River system: Ranking of scenarios at EWR S6 and EWR S8

7.5.2 Sand River system: Integrated ecological consequences

The process to determine an integrated ranking of the different scenarios is described below. The first step was to determine the relative importance of the different EWR sites. The site weight (Table 7.8) indicates thatEWR S8 carries the highest weight due to its high ecological importance and as it represents the KNP.

The weights are provided in the Table 7.8. The weight is based on the conversion of the PES and EIS to numerical values to determine the normalised weight.

Table 7.8 Sand River system: Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas (0 - 5)	Confidence	Normalised Weight
EWR S6	C	High	1	3.25	0.43
EWR S8	B	High	5	2.5	0.57

The weight is applied to the ranking value for each scenario at each EWR site and this provides an integrated score and ranking for the operational scenarios of the Sand River system. The ranking of '1' refers to the REC and the rest of the ranking illustrate the degree to which the scenarios meet the REC. The results are provided in Table 7.9 after the weights have been taken into account.

Table 7.9 Sand River system: Ranking value for each scenario resulting in an integrated score and ranking

EWR site	PES	REC	Sc S4	Sc S51	Sc S52	Sc S53	Sc S71	Sc S72	Sc S73
EWR S6	0.40	0.43	0.42	0.34	0.05	0.32	0.34	0.05	0.32
EWR S8	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.54	0.57
Score	**0.96**	**1**	**0.98**	**0.91**	**0.62**	**0.88**	**0.91**	**0.59**	**0.88**

The above results are plotted on a traffic diagram (Figure 7.6) to illustrate the integrated ecological ranking.

7.5.3 Sand River system: Conclusions

Scenario S52 and S72 are not viable options as a section of the Mutlumuvi River will change to a seasonal system. Scenario S4, although the best option, was recognised not to be a realistic option as the return flows associated with this scenario are too high. Scenario S51 and S53 also include these return flows. The remaining scenarios are Sc S71 and S73. Scenario S71 includes a full EWR release which will have a major impact on the yield. To further optimise, it is recommended that Sc S73 be further investigated.

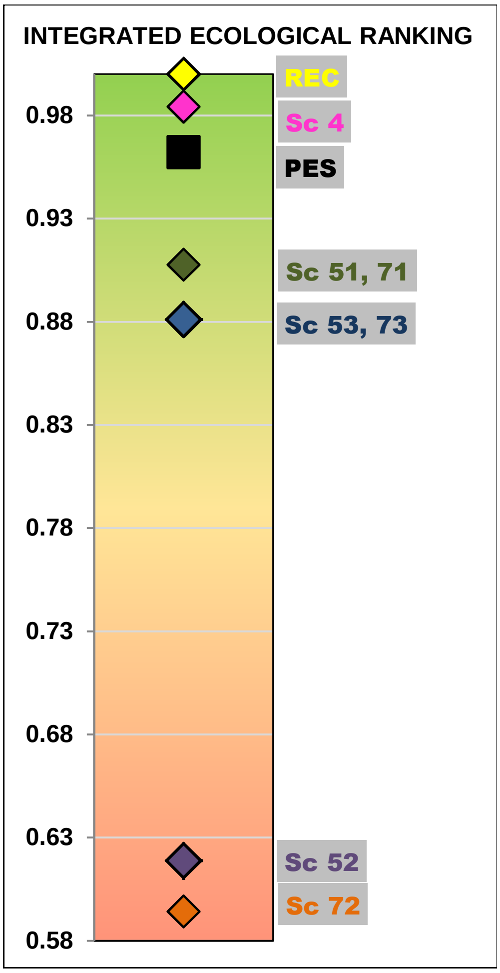


Figure 7.6 Sand River system: Integrated ecological ranking of the scenarios

8 ECOSYSTEM SERVICES SCENARIO CONSEQUENCES

This chapter is an extract from report: DWS (2014b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Operational Scenarios and recommended Water Resource Classes. Authored by Huggins G, Louw MD, Mallory S,Scherman S, Van Jaarsveld P and Van Rooyen P. DWS Report, RDM/WMA05/00/CON/CLA/0214. September 2014.

8.1 BACKGROUND

An analysis of EWR sites S3, S5, S6, and S8 in the Sabie and Sand River system and EWR sites C3, C4, C5, C6 and C7 in the Crocodile River system was undertaken. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. Evaluation was by means of weighted score with a normative value of 1.

8.2 CROCODILE RIVER SYSTEM

8.2.1 EWR C3 (Crocodile River)

This EWR site represents a river section that extends through a river valley with commercial agriculture/orchards noted along much of the river extent. Much of the agriculture is concentrated on the river banks. No concentrated settlements were noted, other than farm houses. Some tourism elements were observed. Given the nature of the river stretch, regulating and cultural services (largely as a result of associated tourism aspects) were given weights of 0.3. These were higher than the weights given to provisioning services and supporting services that were each given weights of 0.2 (Table 8.1).

For the purposes of the ecosystems services analysis, Scenarios C1 and C5 were deemed to have the same or indistinguishably similar impacts. Likewise Scenarios C2, C4, C62 and C72 were treated as the same as were Scenarios C71, C81 and C82. Scenarios C61 and C3 were evaluated separately.

Table 8.1 Crocodile River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR C3

Service	Sc C1, C5	Sc C2, C4, C62, C72	Sc C61	Sc C71, C81, C82	Sc C3	Weight
Provisioning services	1.04	1.01	1.04	0.98	1.00	0.2
Regulating services	1.18	1.18	1.19	1.20	1.18	0.3
Cultural services	1.03	1.07	1.07	1.07	1.03	0.3
Supporting services	1.00	1.00	1.00	1.00	1.00	0.2
Score	**1.07**	**1.08**	**1.09**	**1.08**	**1.06**	**1**

All scenarios had marginally positive impacts over present day. The reversal of flow associated with many of the scenarios has ecological consequences for the fish and indigenous riparian vegetation but this is counteracted by the positive impact for some alien tree species (important in terms of utilisation) and by the overall positive impact on WQ that would accompany the proposed riverine regime. For geomorphological impacts all flow scenarios represent minor to moderate changes from the present day conditions and no change in access to floodplains (for cultivation) relative to the present day conditions were expected. As such the overall positive impact of the regulating services was given a higher weight at this site and this largely counteracts some negative impact on indigenous species.

8.2.2 EWR C4 (Crocodile River)

At EWR C4 and environs the river section extends through a river gorge comprised of open/natural terrain. The township of Matsulu is situated in the lower reaches and as such there is a higher degree of dependence on provisioning services in this reach. Provisioning services were therefore given greater weight, at 0.4, for this site. All other services were given a weight of 0.2. In the scenario consideration Scenarios C1, C2, C3, C4, C61, C71, C81, and C82 were considered together and essentially had no impact and are the same as present day conditions. Scenarios C5, C62 and C72 are an improvement on present day conditions (Table 8.2).

Table 8.2 Crocodile River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR C4

Service	Sc C1, C2, C3, C4, C61, C71, C81, C82	Sc C5	Sc C62	Sc C72	Weight
Provisioning services	1.00	1.02	1.04	1.03	0.4
Regulating services	1.00	1.01	1.02	1.01	0.2
Cultural services	1.00	1.10	1.10	1.03	0.2
Supporting services	1.00	1.00	1.00	1.00	0.2
Score	**1.00**	**1.03**	**1.04**	**1.02**	**1**

Under Sc C5, C62 and C72 the regulating services were deemed to improve as were some cultural services associated with aesthetic benefits. For fish the *Barbus* species were seen to improve under Sc C5 and C62 and these, along with some improvement in sedges, reeds and riparian grazing were deemed to be of benefit to provisioning services. Ecosystem services under ScC5, C62 and C72 improve marginally.

8.2.3 EWR C5 (Crocodile River)

This EWR site is close to Malelane and essentially within the KNP. Given restriction in terms of access, provisioning services are constrained and as such had little influence on the final outcome. Cultural services were however deemed to be important as were regulating services, particularly with regard to downstream impacts and, to a lesser degree the supporting services. Scenario C3 was seen to be the same as present day conditions. Scenario C1 was seen as much the same as present day conditions, but with an improvement in WQ linked to regulating services. Scenarios C2, C4, C61, C71 and C81 were treated as the same with an improvement in present day conditions. Scenario C5, C62 and C72 were treated as generally the same as present day conditions with some slight deterioration in all components bar the geomorphology, which remains stable. Scenario C82 was seen as largely the same as ScenarioC2 with some very minor variation in terms of invertebrate health. Although the scenario was examined as a separate entity the results were virtually identical to Scenario S2. The results are presented in Table 8.3.

Table 8.3 Crocodile River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR C5

Service	Sc C3	Sc C1	Sc C2, C4, C61, C71, C81	Sc C5, C62, C72	Sc C82	Weight
Provisioning services	1	0.90	0.91	0.89	0.91	0.05
Regulating services	1	1.00	1.19	0.94	1.17	0.3
Cultural services	1	0.93	1.08	0.93	1.08	0.4

Service	Sc C3	Sc C1	Sc C2, C4, C61, C71, C81	Sc C5, C62, C72	Sc C82	Weight
Supporting services	1	1.00	1.00	1.00	1.00	0.25
Score	**1**	**0.97**	**1.08**	**0.95**	**1.08**	**1**

Scenario C1, C5, C62 and C72 resulted in a negative impact for ecosystem services. This is largely related to the negative consequences for the regulating services and cultural services. The other scenarios were largely positive and again this is largely related to the regulating services showing a degree of overall improvement.

8.2.4 EWR C6 (Crocodile River)

The north bank of the river section is the KNP. As with EWR C5 this limits the use of some provisioning services, particularly fishing. The south bank is comprised of commercial agriculture but no major settlements are noted proximate to the stretch. Some tourism/recreational features were noted and obviously the KNP is a major tourism destination. As such the cultural services are given a greater weight at this site.

At EWR C6, Sc C4, C61, C71 and C81 are essentially the same as present day, Sc C1 is lower than present day with some deterioration in WQ and the presence of fish.

Scenario C2 is an improvement from present day conditions with some positive consequences for WQ, fish, and riparian vegetation. Scenario C3, C62 and C82 largely maintains present day conditions with some slight deterioration in WQ and fish, with some riparian vegetation improving. Scenario C5 and C72 do not achieve present day conditions and there is some deterioration in all components. The results are provided in Table 8.4.

Table 8.4 Crocodile River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR C6

Service	Sc C4, C61, C71, C81	Sc 1	Sc C5, C72	Sc C3, C62, C82	Sc C2	Weight
Provisioning services	1.00	1.00	1.00	1.01	1.01	0.05
Regulating services	1.00	0.97	0.81	1.04	1.19	0.3
Cultural services	1.00	0.93	0.93	0.93	1.00	0.4
Supporting services	1.00	1.00	1.00	1.00	1.00	0.25
Score	**1.00**	**0.96**	**0.91**	**0.98**	**1.06**	**1**

Overall Sc C1, along with C5, C72, C3, C62 and C82 show marginal decreases in the ecosystems services. For the most part this is driven by the decline in regulating services; particularly those associated with WQ as well as anticipated negative impacts on cultural services allied to the aesthetic appeal of ecotourism associated with the KNP. Scenario C2 shows some improvement.

8.2.5 EWR C7 (Kaap River)

The river section is comprised of commercial agriculture and open terrain. No denser settlement of consequence was noted some recreational/tourism facilities (lodges) were noted. For this site regulating services were given the highest weighting of 0.35 (Table 8.5) followed by cultural services (0.25) and the provisioning services and supporting services (0.20). Scenario C1, C5, and C82 were assessed together. They do not maintain the present state and most components associated with the ecosystem services were likely to show deterioration. Geomorphology and the riparian vegetation were the exceptions. Scenario C2 and C4 was assessed together and they largely maintain the present day conditions but with some slight improvement in fish. Scenario C3, C61, C71, C72, and C81 were considered together and see some deterioration in all components except geomorphology and riparian vegetation that remain largely stable. Scenario C62 was considered on its own. It does not maintain present conditions and there is deterioration in all components.

Table 8.5 Crocodile River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR C7

Service	Sc C62	Sc C81,C3, C61, C71, C72, C82	Sc C1, C5, C82	Sc C2, C4	Weight
Provisioning services	0.87	0.97	0.95	1.03	0.2
Regulating services	0.53	0.82	0.765	1.12	0.35
Cultural services	1	0.85	0.85	1	0.25
Supporting services	1	1	1	1	0.2
Score	**0.81**	**0.89**	**0.87**	**1.05**	**1**

Scenario C62 showed a fairly substantial deterioration over present day conditions. Regulating services, driven by WQ aspects is the key driver here. Scenario C1, C5, C82 and also C3, C61, C71, C72, C81 showed negative declines. Again regulating services, but also cultural services were determining factors. Scenario C2 and C4 showed an overall marginal improvement.

8.3 SABIE RIVER SYSTEM

8.3.1 EWR 3 (Sabie River)

This EWR site falls within the KNP. Given the nature of the site the cultural services, representing the recreational and aesthetic value associated with the Park is given the highest weighting at 0.4. Regulating services are given a weighting of 0.3 while supporting services are given a weighting of 0.2. As there is no legal access to provisioning services in the park these are given the lowest weighting at 0.1.

Scenarios that were evaluated include Sc S1 and S31 that were treated as equivalent in terms of impact on ecosystems services as well as Sc S32. The results are presented in Table 8.6.

Table 8.6 Sabie River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR S3

Service	Sc S1	Sc S31	Sc S32	Weight
Provisioning services	0.99	0.99	0.99	0.1
Regulating services	0.89	1.10	0.89	0.3
Cultural services	0.80	0.97	0.80	0.4
Supporting services	1.05	1.00	1.05	0.2
Score	**0.90**	**1.02**	**0.90**	**1**

Scenario S1 had an overall negative impact and is mainly related to lower flows having a negative impact on the condition of the river and its aesthetic appeal as well as on the ability of the river to deal with WQ issues. Scenario S32 has very similar negative impact. Scenario S31 on the other hand was marginally positive. The positive impact is related largely to the improved conditions for regulating services linked to WQ.

8.3.2 EWR S5 (Sabie River)

The upper section of river represented by this EWR site passes the Marite A Township and Hazyview town. The remaining river extent comprised of open terrain and farmland.The EWR site itself is located in farmland. Given the nature of the site the provisioning services were given a much higher weight, at 0.4, than at EWR S3. Cultural services were given the second highest weight at 0.25, followed by regulating services at 0.2 and supporting services at 0.15.

As with EWR S3 scenarios that were evaluated include S1, S31 and S32. The results are presented in Table 8.7.

Table 8.7 Sabie River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR S5

Service	Sc S1	Sc S31	Sc S32	Weight
Provisioning services	0.98	1.02	0.98	0.40
Regulating services	0.85	1.02	0.78	0.20
Cultural services	0.93	1.00	0.80	0.25
Supporting services	1.05	1.00	1.05	0.15
Score	**0.95**	**1.01**	**0.90**	**1.00**

Scenario S32 was associated with the largest negative impact in the set. This relates largely to the impact on regulating services and associated decline in WQ decline as well as potential increase in pathogens. The potential negative impact on cultural services contributed to overall to the negative score. Provisioning services were likely to remain relatively unchanged bar some negative impact on some of the fish species. Scenario S1 had much the same impact as Scenario S32 although not as severe. Scenario S31 were deemed to be moderately positive.

8.4 SAND RIVER SYSTEM

8.4.1 EWR S6 (Mutlumuvi River)

The EWR site is in a Mutlumuvi River reach that includes dense settlement associated with Orinoco and New Forest townships in the upper third of the reach. The middle third is given over to agriculture. Included in agriculture is high value greenhouse/tunnel development. The lower third is also made up of dense urban development of Thulamahase. Given the nature of the site the provisioning services were given a much higher weight, at 0.4, than at EWR S3 (Sabie River) (Table 8.8). Cultural services were given the second highest weight at 0.25, followed by regulating services at 0.2 and supporting services at 0.15.

For this site four scenarios were evaluated separately and include Scenarios S1, S4, S51 and S53 (Table 8.8).

Table 8.8 Sand River system: Ranking value for each scenario resulting in an integrated score and ranking for EcoSystem Services at EWR S6

Service	Sc S1	Sc S4	Sc S51	Sc S53	Weight
Provisioning services	1.06	1.05	0.96	0.93	0.4
Regulating services	1.04	1.04	0.87	0.86	0.2
Cultural services	1.00	1.00	1.00	1.00	0.25
Supporting services	1.00	1.00	1.00	1.05	0.15

Service	Sc S1	Sc S4	Sc S51	Sc S53	Weight
Score	**1.03**	**1.03**	**0.96**	**0.95**	**1**

Scenarios S1 and S4 had marginal positive impacts. These were associated with the provisioning services with both fish and riparian vegetation being deemed to react positively overall. Likewise Scenarios S51 and S53 were seen to be marginally negative. Here provisioning services with both fish and riparian vegetation being deemed to react negatively overall.

8.4.2 EWR S8 (Sand River)

This EWR site is situated in the KNP. All scenarios were examined as a single scenario. Provisioning services are not present as the site has restricted access being in the Park. Likewise supporting services providing access to utilised resources were also not present. All scenarios resulted in a positive score of 1.15.

9 ECONOMIC SCENARIO CONSEQUENCES

This chapter is an extract from report: DWS (2014b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Operational Scenarios and recommended Water Resource Classes. Authored by Huggins G, Louw MD, Mallory S, Scherman S, Van Jaarsveld P and Van Rooyen P. DWS Report, RDM/WMA05/00/CON/CLA/0214. September 2014.

9.1 BACKGROUND

The results of different scenarios of each catchment as it impacted on the different economic sectors are presented in this Chapter. The impact on Gross Domestic Product (GDP) and then on labour is provided to produce a final integrated in the final result.

9.2 KOMATI RIVER SYSTEM: GDP RESULTS

In Table 9.1 the GDP results of the different scenarios of the Komati River system are presented.

Table 9.1 Komati River system: GDP created per scenario and percentage change if compared with the Baseline (2013 prices)

Scenario	GDP (Rand Million)	Percentage change from baseline	Ranking
Baseline	R 3 592		
K42	R 3 678	2,3%	1
K43	R 3 642	1,4%	2
K32	R 3 628	1,0%	3
K 6	R 3 612	0,6%	4
K41	R 3 593	0,0%	5
K2	R 3 575	-0,5%	6
K31	R 3 562	-0,8%	7
K5	R 3 531	-1,7%	8

Table 9.1 indicates that Sc K2, K31 and K5 have a negative impact on GDP of which Sc K5 has the largest negative impact when compared to the baseline. Figure 9.1 and Figure 9.2 highlight the results.

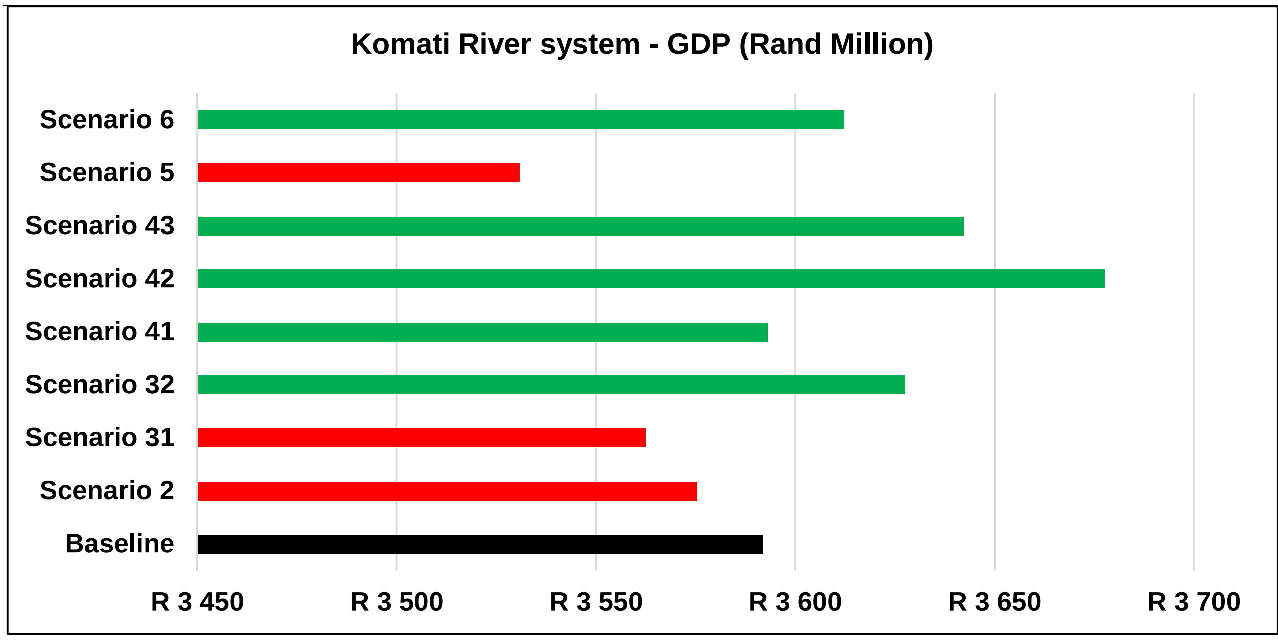


Figure 9.1 Komati River system: The GDP created by each scenario

The comparative change of the impact of each of the scenarios when compared with the baseline is presented in Figure 9.2.

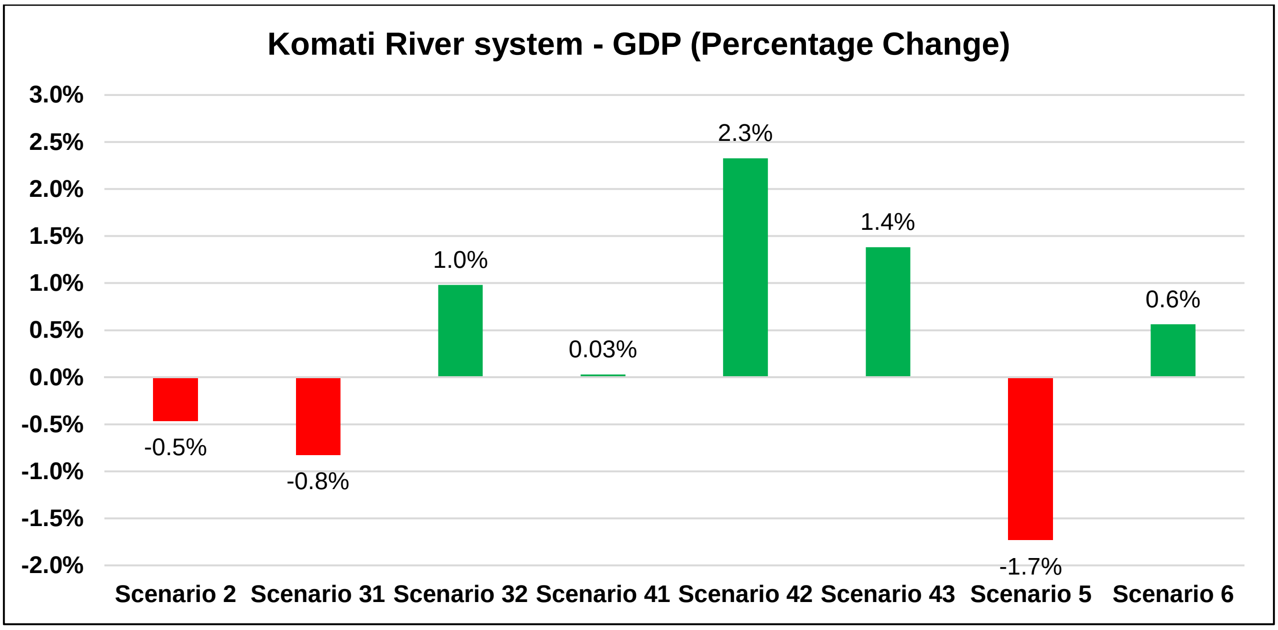


Figure 9.2 Komati River system: Comparative percentage of the impact of each scenario with the Baseline

Figure 9.1 and Figure 9.2 show that Sc K5 will have the severest negative impact followed by Sc K31 and K2. Scenario K32, K41, K42, K43 and K6 will increase the GDP of the Komati River system.

9.3 CROCODILE RIVER SYSTEM: GDP RESULTS

Table 9.2 provides the GDP results of the different scenarios of the Crocodile River system.

Table 9.2 Crocodile River system: GDP created per scenario and percentage change if compared with the Baseline (2013 prices)

Scenario	GDP (Rand Million)	Percentage change from baseline	Ranking
Baseline	R 4 522		
C72	R 5 041	10,3%	1
C5	R 4 626	2,2%	2
C82	R 4 513	-0,2%	3
C62	R 4 384	-3,1%	4
C3	R 4 235	-6,8%	5
C81	R 4 069	-11,2%	6
C61	R 3 988	-13,4%	7
C71	R 3 729	-21,3%	8
C2	R 3 699	-22,3%	9
C4	R 3 656	-23,7%	10

Table 9.2 indicates that all the scenarios except Sc C72 and C5 have a negative impact on GDP with Sc C4 having the largest negative impact when compared to the baseline. Figure 9.3 and Figure 9.4 highlight the results.

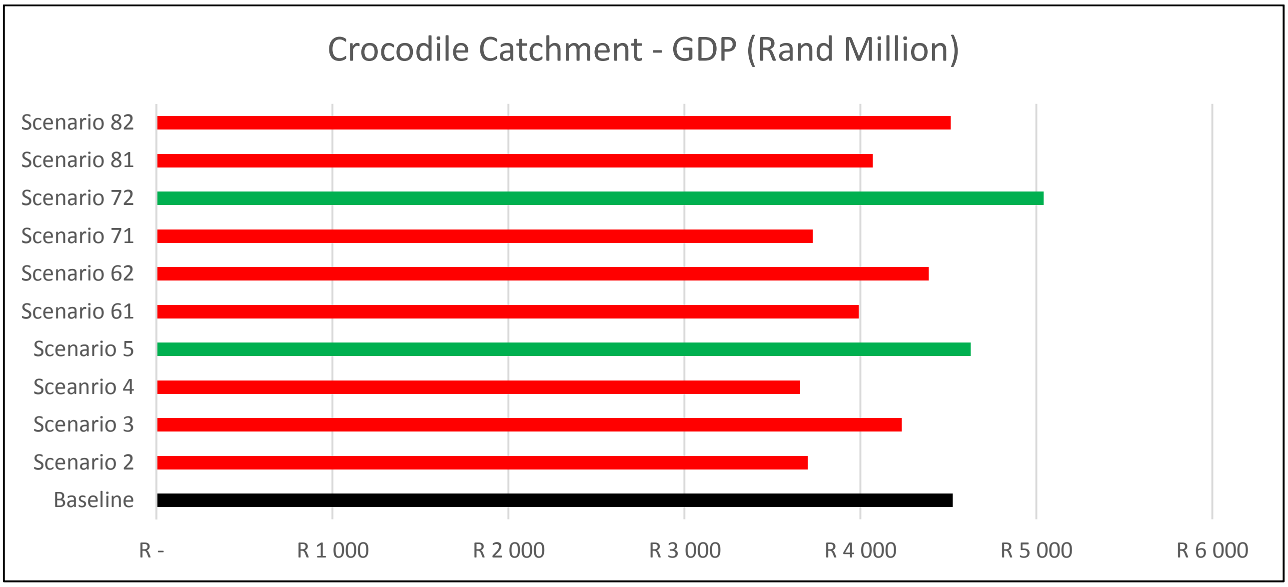


Figure 9.3 Crocodile River system: The GDP created by each scenario

The comparative change of the impact of each of the scenarios when compared with the baseline is presented in Figure 9.4.

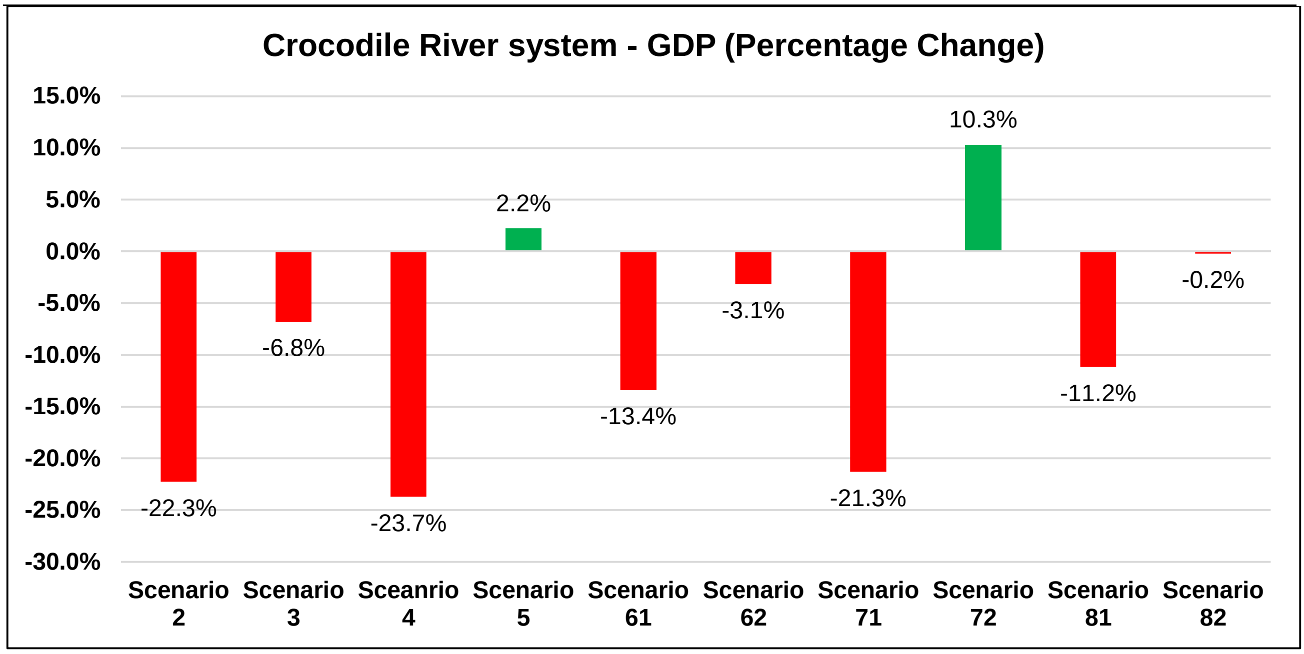


Figure 9.4 Crocodile River system: Comparative percentage of the impact of each scenario with the baseline

Figure 9.3 and Figure 9.4 show that Sc C4 will have the severest negative impact followed by Sc C2, C71 and C61. Scenario C5 and C71 will increase the GDP of the Crocodile River system.

9.4 SABIE RIVER SYSTEM: GDP RESULTS

In Table 9.3 the GDP results of the different scenarios of the Sabie River system are presented.

Table 9.3 Sabie River system: GDP created per scenario and percentage change if compared with the baseline (2013 prices)

Scenario	GDP (Rand Million)	Percentage change from baseline	Ranking
Baseline	R 1 314		
S32	R 12976	1,9%	1
S6	R 12650	-0,9%	2
S2	R 12600	-1,29%	3
S31	R 12250	-4,2%	4

Table 9.3 indicates that Sc S2, S31 and S6 have a negative impact on GDP with Sc S31 having the largest negative impact when compared to the baseline. Figure 9.5 and Figure 9.6 highlight the results.

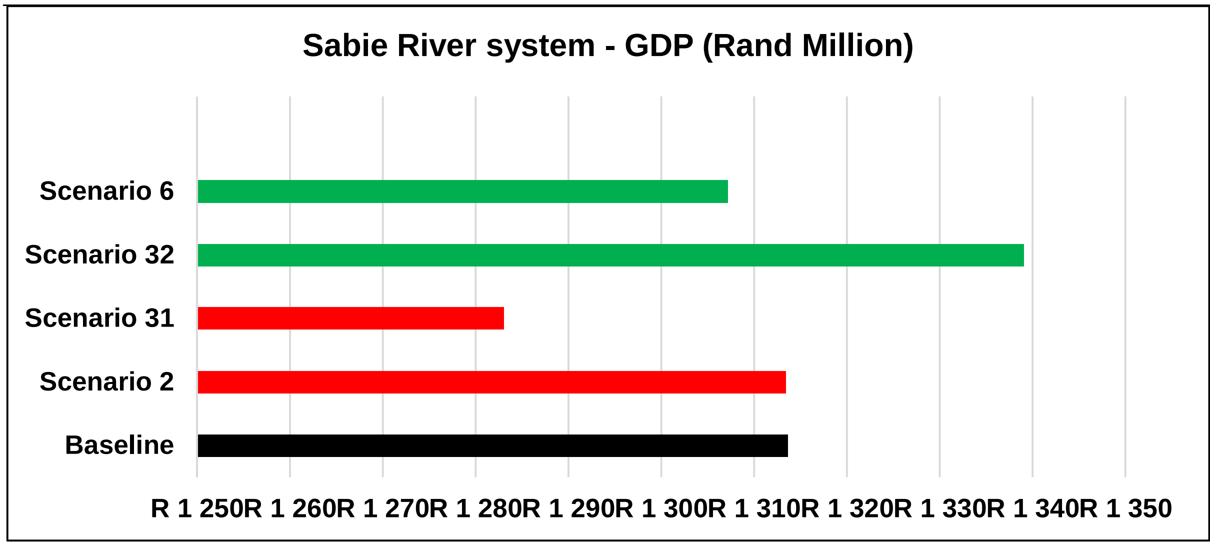


Figure 9.5 Sabie River system: The GDP created by each scenario

The comparative change of the impact of each of the scenarios when compared with the baseline is presented in Figure 9.6.

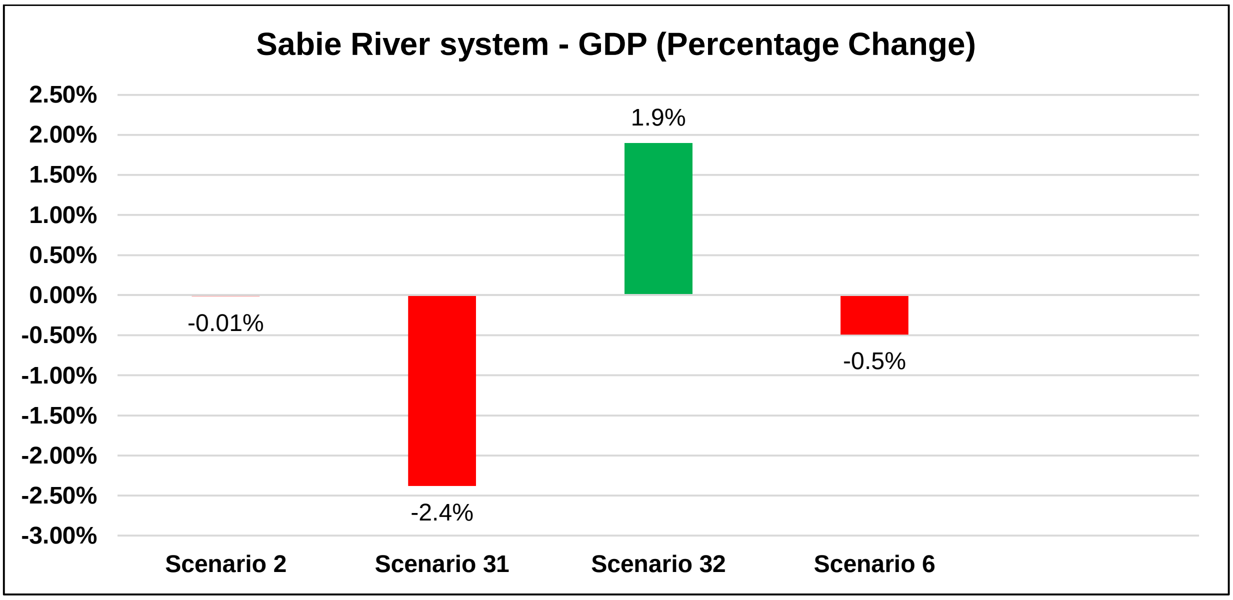


Figure 9.6 Sabie River system: Comparative percentage of the impact of each scenario with the Baseline

Figure 9.5 and Figure 9.6 show that Sc Sc31 will have the severest negative impact followed by Sc S6. Scenario S32 will increase the GDP of the Sabie River system.

9.5 SAND RIVER SYSTEM: GDP RESULTS

Table 9.4presents the GDP results of the different scenarios of the Sand River system.

Table 9.4 Sand River system: GDP created per scenario and percentage change if compared with the Baseline (2013 prices)

Scenario	GDP (Rand Million)	Percentage change from baseline	Ranking
Baseline	R 194		
S52	R 244	20,4%	1
S53	R 238	18,6%	2
S51	R 238	18,5%	3
S72	R 235	17,3%	4
S71	R 223	13,0%	5
S73	R 220	11,9%	6
S80	R 208	6,8%	7

Table 9.4 indicates that all scenarios will have a positive impact on GDP with Sc S52 having the largest positive impact when compared to the baseline. Figure 4.7 and Figure 4.8 highlight the results.

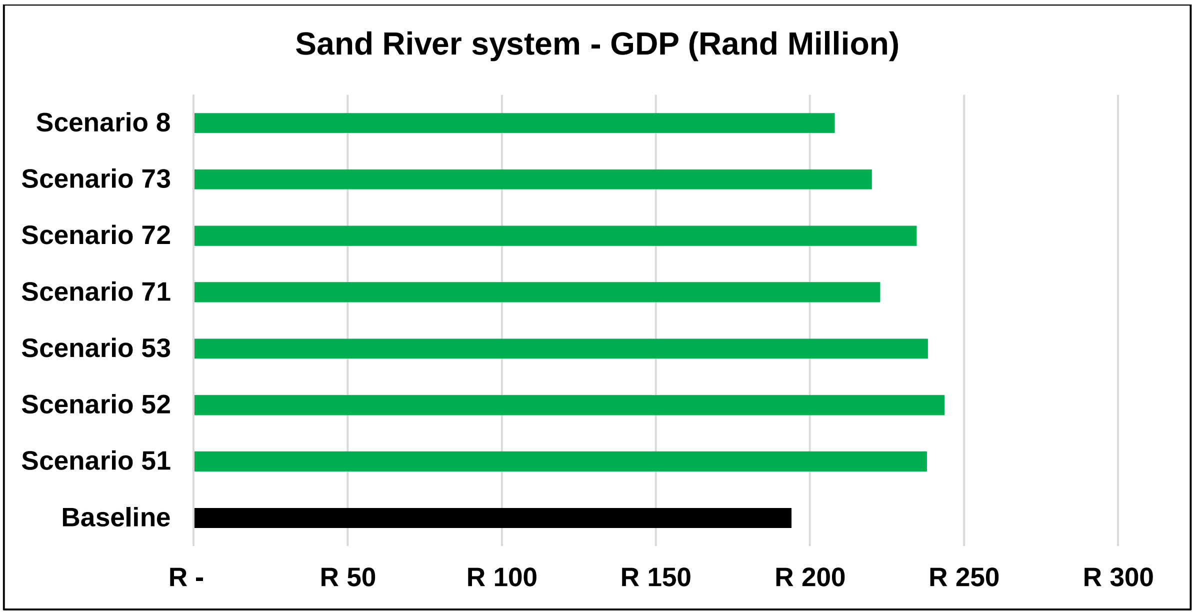


Figure 9.7 Sand River system: The GDP created by each Scenario

The comparative change of the impact of each of the scenarios when compared with the baseline is presented in Figure 9.8.

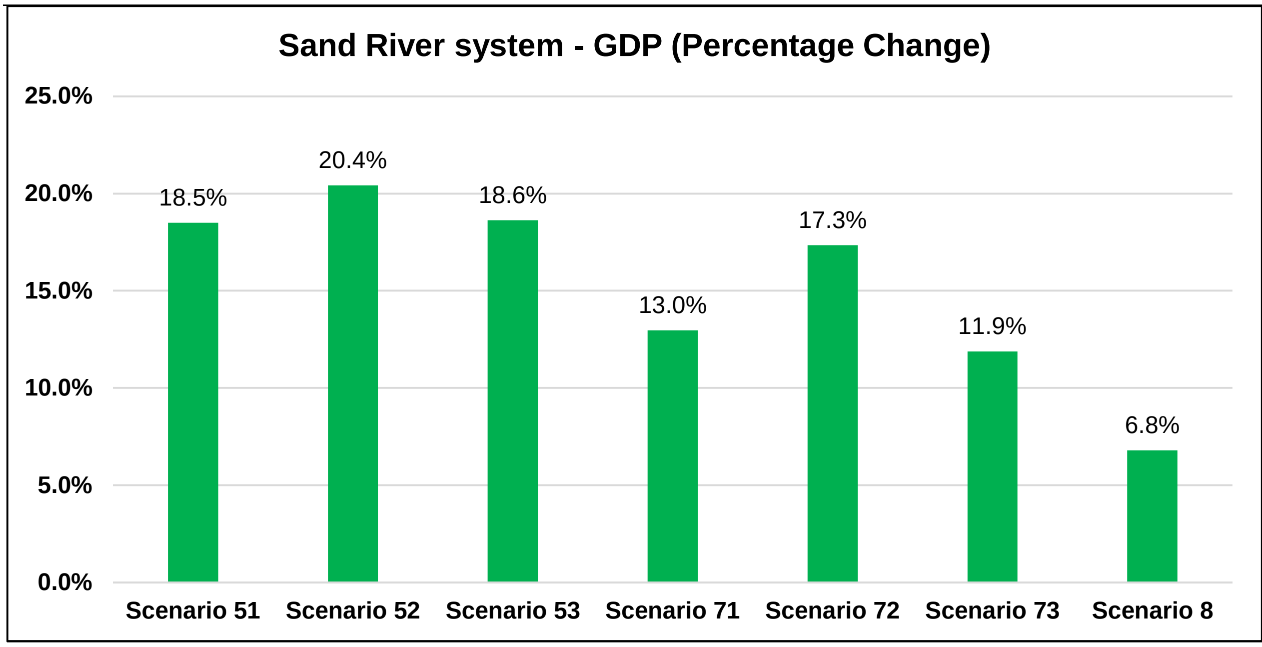


Figure 9.8 Comparative percentage of the impact of each scenario with the Baseline

Figure 9.7 and Figure 9.8 show that Sc S52 will have the largest economic impact in the Sand River system followed by Sc S53.

9.6 EMPLOYMENT

9.6.1 Komati River system: Employment results

In Table 9.5 the impact on employment for the different scenarios in the Komati River system are compared with the baseline.

Table 9.5 Komati River system: Employment and projected job gains or losses per Scenario

Scenario	Employment	Job Creation/Losses	Deviation from Baseline	Ranking
Baseline	19 318			
K6	20690	1372	6,6%	1
K42	19642	324	1,6%	2
K43	19531	213	1,1%	3
K32	19402	84	0,4%	4
K5	19269	-49	-0,3%	5
K2	19155	-164	-0,9%	6
K41	18 945	-373	-2,0%	7
K31	18 860	-458	-2,4%	8

Table 9.5 shows that Sc K43, K6, K42, and K32 will be beneficial for employment creation while K41 and K31 will potentially have the largest negative impact.

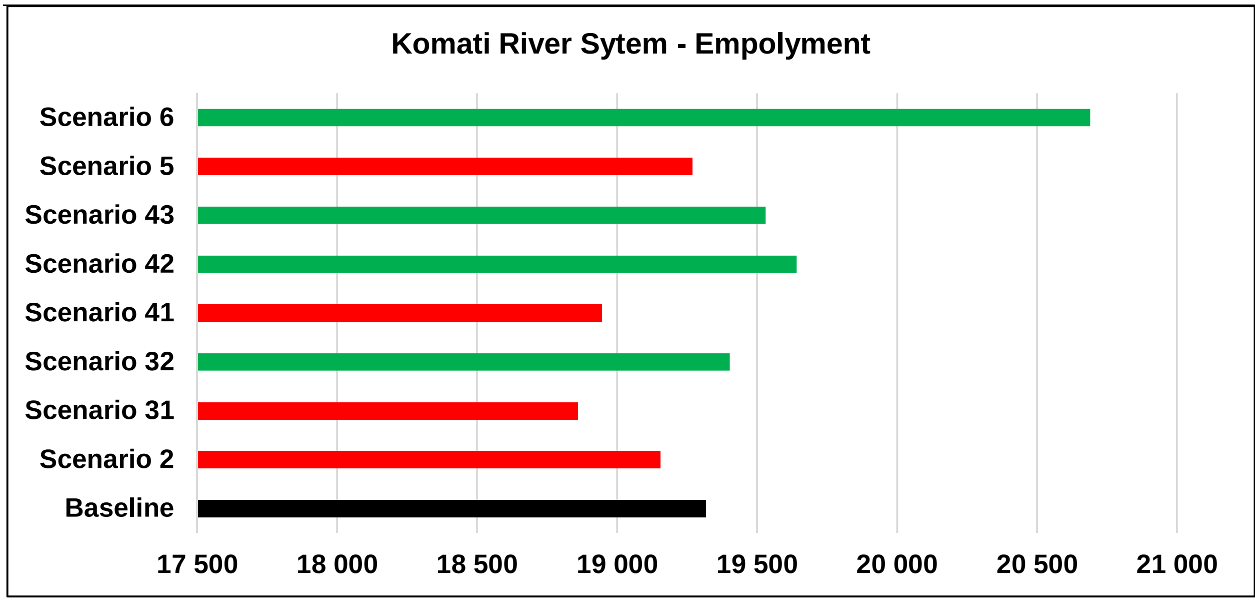


Figure 9.9 Komati River system: Employment deviation from Baseline as percentage

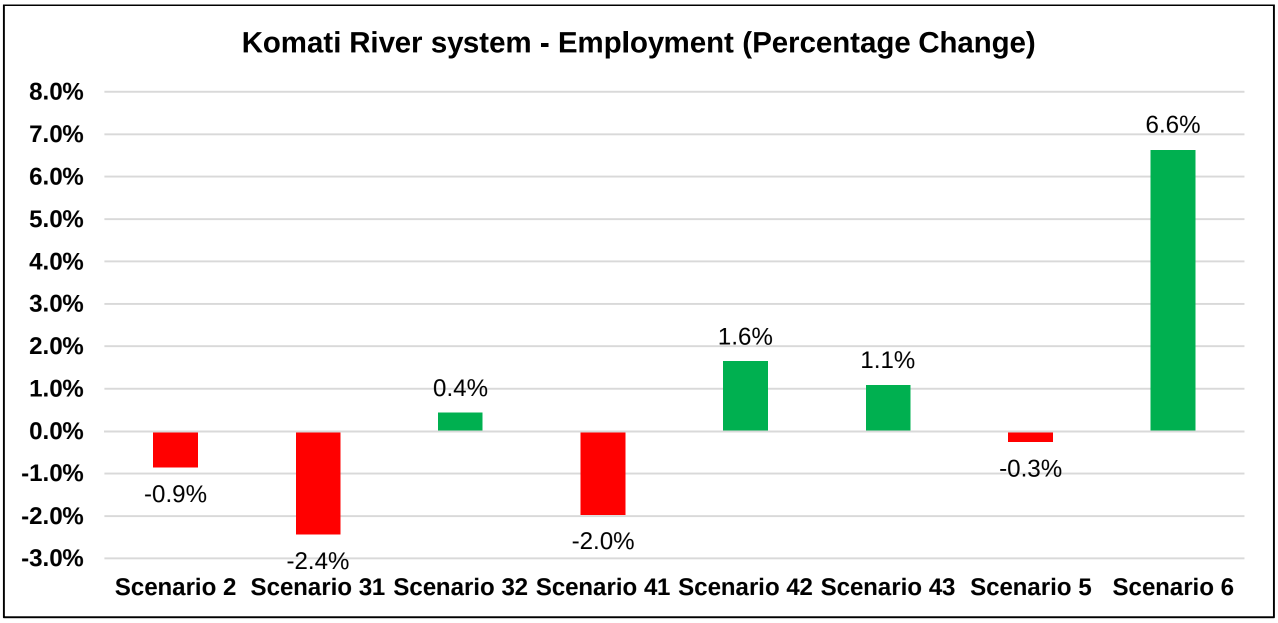


Figure 9.10 Komati River system:Employment deviation from Baseline as percentage

Figure 9.10 illustrates the deviation from the baseline in terms of percentage and very clearly shows that Sc K2, K31 and K41 can have a negative impact on employment in the Komati River system.

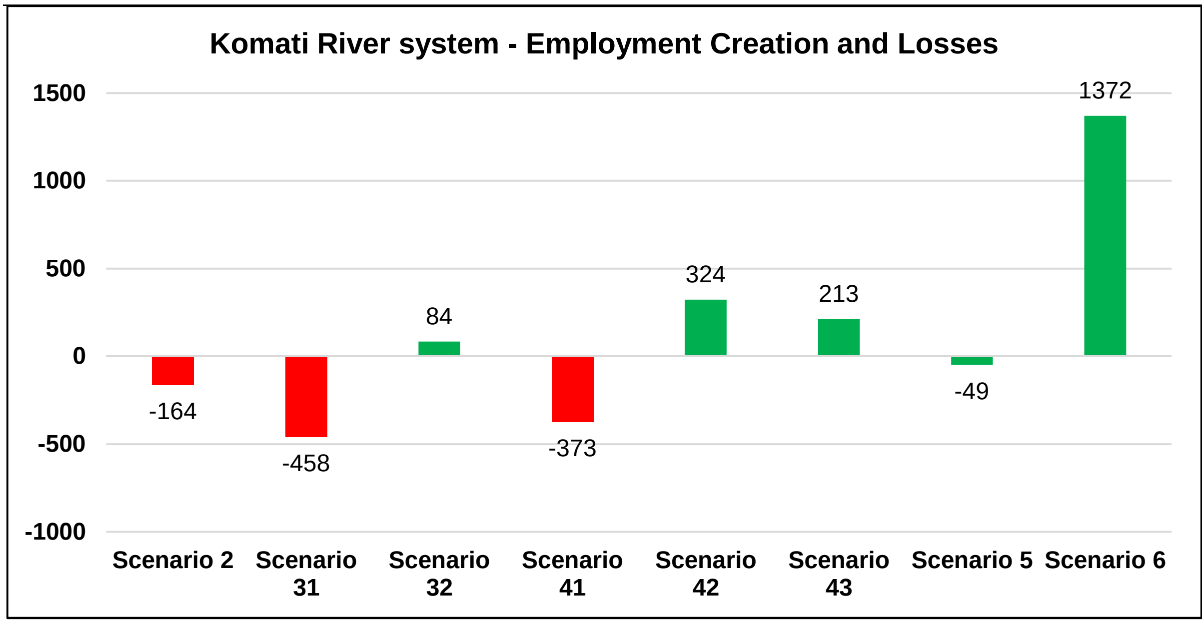


Figure 9.11 Komati River system: Employment creation and job losses numbers

Figure 9.11 illustrates the number of job losses and job created by each of the scenarios in the Komati River system. Scenario K6 will create the most jobs while Sc K31 will result in the most job losses.

9.6.2 Crocodile River system: Employment Results

Table 9.6 presents the impact on employment for the different scenarios in the Crocodile River system compared with the baseline.

Table 9.6 Crocodile River system: Employment and projected job gains or losses per Scenario

Scenario	Employment	Job Creation/Losses	Deviation from Baseline	Ranking
Baseline	35 197			
C72	38167	2970	7,8%	1
C82	36475	1278	3,5%	2
C5	36377	1180	3,2%	3
C62	34653	-544	-1,6%	4
C3	33167	-2031	-6,1%	5
C81	33294	-1903	-5,7%	6
C61	31888	-3309	-10,4%	7
C71	30772	-4425	-14,4%	8
C2	29473	-5724	-19,4%	9
C4	29206	-5991	-20,5%	10

Table 9.6 shows that Sc C72, C82 and C5 will be beneficial for employment creation while Sc C2 and C4 potentially having the largest negative impact.

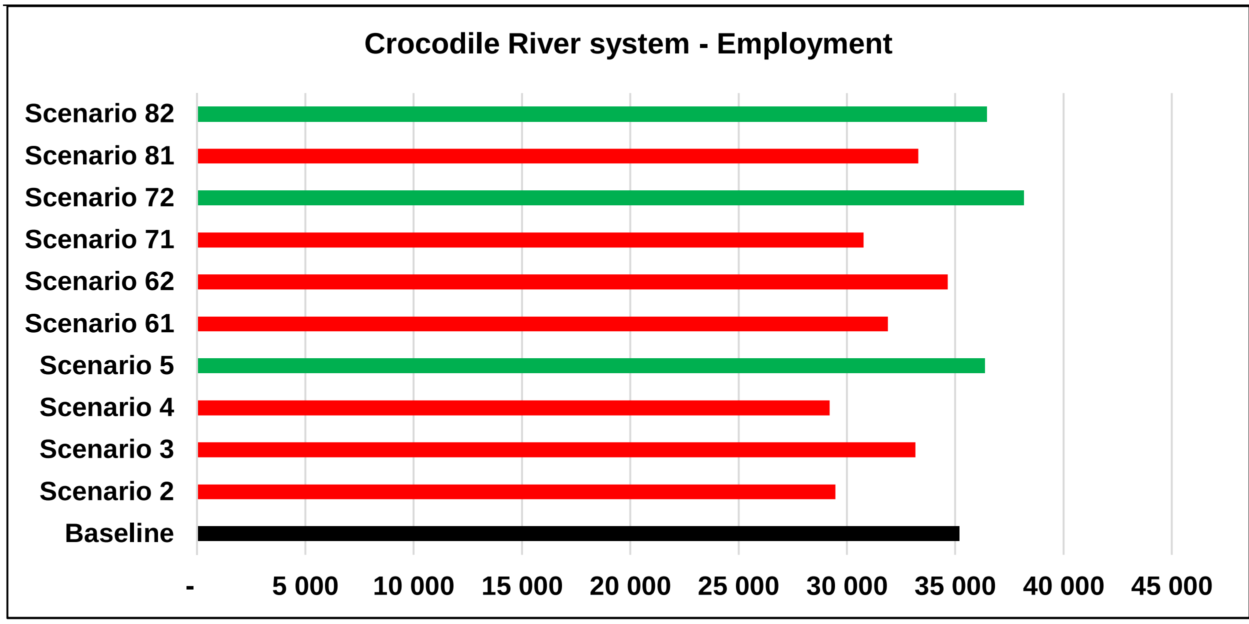


Figure 9.12 Crocodile River system: Employment deviation from Baseline as percentage

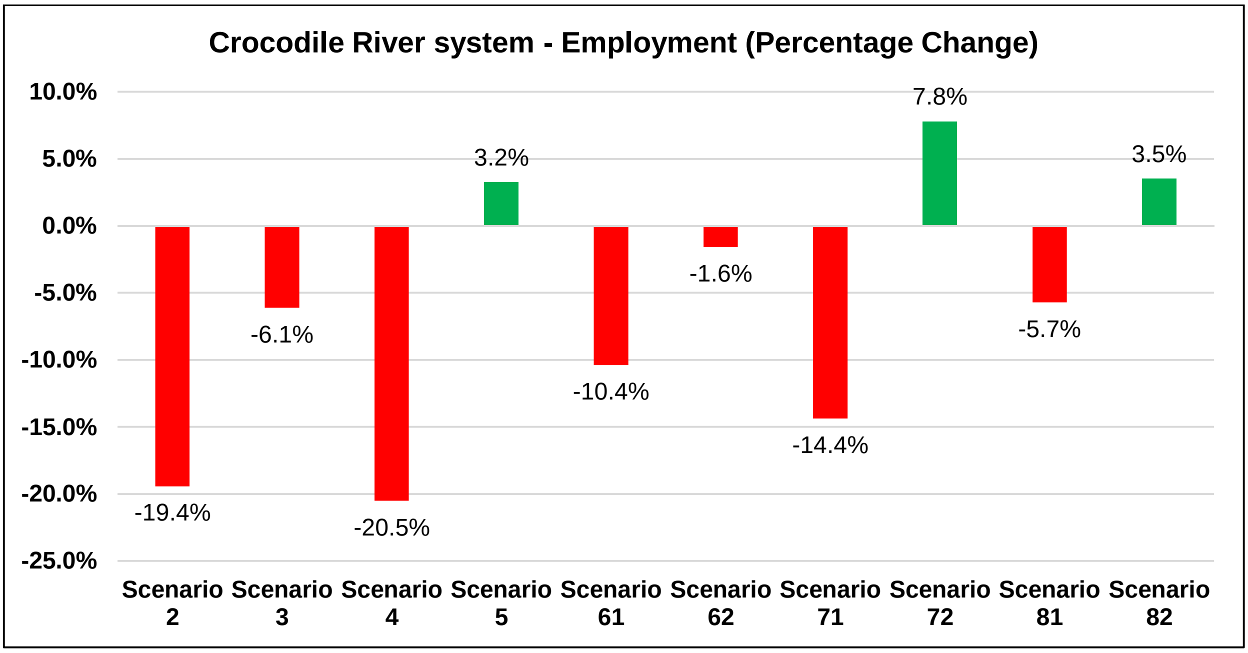


Figure 9.13 Crocodile River system: Employment deviation from Baseline as percentage

Figure 9.13 illustrates the deviation from the baseline in terms of percentage and very clearly shows that Sc C2, C3, C4, C61, C71 and C81 can have a very negative impact on employment in the Crocodile River system.

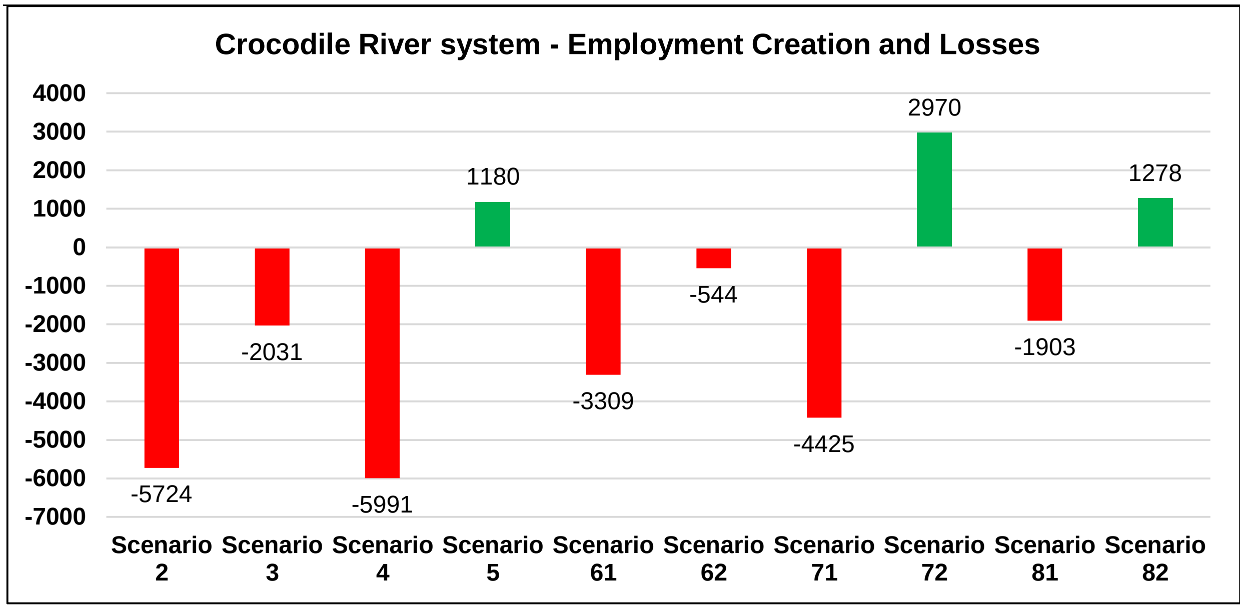


Figure 9.14 Crocodile River system: Employment creation and job losses numbers

Figure 9.14 illustrates the number of job losses and job created by each of the scenarios in the Crocodile River system. Scenario C72 will create the most jobs while Sc C4 will result in the most job losses.

9.6.3 Sabie River system: Employment Results

In Table 9.7 the impact on employment for the different scenarios in the Sabie River system are compared with the baseline.

Table 9.7 Sabie River system: Employment created and projected job gains or losses per Scenario

Scenario	Employment	Job Creation/Losses	Deviation from Baseline	Ranking
Baseline	12762			
S32	12976	215	1,7%	1
S6	12650	-112	-0,9%	2
S2	12600	-162	-1,29%	3
S31	12250	-511	-4,2%	4

Table 9.7 shows that Sc S32 will be beneficial for employment creation while Sc S2 and S31 potentially having the largest negative impact.

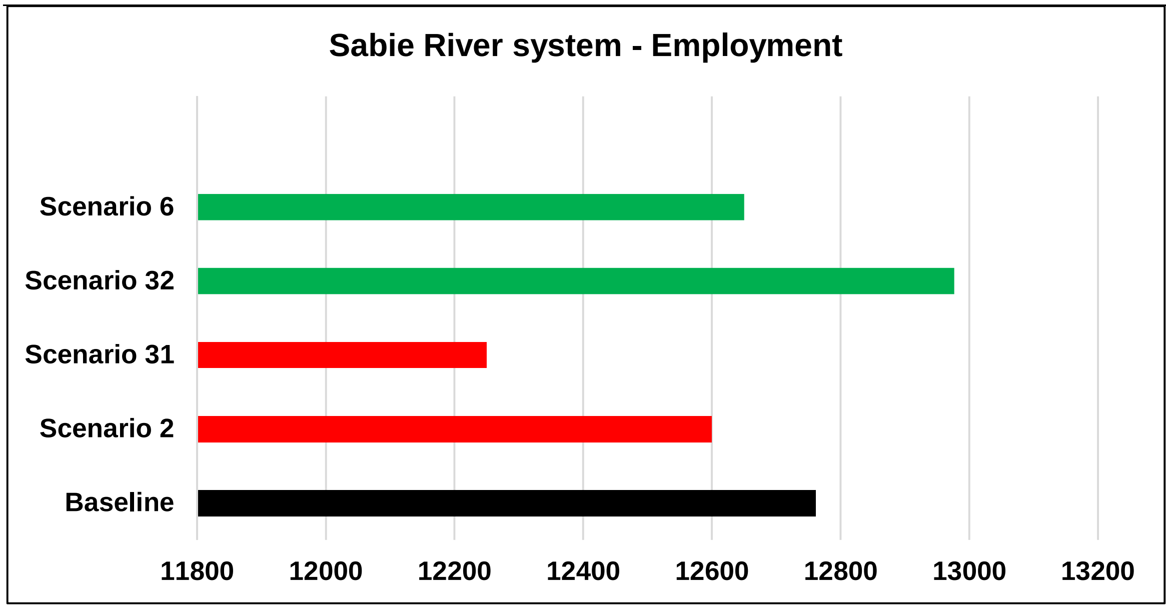


Figure 9.15 Sabie River system: Employment deviation from Baseline as percentage

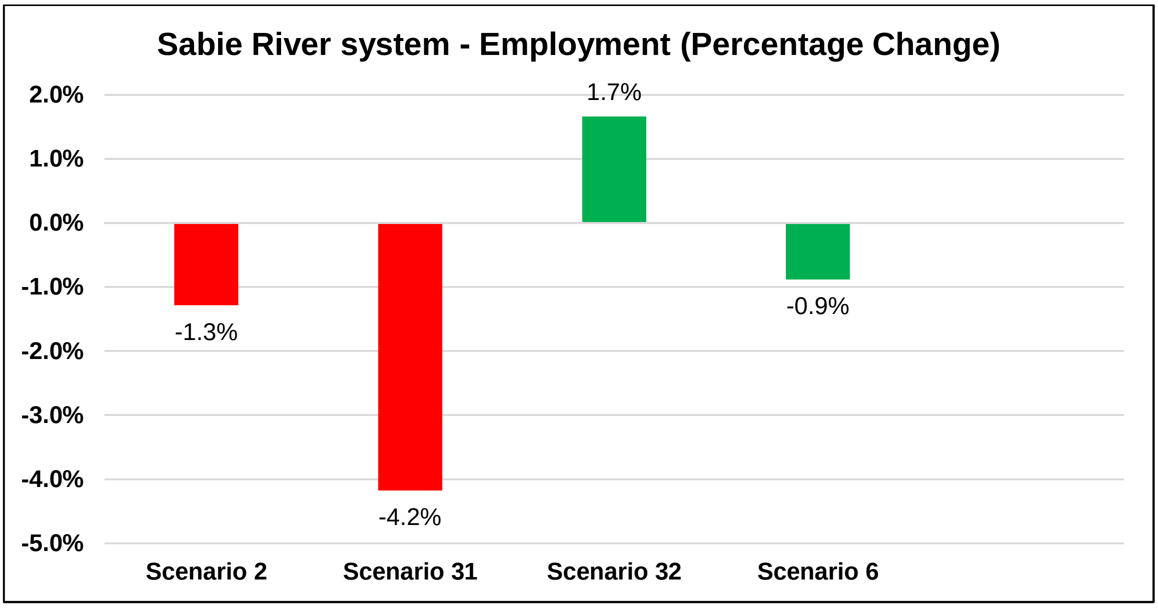


Figure 9.16 Sabie River system: Employment deviation from Baseline as percentage

Figure 9.16 illustrates the deviation from the baseline in terms of percentage and very clearly shows that Sc S2, S31 and S6 can have a negative impact on employment in the Sabie River system.

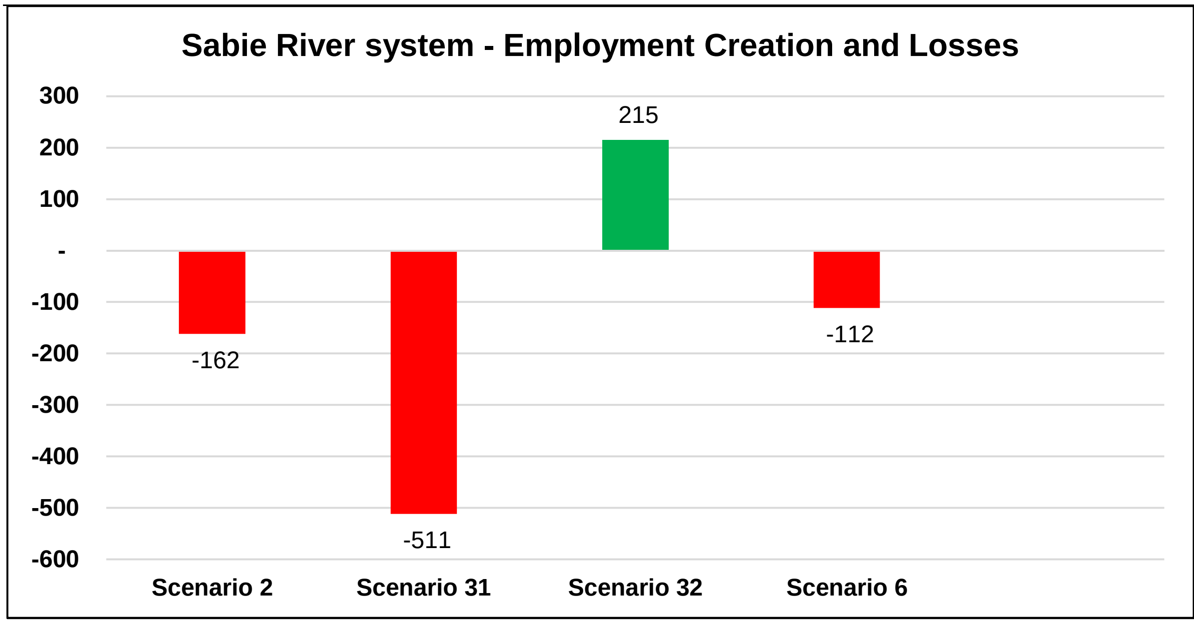


Figure 9.17 Sabie River system: Employment creation and job losses

Figure 9.17 illustrates the number of job losses and job created by each of the scenarios in the Sabie catchment. Scenario S32 will create the most jobs while Sc S31 will result in the most job losses.

9.6.4 Sand River system: Employment Results

In Table 9.8 the impact on employment for the different scenarios in the Sand River system are compared with the baseline.

Table 9.8 Sand River system: Employment and projected job gains per scenario

Scenario	Employment	Job Creation	Deviation from Baseline	Ranking
Baseline	1 789			
Scenario 52	2598	809	31,1%	1
Scenario 53	2548	759	29,8%	2
Scenario 51	2545	756	29,7%	3
Scenario 72	2514	725	28,9%	4
Scenario 71	2405	617	25,6%	5
Scenario 73	2380	591	24,8%	6
Scenario 80	1919	130	6,8%	7

Table 9.8 shows that all the scenarios will be beneficial for employment creation in the Sand River system.

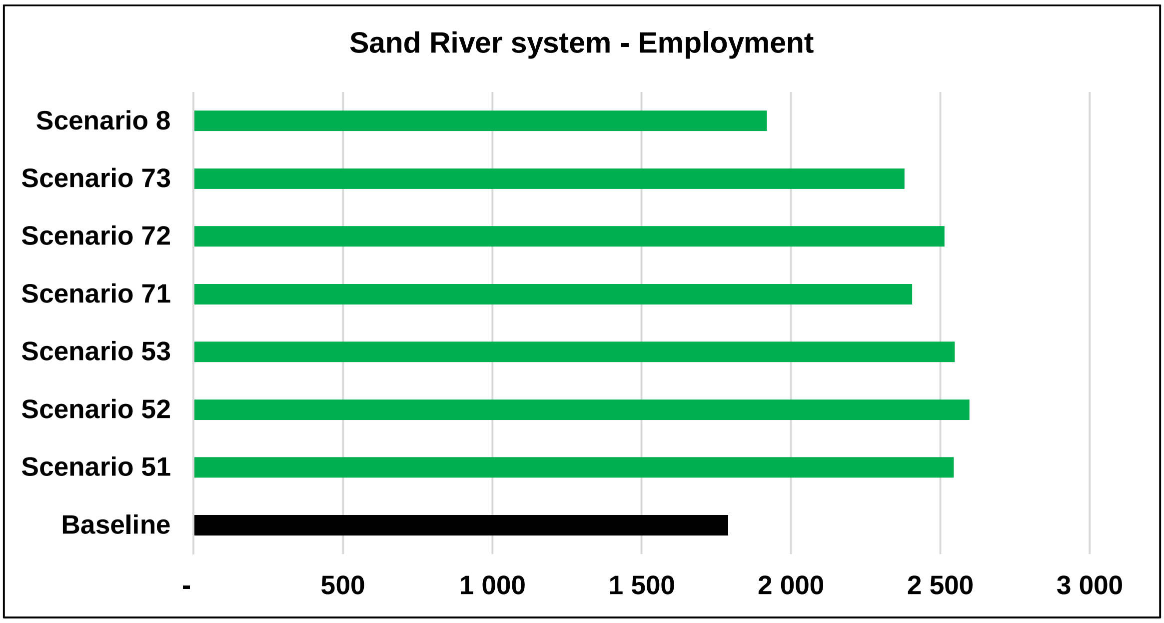


Figure 9.18 Sand River system: Employment deviation from Baseline as percentage

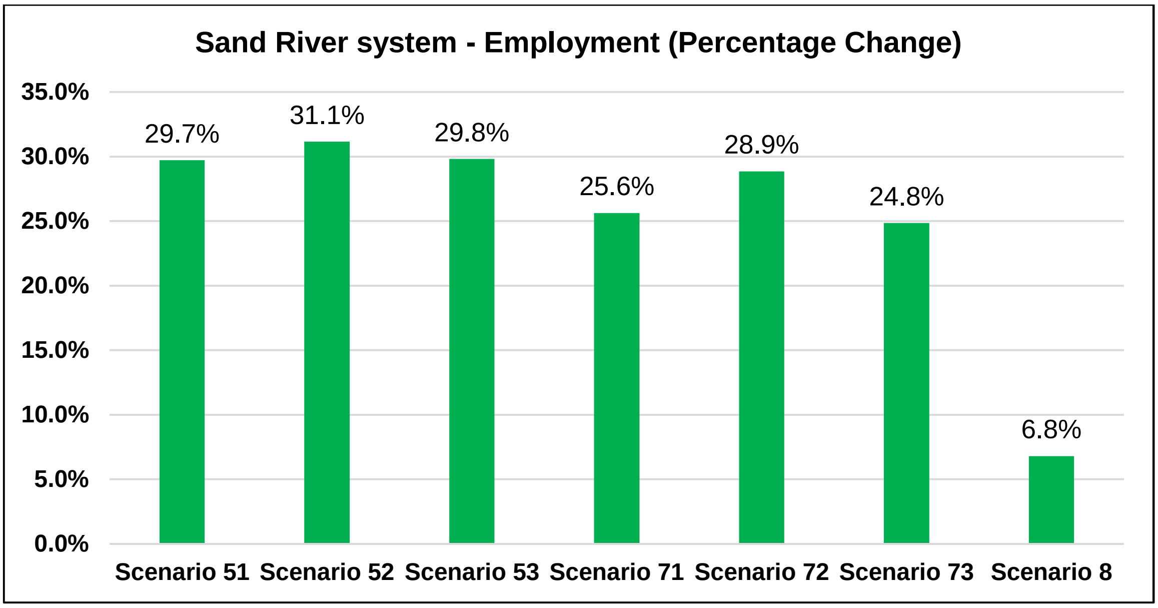


Figure 9.19 Sand River system: Employment deviation from Baseline as percentage

Figure 9.19 illustrates the deviation from the baseline in terms of percentage and very clearly shows that all the scenarios will have a positive impact on employment in the Sand River system.

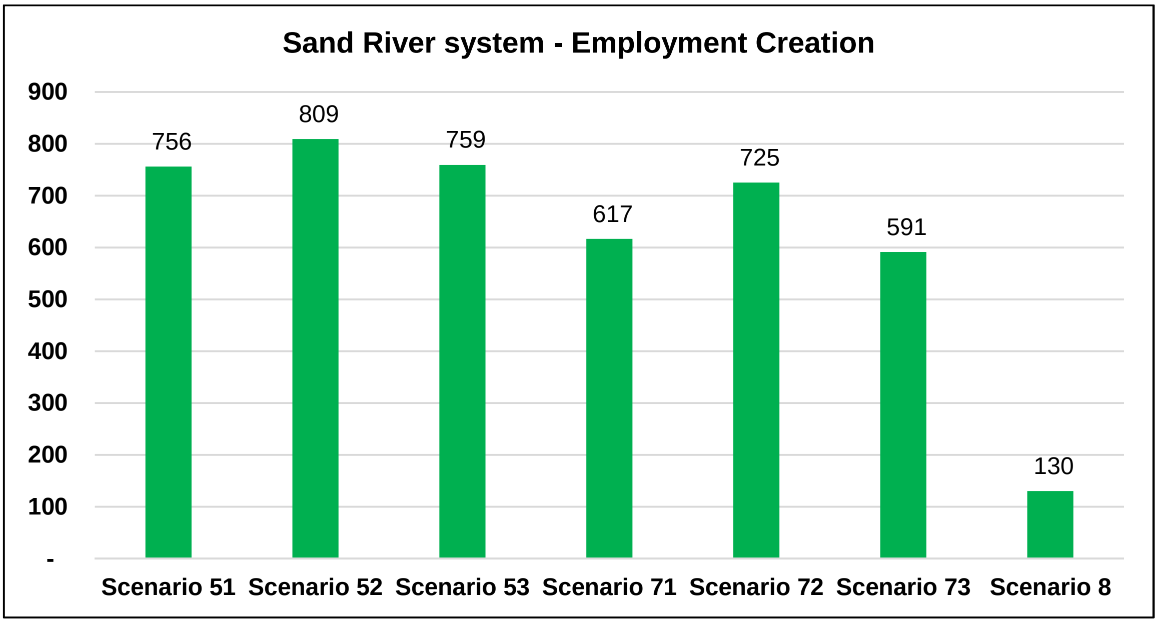


Figure 9.20 Sand River system: Employment creation numbers

Figure 9.20 illustrates the number of jobs created by each of the scenarios in the Sand River system, of which most jobs are created under Sc S52.

10 WATER QUALITY (USER) CONSEQUENCES

This chapter is an extract from report: DWS (2014b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Operational Scenarios and recommended Water Resource Classes. Authored by Huggins G, Louw MD, Mallory S, Scherman S, Van Jaarsveld P and Van Rooyen P. DWS Report, RDM/WMA05/00/CON/CLA/0214. September 2014.

10.1 INTRODUCTION

In the Inkomati Classification study WQ consists of the following two broad components:

- Ecological, i.e. as part of the EWR or Reserve process. A standard process is followed for scenario evaluation.
- User, i.e. UserSpecs (uses such as irrigation and stock-watering, domestic, recreation and industrial).

WQ is therefore incorporated in the consequence assessment as:

- Part of ECOLOGICAL consequences;
- A service identified in ECOSYSTEM SERVICES; and
- Indirectly in the ECONOMICS in terms of water treatment costs.

Steps 4 and 5 of the water resource classification process function as one step and are integrated as such into Step 4 of the Integrated Approach. One of the objectives of this task is to describe and document an approach as to how operational scenarios may impact on WQ for users other than the aquatic ecosystem (i.e. WQ related to users other than ecology, for example: Domestic Use, Agriculture - Stock Watering, Agriculture – Irrigation, Industrial - Category 3 and Recreation - Intermediate Contact).

This document therefore presents the approach undertaken to include user WQinto the consequences evaluation and the results of this assessment.

10.2 WQ OVERVIEW

A description of WQ issues in the Inkomati includes the following:

- Non-point source pollution from agriculture (pesticides, fertilizers).
- Non-point source pollution from residential areas (urban and rural townships) e.g. stormwater run-off, washing in rivers.
- Point source pollution from urban infrastructure (e.g. non-compliant wastewater treatment works, saw mills and paper and pulp mills in the X3 Sabie catchment, sugar mills and processing facilities in the X2 Crocodile catchment).
- Microbiological counts and elevated nutrient concentrations.
- Erosion and sedimentation from vegetation removal and overgrazing.
- Dams are scattered throughout the catchments, which impact on the movement of sediment, and temperature and oxygen levels.
- Mining and manufacturing WQ issues.

10.3 APPROACH

10.3.1 Study area: Consequences for user WQ

The approach undertaken for the study area is listed below as bullet points.

- Identify the RU or nodes of interest (nested within IUAs) which may potentially be impacted by the scenarios.
- Gather background information on water users in the catchment and previously set objectives for WQ (where available).
- Use land use information, the WQ Status Quo task conducted for the study and other background information to identify which users are located where, and where the WQ hotspot areas are found.
- Link users to the RUs or nodes of interest which may potentially be impacted by the scenarios.
- Identify the user groups'WQ requirements and drivers of WQ.
- Utilize the ecological information from the Reserve study to describe aquatic ecosystem requirements.
- Identify primary users and driving WQ variables.
- Test this information with the Technical Task Group and update as required. This meeting was held on 28 August 2014 in Nelspruit.
- Provide an impact rating of selected scenarios on WQ at identified sites for the driving user(s).
- Weight sites to achieve ranks relative to each other and rank the rank the scenarios in terms of WQ impact, if required.

To summarise, user WQ state per scenario and per relevant RU and IUA was scored using the driving WQ variables linked to the primary WQ user(s). Note that although the aquatic ecosystem is the resource base rather than a "user", it was grouped and evaluated with other users for purposes of this step of the Classification process.

The identified IUAs or RUs were evaluated by specialists for a range of consequences (ecological, ecosystem services and economic). The scenario evaluation process therefore estimates the consequences that a set of plausible scenarios will have on these elements by quantifying selected metrics to compare the scenarios on relative bases with one another. The scenarios were ranked, first, for the individual variables and secondly an overall integrated ranking was derived based on multi-criteria analysis methods. Consequences on user WQ were evaluated using a qualitative process and any problem areas identified.

Figure 10.1 is a diagrammatic representation of the steps shown in the approach. The various steps are referred to as Phases 1 to 5. This notation is followed during the explanation of data collection and results.

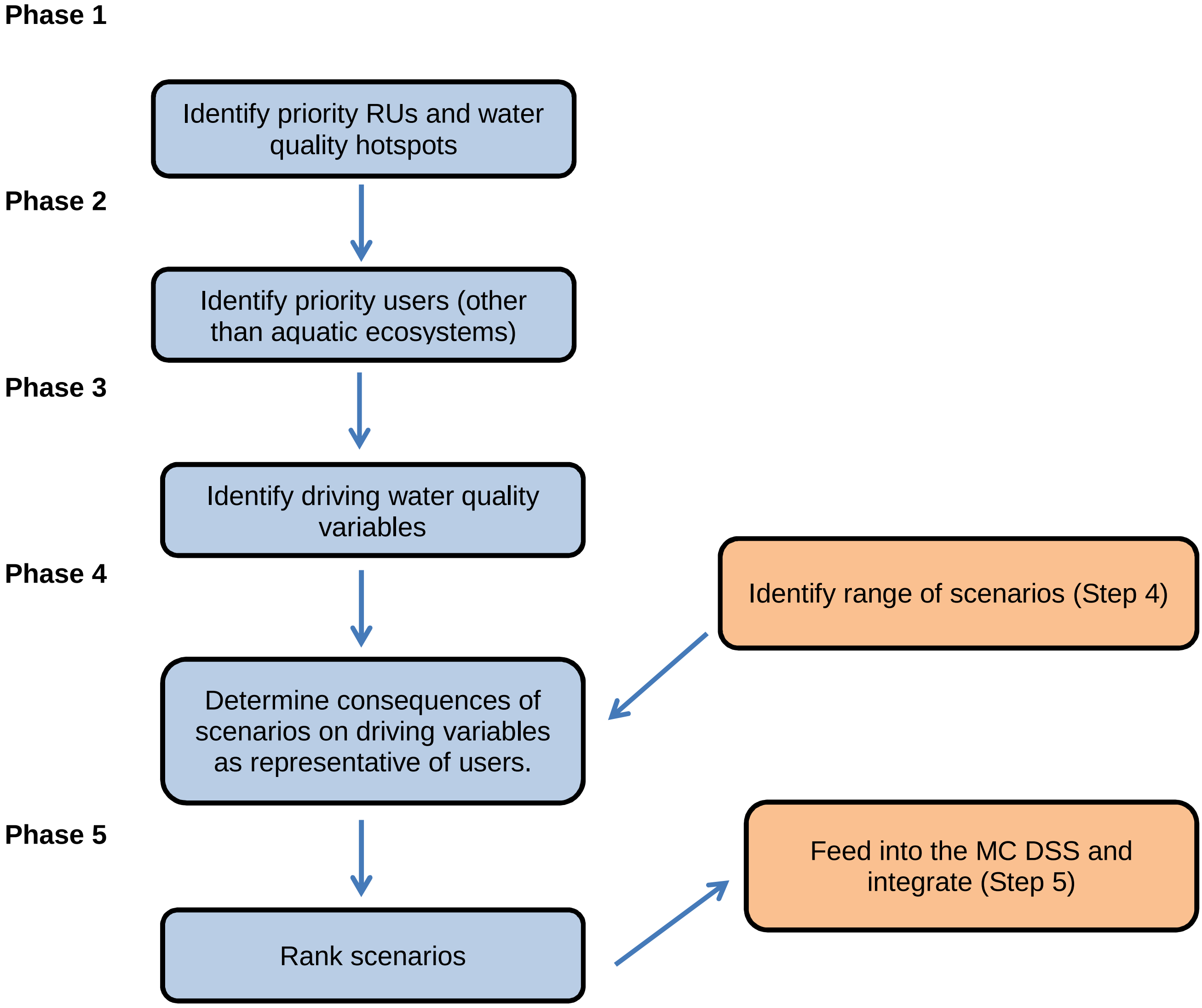


Figure 10.1 A diagrammatic representation of the approach followed for determining consequences of scenarios to user WQ

10.3.2 Upper Komati River: Impacts of coal mining

A scenario (with and without transfers from the Usuthu; Scenario K5) was selected for the Upper Komati catchment to test the impacts of additional coal mining in the area, and the impacts of increasing AMD levels. A modelling exercise was conducted by Stephen Mallory of IWR Water Resources to simulate increasing levels of AMD, represented by increasing sulphate (SO_4) levels. The impact area was confined to the Upper Komati due to the presence of the two large dams, Nooitgetdacht and Vygeboom, which are expected to prevent the potential contaminant plume from migrating into Swaziland and beyond. The Boesmanspruit Dam which is the main water source for Carolina, was included in the modelling exercise.

The model used for the exercise was the Water Resources Yield Model known as the WRYM and set up for previous studies such as the IWAAS (DWAF, 2009b). The following figures were used for the modelling exercise. Note that no estimates are available for the Komati mines as modelling has not previously been undertaken and little information exists on potential volumes. The AMD figure below is therefore a guesstimate in the absence of any other information, and based on the smaller number of mines in the Komati versus an area such as the Olifants where detailed modelling has been undertaken and expected volumes can be predicted with higher confidence.

- An AMD volume of 5 million m^3/a; equating to a concentration of 2 000 mg/L of SO_4.
- A background concentration of 50mg/L SO_4 in surface runoff.
- Two scenarios were run for each of the Nooitgedacht and Vygeboom dams, i.e. with and without the Usutu transfer.

10.4 DATA COLLECTION

Data collection steps for the priority RUs are shown for Phases 1 to 3.

10.4.1 Phase 1: Identify priority RUs and WQ hotspots

Priority RUs or Management Resource Units (MRUs) for the determination of consequences to users are those reaches containing the EWR sites, which are listed below. Note that the impact of operational scenarios has been assessed at the key biophysical nodes in the study area, i.e. the EWR sites. All consequences, i.e. ecological, economic, ecological services and user WQ, were therefore been assessed at these driving nodes or reaches of the rivers. WQ hotspots per area are also depicted - information is taken from DWA (2013b).

Komati River system(X1)

- This reach is MRU Komati M in IUA X1-8 and includes EWR L1 on the Lomati River. This IUA consists of the Lomati River downstream of the Swaziland border to the confluence with the Komati River, with the MRU being the main stem of the Komati River. The IUA contains Driekoppies Dam.
- This reach is MRU Komati D in IUA X1-9 and includes EWR K3 on the Komati River. This IUA consists of the lower Komati River from the Swaziland border to the confluence with the Lomati River.

WQ hotspots

1. <u>Gladdespruit (X11K-01194):</u> Impacts are related to a reduction in low-flows due to forestry, WQ problems due to acid mine drainage from old gold mines, sulphates and raw sewage, erosion and sedimentation, alien invasives and trout dams. **WQ RATING: 3.**
2. <u>Komati River (X13J-01130):</u> Sewage effluent and extensive settlements resulting in elevated nutrients. **WQ RATING: 3.**
3. <u>Teespruit (X12E-01287):</u> Lower reaches only due to sewage effluent resulting in elevated nutrients.**WQ RATING: 3.**
4. <u>Boesmanspruit (X11B-01272):</u> Four open-cast mines in the Boesmanspruit catchment have impacted on WQ in the area. **WQ RATING: 3.**
5. <u>Seekoeispruit (X12D-01235):</u> Number of WWTW result in elevated nutrients and increased salination around Badplaas. **WQ RATING: 3.**
6. <u>Lomati River (X14E-01151, X14G-01128, X14H-01066):</u> Stretch includes Driekoppies Dam and impacts on temperature and oxygen; also elevated nutrients from irrigation return flows. **WQ RATING: 3.**
7. <u>Middle Komati River (X13G-01282, X13H-01281, X13H-01277, X13H-01280):</u> Irrigation return flows.**WQ RATING: 3.**
8. <u>Lower Komati River (X13K-01114, X13J-012210, X13J-01210, X13J-01149):</u> Irrigation return flows. **WQ RATING: 3.**
9. <u>Lower Komati River (X13K-01114, X13J-012210, X13J-01210, X13J-01149):</u> Irrigation return flows. **WQ RATING: 3.**
10. <u>Lower Komati River (X13K-01038, X13L-01027, X13L-00995):</u> Extensive agricultural activities and irrigation return flows, exacerbated by low flows. **WQ RATING: 4.**

Crocodile (X2) catchment

- This reach is MRU Croc B in IUA X2-1 and includes EWR C3. This IUA consist of the Crocodile River and tributaries from the Kwena Dam to the confluence of the Elands River, with this MRU being the mainstem of the Crocodile River from the Buffelskloofspruit to the confluence with the Elands River.
- This reach is MRU Croc C in IUA X2-9 and includes EWR C4. The main stem of the Crocodile River this IUAis subject to upstream flow modification all the way to the Kwena Dam, as well as additional abstraction for irrigation as it flows towards the Lowveld. The MRU is comprised of X22K-01018 on the main stem of the Crocodile River.
- This reach is MRU Croc E in IUA X2-11 and includes EWR C5. This MRU stretches from the confluence with the Kaap River to the end of the system, i.e. the confluence with the Komati River.
- This reach is MRU Croc E in IUA X2-11 and includes EWR C6. This EWR sites is located at the bottom end of the system on the Crocodile River in the KNP and is therefore the key site of the system.
- This reach is MRU Kaap A in IUA X2-10 and includes EWR C7. This site is located on the Kaap River before the confluence with the Crocodile River.

WQ hotspots

1. Crocodile River (X22K-00981): Extensive urban impacts from the Kanyamazane and Kabokweni area, including High Risk WWTW at Kabokweni which drains into the Crocodile River. **WQ RATING: 4.**
2. Crocodile River (X24C-01033): Impacts are from extensive settlements on the left bank and irrigation on the right bank. **WQ RATING: 3.**
3. Crocodile River (X24D-00994): Urban impacts, including extensive irrigation effluent impacting on WQ due to the Critical Risk WWTW at Malelane and the High Risk WWTW at Mhlatikop.**WQ RATING: 4.**
4. Crocodile River (X24H-00880): Irrigation effluent and upstream impacts. **WQ RATING: 3.**
5. Crocodile River (X24H-00934): Extensive irrigation effluent impacting on WQ and a Critical Risk WWTW at Komatipoort.**WQ RATING: 4.**
6. Crocodile River (X24F-00953): Extensive irrigation effluent impacting on WQ and a Critical Risk WWTW at Hectorspruit. **WQ RATING: 3.**
7. Gutshwa River (X24B-00903): Extensive urban and rural impacts from the Kabokweni and Malekutu towns. **WQ RATING: 3.**
8. Elands River (X21F-01046; around Machadodorp only): Urban impacts, including the Critical Risk WWTW at Machadodorp and ferro-chrome processing. **WQ RATING: 3.**
9. Noordkaap (X23B-01052): Mining and water treatment impacts present. **WQ RATING: 3.**
10. Kaap River (X23G-01057): Mining activities and forestry in the upper catchment. **WQ RATING: 3.**
11. Elands River (X21K-01035): Impacts from Sappi Ngodwana directly into the Elands, and from impacts on the lower end of the Ngodwana Dam. **WQ RATING: 4.**
12. Crocodile River (X22J-00993): Urban impacts from Nelspruit. Diffuse source releases from Papas Quarry at the confluence with the Gladdespruit, is a source of increased manganese concentrations in the Crocodile River.**WQ RATING: 3.**
13. Crocodile River (X22J-00958): Urban impacts from Nelspruit. **WQ RATING: 3.**
14. Crocodile River (X22K-01018): Upstream impacts from Nelspruit, Kanyamazane and Kabokweni areas.**WQ RATING: 3.**
15. Wit River (X22H-00836): Urban impacts from White River and Kabokweni and agricultural impacts. **WQ RATING: 3.**

Sabie-Sand (X3) catchment

- This reach is MRU Sabie B in IUA X3-3 and includes EWR S3 on the Sabie River downstream of the Marite confluence. This IUA consists of the main stem of the Marite and Sabie rivers from Inyaka Dam to the confluence with the Sand River.
- This reach is MRU Marite A in IUA X3-3 and includes EWR S5 on the lower Marite River, downstream of Inyaka Dam.
- This reach is MRU Mut A in IUA X3-7 and includes EWR S6 on the Mutlumuvi River, a major tributary of the Sand River.
- This reach is MRU Sand B in IUA X3-10 and includes EWR S8 (Thulandziteka) on the Sand River.

WQ hotspots

1. <u>A tributary of the Sabie River (X31K-00752):</u> Effluent discharge from the Manghwazi WWTW causing high nutrient levels and introducing hazardous microbiological organisms into the system.**WQ RATING: 3.**
2. <u>Sabie River (X31D-00755):</u> Hazyview WWTW. In addition, vegetation removal is high and irrigation is extensive within this catchment, with moderate irrigation effluent impacting on WQ. **WQ RATING: 3.**
3. <u>Ndlobesuthu (X32E-00639):</u> Urban run-off, effluent discharge and vegetation removal represent predominant and critical impacts. Sedimentation and erosion is serious. Indirect impacts are probably high turbidity and nutrient levels, the latter indicated by elevated algal growth. **WQ RATING: 4.**
4. <u>A tributary - Klein Sand River/Acornhoek (into Marite River: X31E-00647)</u>: Effluent discharge from the Acornhoek WWTW causing high nutrient levels and introducing hazardous microbiological organisms into the system. According to the DWA State of Rivers report, conditions are poor in the Klein Sand River, due to clearing of riparian vegetation and resultant erosion, coupled with alien plant infestation (DWAF, 2002). **WQ RATING: 3.**
5. <u>Marite River (X31E-00647):</u> Urban run-off and effluent from urban areas are the predominant WQ related impacts, along with extensive afforestation, vegetation removal and erosion, which most likely results in high turbidity levels and nutrient concentrations.**WQ RATING: 3.**
6. <u>Marite River (X31G-00728):</u> High algal growth is evident probably due to high nutrient inputs from irrigation run-off and agriculture. Erosion, alien vegetation, vegetation removal are also evident, with small impacts relating to urban run-off/effluent, sedimentation, and overgrazing. Indirect impacts are probably high turbidity and nutrient levels. According to the Inkomati Reserve Study (DWA, 2009a), increased suspended solids loads, elevated nutrients and toxics, as well as temperature and oxygen fluctuations at low flows occur. This is due to extensive citrus cultivation in the area and clearing for subsistence farming. The diatom *A. minutissimum* indicates anthropogenic disturbances and the presence of diffuse pollutants (upstream citrus farming) (EWR S5). According to the PES Fact Sheets irrigation run-off is moderate, which may result in pesticide and fertilizers discharging into the river. **WQ RATING: 4.**
7. <u>Noord-Sand (X31J-00774):</u> High algal growth is evident probably due to urban and irrigation run-off/effluent. Extensive vegetation removal and moderate afforestation probably results in high turbidity levels. Moderate impacts associated with erosion, alien vegetation, overgrazing and irrigation effluent are also evident. Indirect impacts are probably high turbidity and nutrient levels.**WQ RATING: 3.**
8. <u>Noord-Sand (X31J-00835):</u> Urban run-off and effluent from urban areas are the predominant impacts, with moderate levels of algal growth being the likely result of effluent discharges. Alien vegetation, overgrazing and irrigation effluent are also evident. Indirect impacts are probably high turbidity and nutrient levels.**WQ RATING: 3.**

9. Bejani (X31K-00713): Urban run-off, effluent discharge (i.e. Mkhuhlu WWTW) and vegetation removal represent serious impacts. Sedimentation and algal growth is high, with moderate erosion impacts. Indirect impacts are probably high turbidity and nutrient levels, especially since algal levels are high, as well as hazardous microbiological organisms.**WQ RATING: 3.**
10. A tributary that flows into Inyaka Dam, proximate to Marite River (X31G-00728): Effluent discharge from the Maviljan WWTW causing high nutrient levels and introducing hazardous microbiological organisms into the system.**WQ RATING: 3.**
11. Thulandziteka (X32A-00583): The Reserve study of 2007 - 2010 (DWAF, 2009a) indicated a C Category for this river, with elevated nutrients, turbidity and toxics present. Impacts on temperature and oxygen were also seen due to fluctuating flows.**WQ RATING: 3.**

10.4.2 Phase 2: Identify primary water users in priority reaches

Primary user groups in the priority river reaches are shown in Table 10.1 – 10.3 for the Komati, Crocodile and Sabie-Sand systems, respectively.

Table 10.1 Komati River system (X1): Primary users groups in river reaches considered during the scenario impact assessment process

Reach number	Priority river reaches	Primary user groups
1	MRU Komati M, including EWR L1 on the Lomati River.	Settlements, WWTW, sand-mining, extensive crop farming.
2	MRU Komati D, including EWR K3 on the Komati River.	Irrigation return flows, Tongo WWTW.

Table 10.2 Crocodile River system (X2): Primary users groups in river reaches considered during the scenario impact assessment process

Reach number	Priority river reaches	Primary user groups
1	MRU Croc B, including EWR C3 on the Crocodile River.	Irrigation, particularly citrus.
2	MRU Croc C, including EWR C4 on the Crocodile River.	Kanyamazane urban and industrial area.
3	MRU Croc E, including EWR C5 on the Crocodile River.	Urban (Malelane, Marloth Park, Komatipoort) impacts impacting on WQ, including sugar mill and fruit processing. Critical Risk WWTW at Malelane, Hectorspruit and Komatipoort, and a High Risk WWTW at Mhlatikop.
4	MRU Croc E, including EWR C6 on the Crocodile River.	
5	MRU Kaap A, including EWR C7 on the Kaap River.	Some irrigation; Lily and Barbrooke Goldmines.

Table 10.3 Sabie-Sand River system (X3): Primary users groups in river reaches considered during the scenario impact assessment process

Reach number	Priority river reaches	Primary user groups
1	MRU Sabie B, including EWR S3 on the Sabie River.	Rural settlements and urban areas such as Hazyview. Manghwazi WWTW; extensive irrigation return flows and Pabeni quarry.
2	MRU Marite A, including EWR S5 on the Marite River.	Impacts from extensive settlements and irrigation activities, including fertilizer use.
3	MRU Mut A, including EWR S6 on the Mutlumuvi River, a tributary of the Sand River.	Settlements and irrigation return flows.
4	MRU Sand B, including EWR S8 on the Sand River (Thulandziteka).	Thulamahashe WWTW (outside the nature reserve).

10.4.3 Phase 3: Identify driving WQ variables per primary user

Driving WQ variable per user group are shown in Table 10.4 – 10.6 for the Komati, Crocodile and Sabie-Sand systems respectively. Current state of integrated WQ is also shown.

Table 10.4 Komati River system (X1): Driving WQ variable per primary user groups in identified river reaches

Reach number	Priority river reaches	Primary user group	Driving WQ variables	Current State
1	MRU Komati M, including EWR L1 on the Lomati River.	Settlements, WWTW, sand-mining, extensive crop farming.	Nutrients, salts, toxics, turbidity, *E.coli*/coliforms.	Good - Fair (B/C)
2	MRU Komati D, including EWR K3 on the Komati River.	Irrigation return flows, Tongo WWTW.	Nutrients, turbidity, *E.coli*/coliforms.	Fair - Poor (C/D) *

* Note that the PES of a C/D was taken from a PAI table prepared using the data in the WQ table for K3 in AfriDev (2006b), i.e. the WQ Report for the Komati EWR study. It is not known what Present Day (or Scenario 1) refers to in this report, as it mentions a WQ category of a D/E (PAI table for K3 Scenario: PD = Sc1; pg. 64), while the overall site classification for WQ on the table for EWR site K3 was a C/D (pg. 42).

Table 10.5 Crocodile River system (X2): Driving WQ variable per primary user groups in identified river reaches

Reach number	Priority river reaches	Primary user group	Driving WQ variables	Current State
1	MRU Croc B, including EWR C3 on the Crocodile River.	Irrigation, particularly citrus.	Elevated nutrients, salts and toxics (e.g. pesticides).	Fair (C)
2	MRU Croc C, including EWR C4 on the Crocodile River.	KaNyamazane urban and industrial area.	Nutrients, salts, toxics, *E.coli*/coliforms.	Fair (C)
3	MRU Croc E, including EWR C5 on the Crocodile River.	Urban (Malelane, Marloth Park, Komatipoort) impacts impacting on WQ, including sugar mill and fruit processing. Critical Risk WWTW at Malelane, Hectorspruit and Komatipoort, and a High Risk WWTW at Mhlatikop. KNP on one bank, so biodiversity and conservation. EWR C6 is at the end of the system so international agreements must be met.	Nutrients, salts, toxics, *E.coli*/coliforms, temperature (sugar mill impact); international obligations at EWR C6.	Fair (C)
4	MRU Croc E, including EWR C6 on the Crocodile River.			Fair (C)
5	MRU Kaap A, including EWR C7 on the Kaap River.	Some irrigation; Lily and Barbrooke Goldmines.	Elevated nutrients, salts and toxics (As, Cn).	Good (B)

Table 10.6 Sabie-Sand River system (X3): Driving WQ variable per primary user groups in identified river reaches

Reach number	Priority river reaches	Primary user group	Driving WQ variables	Current State
1	MRU Sabie B, including EWR S3 on the Sabie River.	Rural settlements and urban areas such as Hazyview. Manghwazi WWTW; extensive irrigation return flows and Pabeni quarry.	Nutrients, salts, toxics, turbidity/suspended solids, *E.coli*/coliforms.	Good (B)
2	MRU Marite A, including EWR S5 on the Marite River.	Impacts from extensive settlements and irrigation activities, including fertilizer use.	Nutrients, salts, toxics.	Good (B)
3	MRU Mut A, including EWR S6 on the Mutlumuvi River, a tributary of the Sand River.	Settlements and irrigation return flows.	Nutrients, salts, toxics, turbidity, *E.coli*/coliforms.	Good – Fair (B/C)
4	MRU Sand B, including EWR S8 on the Sand River (Thulandziteka).	Thulmahaxi WWTW (outside the nature reserve).	Nutrients, *E.coli*/coliforms.	Good (B)

10.5 RESULTS

10.5.1 Study area: Consequences for user WQ

Results are presented as bar diagrams (Figures 10.2 – 10.7) per identified reach. Note the following explanatory points:

- No scale is shown on the bars as the process undertaken was qualitative and in relation to Current State (CS).
- CS shown on the bar relates to the WQ state, for example, a Good CS will be located along the upper third and in the green portion of the bar.
- CS per river reach can therefore be assessed comparatively, that is, if CS is lower on one bar than the other, then WQ is assumed to be poorer at that site.
- The impact of operational scenarios (denoted as Sc x) have been considered in relation to CS. So therefore, if Sc 1 (for example) results in a small impact on the WQ of the primary user in the river reach, the small impact of that scenario will be shown by placing the symbol for the scenario close or alongside that denoting the CS.
- It is expected that if a scenario has little impact on ecological WQ, it is unlikely to have a large impact on the WQ linked to any user.
- Scenarios relevant to the site are shown on the bars. See Appendix A - Chapter 10 (DWS, 2014b) for an explanation of operational scenarios.
- As a WQ model and load calculations were not available for most of the Inkomati catchments at the time of assessment, a qualitative assessment was conducted for the scenario assessment phase of the study.

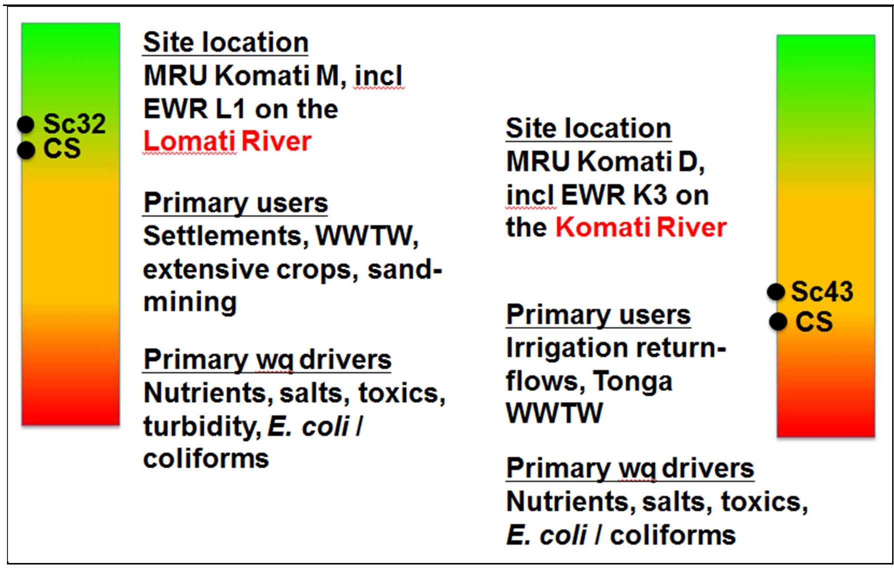


Figure 10.2 **Consequences of selected scenarios on user WQ drivers for selected reaches in the Komati River system (X1)**

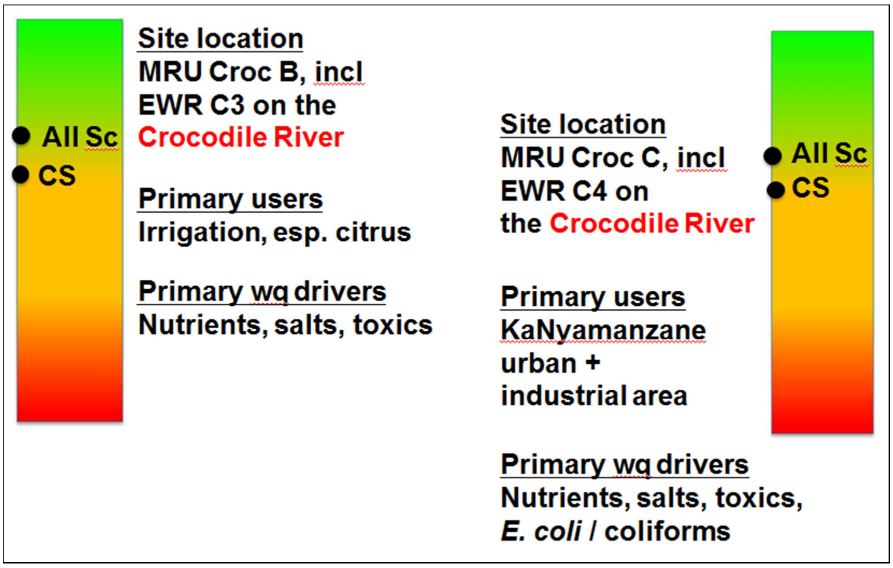


Figure 10.3 **Consequences of selected scenarios on user WQ drivers for MRU Croc B and MRU Croc Cin the Crocodile River system (X2)**

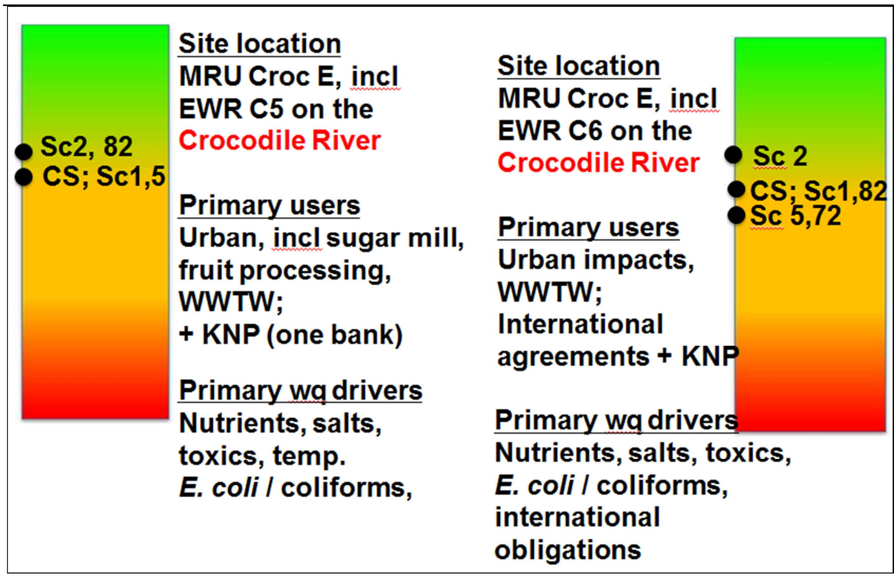


Figure 10.4 Consequences of selected scenarios on userWQ drivers for MRU Croc Ein the Crocodile River system (X2)

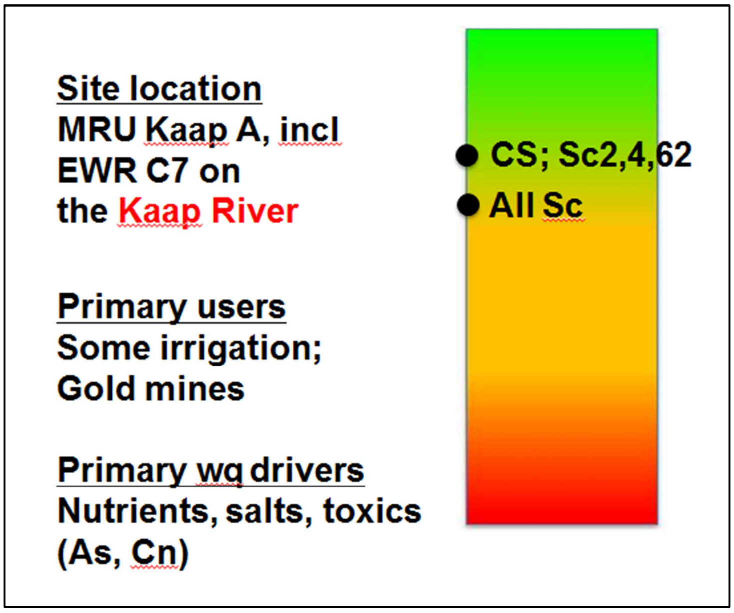


Figure 10.5 Consequences of selected scenarios on user WQ drivers for MRU Kaap A in the Crocodile River system (X2)

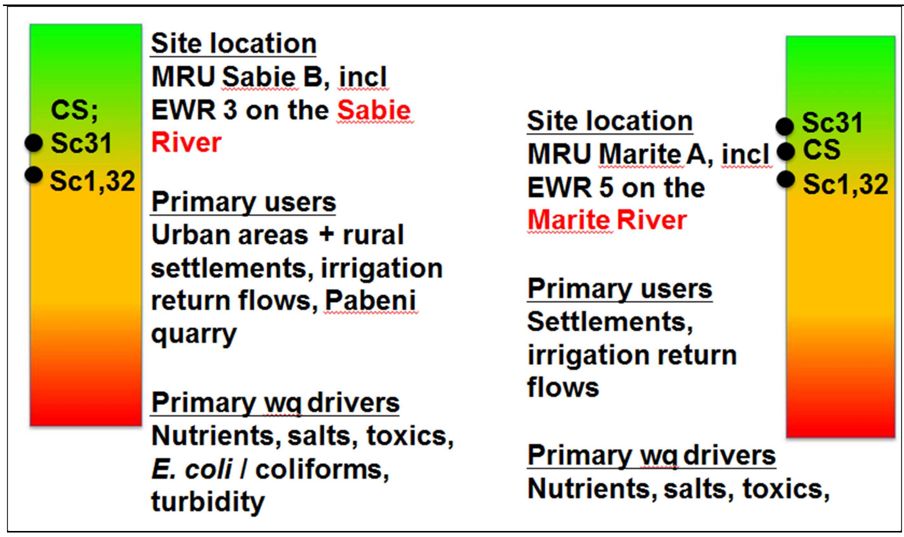


Figure 10.6 Consequences of selected scenarios on userWQ drivers for MRU Sabie B and MRU Marite A in the Sabie - Sand River system (X3)

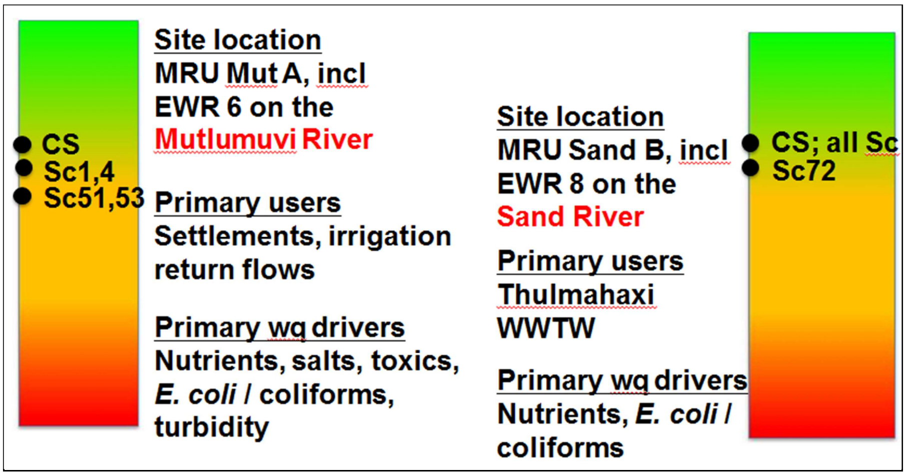
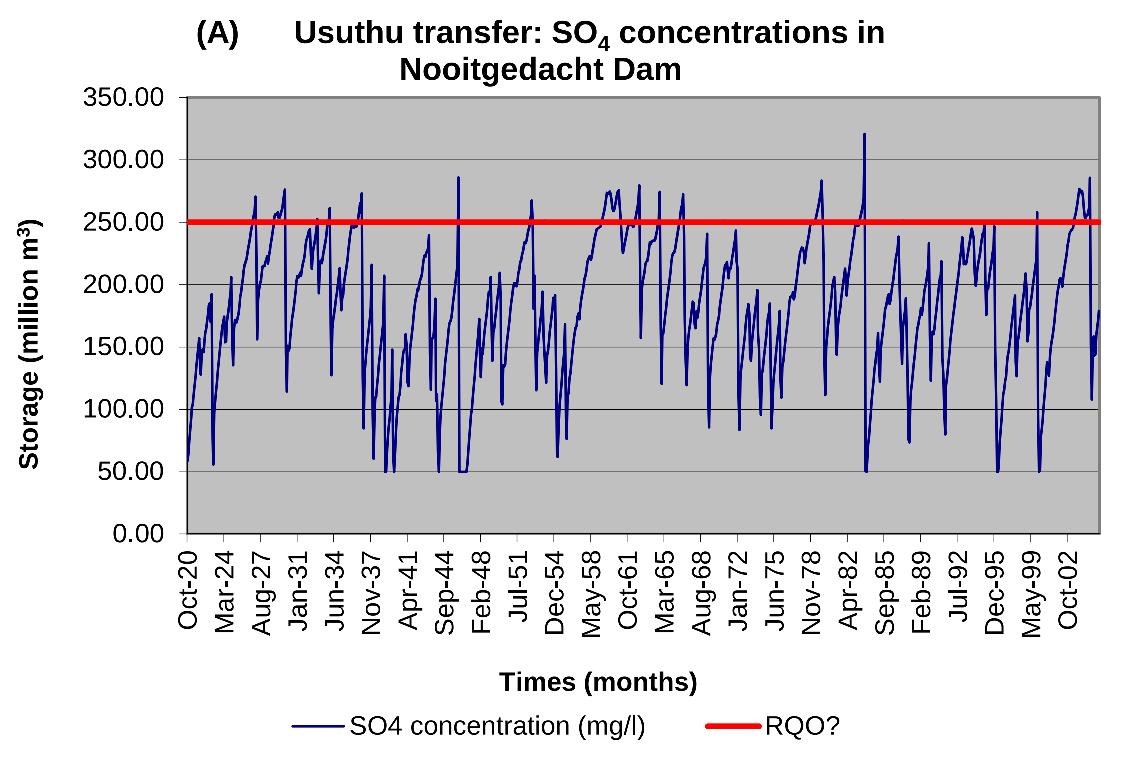


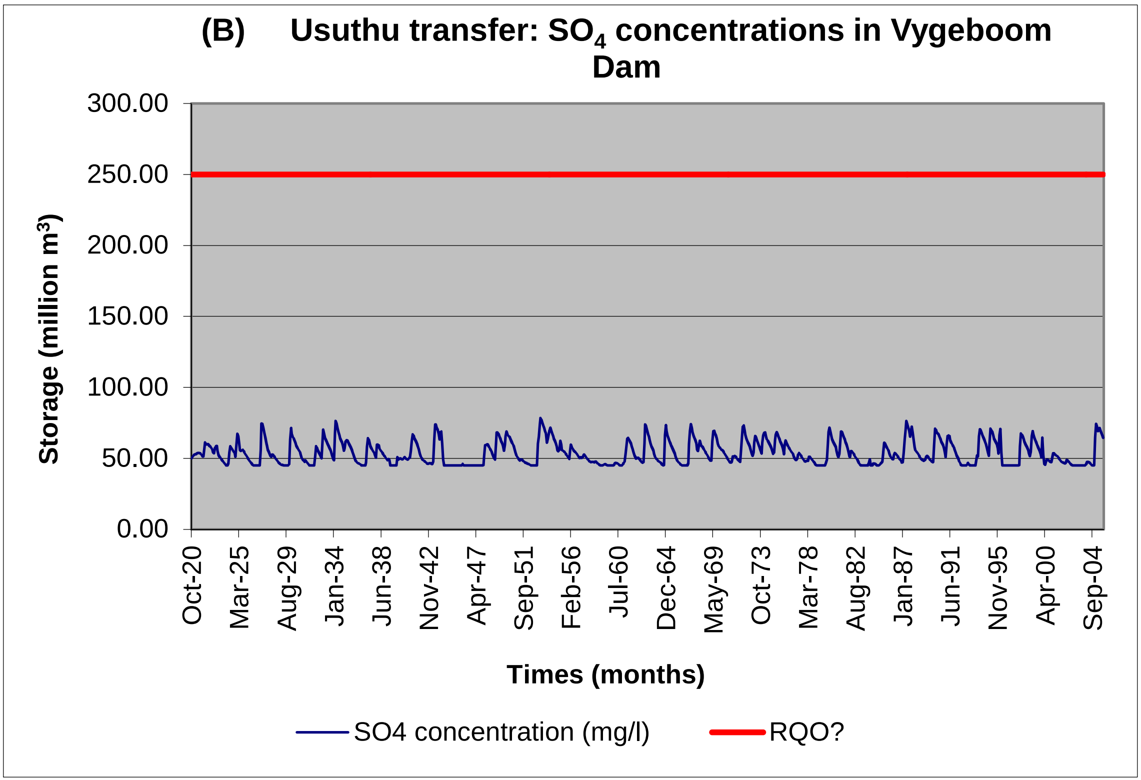
Figure 10.7 Consequences of selected scenarios on userWQ drivers for MRU Mut A and MRU Sand B in the Sabie - Sand River system (X3)

10.5.2 Upper Komati River: Additional coal mining

The results of the modelling exercise are shown in Figure 10.8 for the scenario with transfers from Usuthu, and Figure 10.9 without transfers from Usuthu. Note that transfers from the Usuthu are currently being phased out, so although included in the modelling, the graphs showing the dilutory effects of water from the Usuthu are not likely to be applicable for much longer. A tentative RQO for sulphate of 250 mg/L (i.e. Acceptable levels; DWA, 2012) is shown on the graphs.



(A) Usuthu transfer: SO4 concentrations in Nooitgedacht Dam
Storage (million m3)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Oct-20
Mar-24
Aug-27
Jan-31
Jun-34
Nov-37
Apr-41
Sep-44
Feb-48
Jul-51
Dec-54
May-58
Oct-61
Mar-65
Aug-68
Jan-72
Jun-75
Nov-78
Apr-82
Sep-85
Feb-89
Jul-92
Dec-95
May-99
Oct-02
Times (months)
SO4 concentration (mg/l)
RQO?



(B) Usuthu transfer: SO4 concentrations in Vygeboom Dam
Storage (million m3)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Oct-20
Mar-25
Aug-29
Jan-34
Jun-38
Nov-42
Apr-47
Sep-51
Feb-56
Jul-60
Dec-64
May-69
Oct-73
Mar-78
Aug-82
Jan-87
Jun-91
Nov-95
Apr-00
Sep-04
Times (months)
SO4 concentration (mg/l)
RQO?

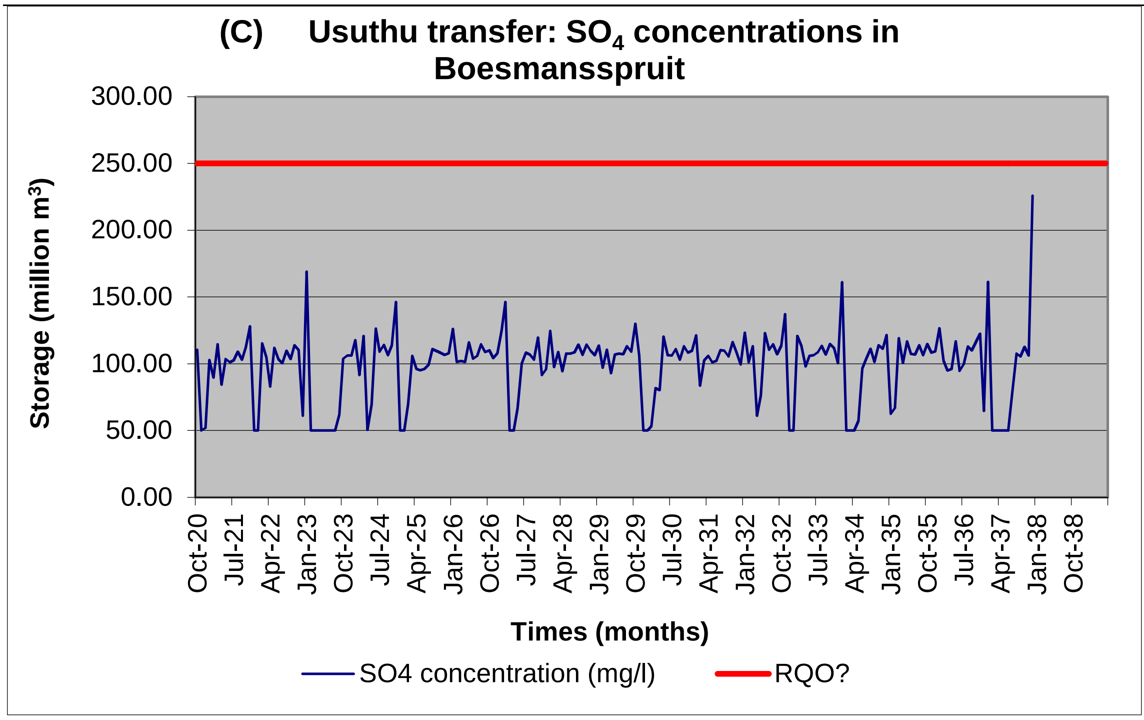
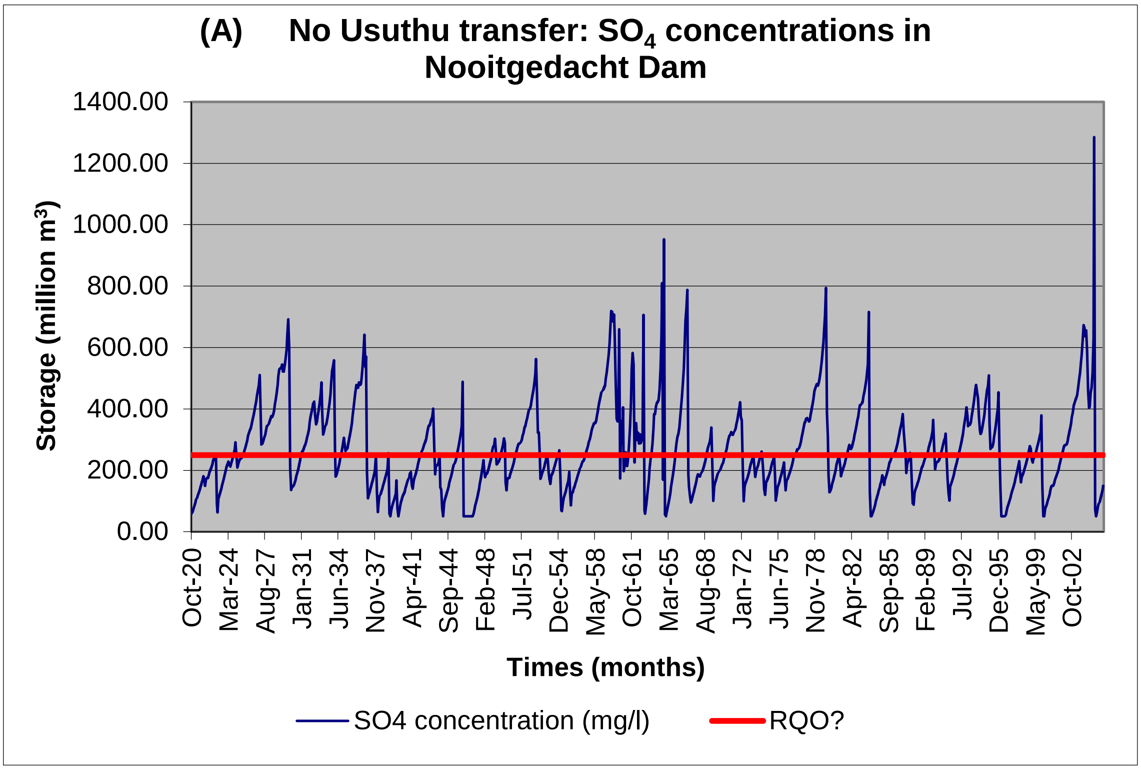
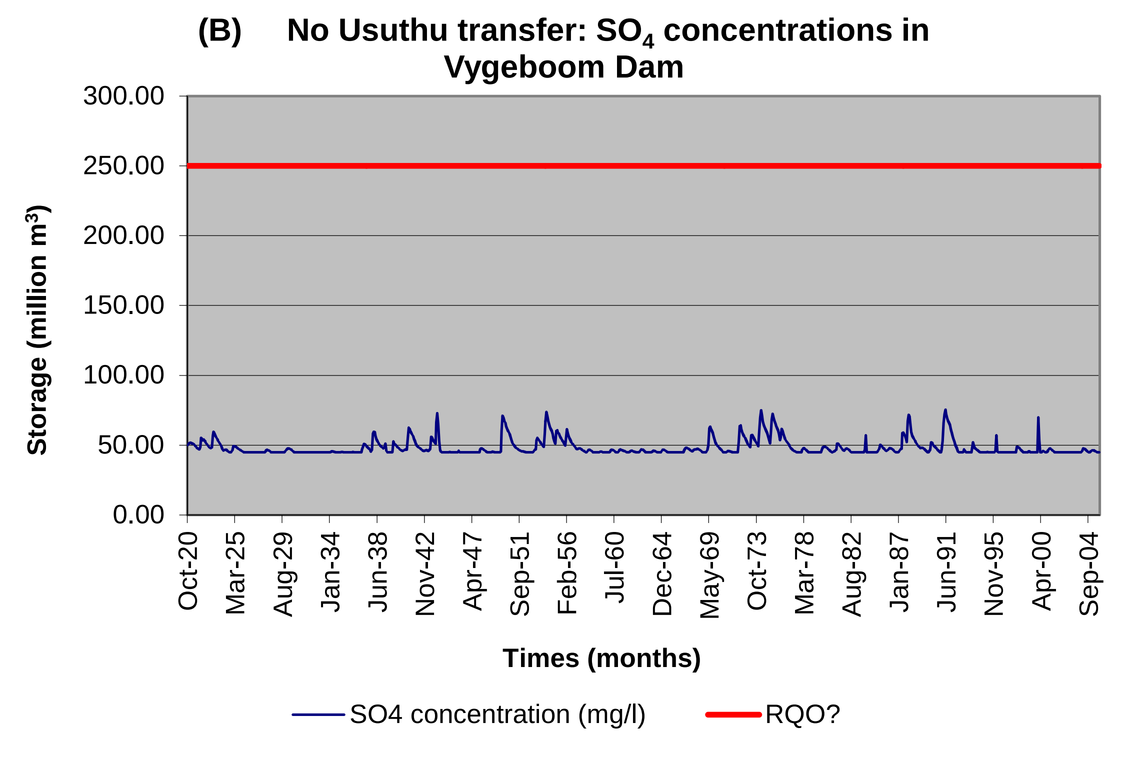


Figure 10.8 Results of the scenario WITH TRANSFERS FROM USUTHU for Nooitgedacht (A), Vygeboom (B) and Boesmanspruit (C) dams





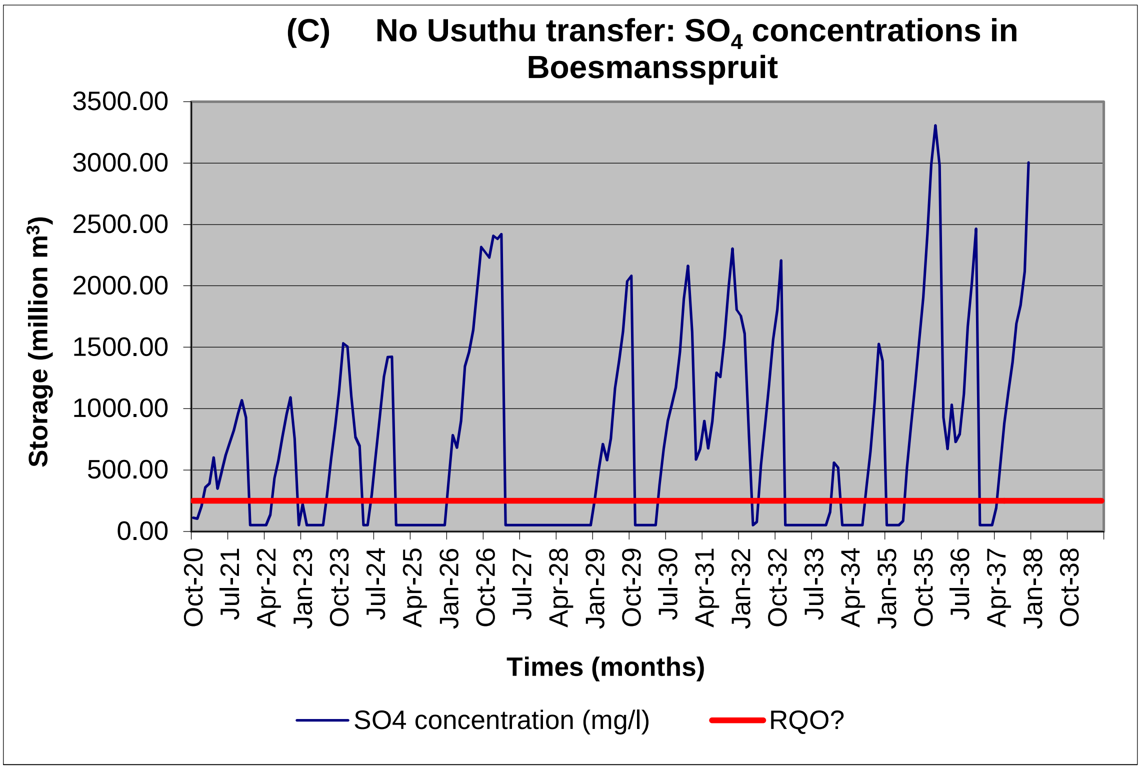


Figure 10.9 Results of the scenario WITH NO TRANSFERS FROM USUTHU for Nooitgedacht (A), Vygeboom (B) and Boesmanspruit (C) dams

10.6 CONCLUSION

10.6.1 General

The qualitative assessment of the consequences of operational scenarios on user WQ, i.e. users such as agriculture – irrigation and stock-watering to urban and rural settlements, shows that little impact is expected under any of the operational scenarios for these users. Phase 5 of the process would be to rank the scenarios. This step was not undertaken for the Inkomati study due to the small differences and lack of resolution to actually differentiate between the scenarios for the various sites.

10.6.2 Coal mining scenario

Figures 10.8 and 10.9 show the dilutory effect of pumping water from the Usuthu into the dams in the study area. Results also show that the poor quality of water in the Nooitgedacht Dam would not significantly affect the quality of the Vygeboom Dam, even without the Usuthu transfer. However, should AMD volumes and sulphate concentrations reach those modelled, a significant impact would be seen on the water quality in Nooitgedacht Dam, with an even greater potential impact on the Boesmanspruit Dam due to its smaller size, which will be exacerbated well above sulphate guideline levels without the Usuthu transfer. As the Usuthu transfer is being phased out, significant impacts can be expected under modelling conditions for both the Nooitgedacht and Boesmanspruit dams.

Note that the tentative SO_4 level shown on the graphs is the Acceptable level set by Water Quality Planning in 2012. The Target Water Quality Range (TWQR) set at that time was 38 mg/L, based on industrial and domestic users. This level would be well exceeded in all dams under both transfer scenarios.

11 WATER RESOURCE CLASSES

This chapter is an extract from report: DWS (2014b) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Operational Scenarios and recommended Water Resource Classes. Authored by Huggins G, Louw MD, Mallory S, Scherman S, Van Jaarsveld P and Van Rooyen P. DWS Report, RDM/WMA05/00/CON/CLA/0214. September 2014.

11.1 BACKGROUND

The results of the rating, weighting and scoring for the three variables, economy, ecology and Ecosystem Services presented in the previous chapters were integrated to obtain the overall ranking of the scenarios. Provision was made in this process to incorporate all the biophysical nodes in each of the IUAs. These results in turn led to the draft Water Resource Classes.

The integrated steps for the National Water Classification System, the Reserve and RQOs are supplied in Table 11.1.

Table 11.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and Resource Units, and describe the status quo of the water resource(s).
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the Ecological Water Requirements and changes in non-water quality ecosystem goods, services and attributes.
4	**Identify and evaluate scenarios within the Integrated Water Resource Management process.**
5	**Evaluate the scenarios with stakeholders and determine Water Resource Classes.**
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

This Chapter summarises Step 5 focussing on the determination of the Management Classes which was presented to stakeholders.

11.2 INTEGRATED SCENARIO RANKING RESULTS

Considering that the core purpose of the Classification process is to select the Water Resource Class (DWA, 2007) for a water resource, the scenario evaluation process provides the information needed to assist in arriving at a recommendation that will be considered by the Minister of the Department of Water and Sanitation or delegated authority to make the final decision.

The overarching aim of the scenario evaluation process is to find the appropriate balance between the level of environmental protection and the use of the water to sustain socio-economic activities. Once the preferred scenario has been selected, the Water Resource Class is defined by the level of environmental protection embedded in that scenario.

There are three main elements (variables) to consider in this balance, namely the Ecology, Ecosystem Services and the Economic benefits obtained from the use of a portion of the water resource. The scenario evaluation process therefore estimates the consequences of a set of plausible scenarios will have on these elements by quantifying selected metrics to compare the scenarios on relative bases with one another. The scenarios were ranked, first, for the individual variables and secondly an overall integrated ranking was derived based on multi-criteria analysis methods.

The results of the initial set of scenarios were interpreted to identify alternative release rules to improve the integrated scores with the objective to find and recommend an optimised scenario.

Thirty three scenarios were finally (after stakeholder input) identified for determination of consequences.

11.3 SCENARIO DESCRIPTION

Table 6.1 - 6.4 in Chapter 6 summarise the scenario definition in the form of a matrix, where each row represents a scenario and the columns indicate each of the variables applicable to each scenario. The scenarios are grouped into four sub-catchments, the Komati, the Crocodile, the Sabie and the Sand River. The reason that the Sand River was separated from the Sabie is that it was found that most of the scenarios were applicable to either the Sabie (X31) or the Sand catchment, but not both.

11.4 ECONOMIC CONSEQUENCES

The economic evaluation of the impact of the different scenarios as evaluated is based on the broad assumption that the utilisation of any additional or current water allocation is utilised at maximum efficiency. Any economic evaluation takes place within the specific current situation, not an empty space, and it is necessary that the current situation be taken into consideration in the evaluation of any of the operational scenarios.

An economic baseline was established and the estimated deviation from the baseline was determined with water as the main driver. The economic impacts on employment for each scenario were calculated in the four river systems that make up the Inkomati Catchment. The results are described in detail in Chapter 9 and summarised below.

11.4.1 Impact of the identified scenarios on Gross Domestic Product

Komati River system

- Scenario K32, K41, K42, K43 and K6 will have a positive impact on the GDP due to the additional water to the domestic services sector.
- Scenario K2, K31, and K5 will have a negative impact on GDP due to the reduction of irrigation water to the irrigation sector.
- Scenario K42 will have the biggest economic impact while Sc K5 will have the most negative impact from a GDP perspective.

Crocodile River system

- Scenario C5 and C72 will have a positive economic impact on GDP mainly due to the increased allocation towards irrigation and the value added impact in the sugar manufacturing industry. There is also additional water available to the domestic service sector.
- Scenario C2, C3, C4, C61, C72 and C81 will have a significant negative impact on the GDP mainly due to the reduction of irrigation water in these scenarios which negatively impacts the GDP of the irrigation sector and to a certain extent the industry sector. There is additional water available to the domestic service sector but the negative impact on the irrigation sector outweighs the positive impact on the domestic service sector.
- Scenario C72 will have the biggest impact on GDP while on the other end of the scale, Sc C4 will have to most negative impact, with a severe decline in GDP.

Sabie River system

- Scenario S32 will have positive economic impact on the GDP due to the increased water allocation to the domestic services sector.
- Scenario S31 will have a negative impact on GDP as a result of a decrease in irrigation, while Sc S6 will have a slight negative impact due to the decrease in domestic water for this scenario.

Sand River system

- All the scenarios will have a positive impact on GDP, due to a significant increase in domestic water to the domestic services sector.

11.4.2 Impact of the identified Scenarios on Employment

Komati River system

- Scenario K32, K42, K43 and K6 will have a positive impact on employment due to the additional water to the domestic services sector.
- Scenario K2, K31, K41 and K5 will have a negative impact on employment due to the reduction of irrigation water to the irrigation sector.
- Scenario K6 will create the most employment opportunities while Sc K31 will have the most negative impact on employment.

Crocodile River system

- Scenario C5, C72 and C82 will have a positive impact on employment opportunities mainly due to the increased allocation towards irrigation and the value added impact in the sugar manufacturing industry.
- Scenario C2, C3, C4, C61, C72 and C81 will have a significant negative impact on employment and most job losses will be in the irrigation sector due to a reduction in the irrigation water allocation.
- Scenario C72 will have the biggest impact on employment while on the other end of the scale, Sc C4 will have to most negative impact, with a severe decline in jobs.

Sabie River system

- Scenario S32 will have positive impact on employment due to the increased water allocation to the domestic services sector.
- Scenario S31 will have a negative impact on employment as a result of a decrease in irrigation water for this scenario, while Sc S6 will have a slight negative impact due to the decrease in domestic water for this scenario.

Sand River system

- All the scenarios will have a positive impact on employment; this is due to a significant increase in domestic water to the domestic services sector.

11.5 ECOLOGICAL CONSEQUENCES

The scenarios were evaluated and, during a specialist meeting, the consequences were determined at each site by ranking the scenarios in terms of how successful they are in meeting the Recommended Ecological Category. Based on the site weighting, a system ranking is determined. The results areprovided in Chapter 7 and summarised in Section 11.5.1 to 11.5.5 below.

11.5.1 Komati River system

The scenarios applicable to the Komati River system are only relevant for EWR K3 (Komati River at Tonga Rapids) and EWR L1 (Lomati River downstream of Driekoppies Dam). There is no impact of the scenarios at K3. The Lomati River at EWR L1 is largely impacted on by the unseasonal releases for irrigation from Driekoppies Dam. The scenario results illustrate that Sc K2, K31 and K41 are similar to the present day flows (i.e. maintain the PES) whereas the other scenarios are in a worse state due to the impacts on riparian vegetation which in turn impacts on the instream components. This results in a change from a C to a C/D EcoStatus.

11.5.2 Crocodile River system

The scenarios only impact on EWR C3, C4, C5 and C6 on the Crocodile River and EWR C7 in the Kaap River. The worst case scenarios are Sc C72 and C5 which both includes new dam options but with no EWR releases. Scenario C1 which represents the current operating rule also has the potential to degrade the river although it will still maintain the EcoStatus of a C at EWR C6. The best options are those options that include the REC. It is however known that these have serious potential economic consequences. Scenario C3 (with no new dams) and Sc C82 (that includes new dams) are potentially the best compromise options to explore further.

11.5.3 Sabie River system

The scenarios only impact on EWR S3 (Sabie River) and EWR S5 (Marite River). At all the other EWR sites, the status quo is therefore maintained. Scenarios S31 and S6 are the best options as they are the closest to meeting the ecological objectives. If one however considers that the Sabie River has always been seen as the flagship river in the KNP as well as one of the few rivers left in South Africa in excellent condition, then the ranking order of the Sabie River should (from an ecological view point) override the integrated ranking. As Sc S6 is the only scenario that maintains the PES (and REC) in the Sabie River, this scenario is the ecological recommendation.

11.5.4 Sand River system

The scenarios largely impact on EWR S6 (Mutlumuvi River) and EWR s8 (Sand River). Due to the lower confidence at EWR S7 (Thulandziteka (Sand) River) and as it is situated upstream of the impact of the New Forest Dam, this site was not considered during the scenario evaluation.

The results at EWR S6 (Mutlumuvi River) illustrate that none of the scenarios meet the ecological objectives of the REC. Scenario S4 meets the ecological objectives of the PES and has the least impact of all the scenarios. Scenario S51 and S71 result in the PES EcoStatus although geomorphology and fish are impacted. Scenario S53 and S73 result in a deterioration in the PES while Sc S52 and S72 have serious impacts as the EWR site will receive zero flows except when the dam spills.

Although affected by the proposed New Forest Dam under Sc S51, S52 and S53, the impacts of these scenarios are ameliorated by the return flows from the lower catchment. Scenario S72 is marginally lower than the EWR during some months but does maintain the REC for all components and the EcoStatus.

Scenario S52 and S72 are not viable options as a section of the Mutlumuvi River will change to a seasonal system. Scenario S4, although the best option, was recognised not to be a realistic option as the return flows associated with this scenario are too high. Scenario S51 and S53 also include these return flows. The remaining scenarios are Sc S71 and S73. Scenario S71 includes a full EWR release which will have a major impact on the yield. To further optimise, it is recommended that Sc S73 be further investigated.

The integrated ecological ranking of operational scenarios of the Inkomati is provided in Figure 11.1.

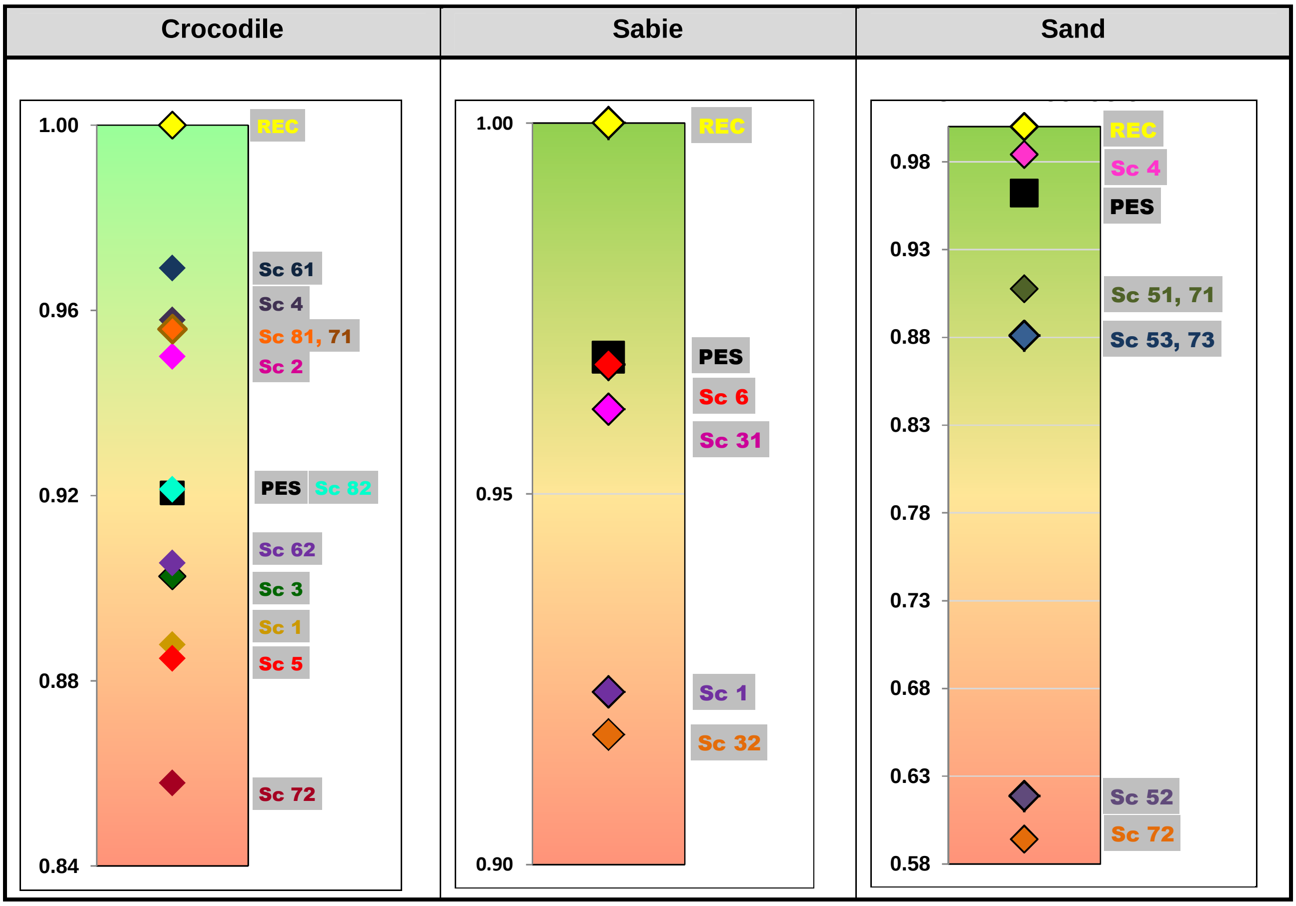


Figure 11.1 Integrated ecological ranking of the operational scenarios

11.6 ECOSYSTEM SERVICES CONSEQUENCES

Natural habitats and ecosystems provide a range of environmental goods and services that contribute enormously – and are even essential – to human well-being. Protecting these areas is essential in order to achieve sustainable development. River systems and their associated use values are of particular importance.

An analysis of the EWR 3, 5, 6, 7 and 8 was undertaken for the Sabie and Sand River systems. Here Sc S1, S4, S51 and S53 were evaluated. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. Each site was evaluated under the impact against a base value of 1, representing the status quo. Anticipated change was evaluated against the base value with a negative impact represented as a score lower than 1 and an overall positive score represented as greater than 1. The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites. Here the perceived vulnerability of households dependent on the provisioning aspect of Ecosystem Services played a major role. For the Sabie River system Sc S1 and S32 were deemed to be largely negative with respect to impact on Ecosystems Services. For the Sand River system all scenarios were either neutral in impact or marginally positive.

For the Crocodile River system EWR 3, 4, 5, 6 and 7 were examined. Here Sc C1, C2, C3, C4, C5, C61, C62, C71, C72, C81 and C82 were evaluated. Overall Sc C1, C5, and C72 were deemed to be marginally negative. The remaining scenarios were either neutral or marginally positive.

11.7 INTEGRATED MULTI-CRITERIA RESULTS

The scenario scores for the four variables, Ecology, Ecosystem Services, Economy and Employment were determined (Chapter 7). The rationale for the weights selected is to assess what the balance is between the ecological health and the socio-economic benefits (i.e. protection and use), therefore a weight of 0.5 (or 50%) is assigned to the ecology and the remaining 50% is divided among the other three variables; Ecosystem Services (5%), Economy (20%) and Employment (25%).

11.7.1 Komati River system

Scenario K42 and K6 rank the highest among the scenarios with both having similar scores. Scenario K6 has the highest employment score while Sc K42 the highest economic score. The selection of either scenario for the purpose of classification would result in the same Water Resource Class and set of ECs for the biophysical nodes in the system.It can therefore be concluded that for the Komati River system the Water Resource Class and the set of ECs for the biophysical nodes is not sensitive to the range of scenarios that were evaluated and analysed.

11.7.2 Crocodile River system

The scenario scores indicated that there is a large advantage in the socio-economic variable scores for Sc C82 compared to Sc C61, while the ecology is maintained at levels slightly above the PES (as represented by Sc C1). This implies Sc C82 is an improvement for both the ecology and socio-economics compared to current conditions (Sc C1) while Sc C61 only improves the ecology. A further aspect to consider is that the ecological score for Sc C61 is the highest for all the scenarios and as such represents an “extreme” option and not a balanced outcome.

11.7.3 Sabie Sand River system

The Sabie scenario scores indicated that Sc S31 and S32 represent the “extreme” cases where either the ecological protection or the socio-economic benefits is respectively the best or worst. Scenario S6 was therefore formulated as a “compromise” where the growth in water needs for rural/urban areas are supplied from the Sabie River system in order to improve the ecological conditions of Sc S32 towards achieving the REC. Scenario S6 therefore represents the case where a balance is achieved between the need to supply growing water requirements for socio-economic activities while still providing protection of the ecology.

Scenario S6 in the Sabie implies that additional water for growth in water use in the urban domestic sector need to be sourced and the proposed New Forest Dam (see description of Sc S71) in the Sand River system serve as a solution to make more water available.

The Sand scenario scores indicated opposing outcomes between ecological protection and socio economic benefits and a compromise would most likely result in the optimum solution – the desired balance between protection and use. Considering the need for a possible New Forest Dam identified during the evaluation of the Sabie River system, and the ranking in the Sand, Sc 71 is recommended as the preferred scenario.

11.8 DRAFT WATER RESOURCE CLASSES: SUMMARY OF RECOMMENDATIONS AND IMPLICATIONS

11.8.1 Komati River system

- The scenario immediately applicable:
  - o Maintain the current ecological state and operation of the Komati and Lomati Rivers.
  - o Institute measures (non flow-related) to achieve the REC in tributaries of the main rivers (relevant for future scenarios as well).

Implications: No implications to users. The REC in the Lomati River is not achieved under the current situation and the ecological status quo is maintained.

- Long-term scenario / the scenario that may be applicable in future (Sc K42):
  - o Maintain the current ecological state.
  - o Provision of IIMAflows.
  - o Providing water for domestic growth up to the year 2030.
  - o Reinstatement of fallow irrigation as suggested by DARDLA.

Implications: No negative economic implications as a whole but a reduction of the assurance ofsupply in irrigation downstream of Swaziland (other than the DARDLA irrigation).

The draft Water Resource Classes are provided in Table 11.2. The catchment configuration is provided in Table 11.3.

Table 11.2 Komati River system (X1): Draft Water Resource Classes

Green - Immediately applicable.
Blue - Applicable in the medium to long term.

IUA (EWR site)	PES	REC	Sc K42
X1-1	II	**II**	**II**
X1-2	II	**II**	**II**
X1-3 (K1)	II	**II**	**II**
X1-4 (G1)	III	**III**	**III**
X1-5 (K2)	II	**II**	**II**
X1-6 (T1)	II	**I**	**I**
X1-7	**II**	I	**II**
X1-8 (L1)	**III**	II	**III**
X1-9 (K3)	III	**III**	**III**
X1-10	XXX	**III**	**III**

The results for IUA 10 indicated by “XXX” in Table 11.2 imply that Sc K42 did not comply with the criteria for a Class III outlined in DWS (2014b). This is due to a large portion of the river reach length being in a D, D/E or E EC (mostly due to inundation and the significant number of weirs) and therefore not complying with the criteria set in DWS (2014b).

Table 11.3 Komati River system (X1):Draft Water Resource Classes and Catchment Configuration

Note: The red blocks indicate SQs which require non flow-related improvements to achieve the REC.
Note: The purple blocks indicate a change in the target EC once Sc K42 or similar is applicable.

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for:	
					Immediate[1]	Sc K42[2]
X1-1	II	X11A-01300		12.3	B	B
		X11A-01354		25.6	C	C
		X11A-01358	Vaalwaterspruit	23.6	C	C
		X11A-01295	Vaalwaterspruit	12.0	C	C
		X11A-01248	Vaalwaterspruit	30.2	C	C
		X11B-01370	Boesmanspruit	15.7	B	B
		X11B-01361		17.5	B/C	B/C
		X11B-01272	Boesmanspruit	29.1	C	C
X1-2	II	EWRK1	Komati	93	C	C
X1-3	II	X11C-01147	Witkloofspruit	33.5	C	C
		X11D-01129	Klein-Komati	39.6	C	C
		X11D-01137	Waarkraalloop	21.1	C	C
		X11E-01237	Swartspruit	29.3	B	B
		X11F-01133	Bankspruit	17.6	B	B
		X11G-01188	Ndubazi	22.3	B	B
		X11G-01143	Gemakstroom	14.9	C	C
X1-4	III	EWRG1	Mngubhudle	49.6	D	D
		X11K-01165	Poponyane	13.8	C	C
		X11K-01199		8.5	D	D
X1-5	II	EWRK2	Komati	80.8	C	C
X1-6	I	X12A-01305	Buffelspruit	33.6	B	B
		EWRT1	Teespruit	66.1	C	C
		X12B-01246	Hlatjiwe	22.8	C	C
		X12C-01242	Phophenyane	10.7	B	B
		X12C-01271	Buffelspruit	12.5	B	B
		X12D-01235	Seekoeispruit	26.7	C	C
		X12H-01338	Sandspruit	12.6	B	B
		X12H-01340		10.4	B	B
		X12H-01318	Sandspruit	8.3	C	C
		X12J-01202	Mtsoli	54.4	B	B
		X12K-01333	Mlondozi	23.8	B/C	B/C
		X12K-01332	Mhlangampepa	17.0	B	B
X1-7	II	X14A-01173	Lomati	47.7	B/C	B/C
		X14B-01166	Ugutugulo	24.8	C	C
		X14F-01085	Mhlambanyatsi	41.1	C	C
X1-8	III	EWRL1	Lomati	57.3	C	C/D

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for:	
					Immediate[1]	Sc K42[2]
		X14G-01128	Lomati	23.5	D/E	D/E
X1-9	III	X13J-01214	Mgobode	24.2	C	C
		X13J-01205	Mbiteni	20.0	D	D
		X13J-01141	Mzinti	43.4	D	D
		EWRK3A	Komati	71.21	D	D
X1-10	III[3]	X13K-01114	Komati	5.2	D	D
		X13K-01136	Mambane	19.2	D	D
		X13K-01068	Nkwakwa	44.7	C/D	C/D
		X13K-01038	Komati	35.3	E	E
		X13L-01000	Ngweti	44.9	D	D
		X13L-01027	Komati	10.7	E	E
		X13L-00995	Komati	3.1	D	D

1 Immediately applicable until Sc K42 or a similar scenario is implemented.
2 Applicable in the medium to long term.
3 Due to the large sections of river in an E EC, this IUA does not comply with a Level III Water Resource Class The Level III that has been allocated is applicable to the rest of the IUA which is in a D and C/D EC.

It is proposed to gazette the Water Resource Classes and catchment configuration as in Table 11.3 above for the immediate target ECs. RQOs were set for the short term ECs.

11.8.2 Crocodile River system

- The scenario immediately applicable:
  - The current situation which includes the release of a portion of the EWRs that were determined to maintain the PES.
  - Institute measures (non flow-related) to achieve the REC in tributaries of the main rivers (Elands, Crocodile and Kaap rivers) (relevant for future scenarios as well).

Implications: There are no implications to users as this scenario represents the current baseline.The REC in the downstream Crocodile River will not be met and the scenario will in the long term possibly result in a deterioration in the PES.

- The scenario that may be applicable in the near future (medium term) (Sc C3):
  - Allow for future domestic growth.
  - Give effect to the IIMA.
  - Supply the full EWR to maintain the PES.

Implications: Some negative impact on GDP and jobs. The REC in the downstream Crocodile River will not be met. The ecological state may improve from Sc C1 but will likely still not achieve the PES.

- The scenario that may be applicable in the far future (long term) (Sc C62):
  - Supply the full EWR to maintain the PES.
  - Allow for future domestic growth.
  - Give effect to the IIMA.
  - Mountain View Dam development in the Kaap River.

Implications: Job losses in the irrigation sector due to the provision of water for the domestic section (improvement from Sc C3). The ecological implications are the same as for Sc C3.

- The scenario that may be applicable in the far future (next phase after Sc C62 has been implemented - Sc C82):
  - Dam developments in both the Kaap River (Mountain View) and the Nels River (Boschjeskop).
  - Supply the full EWR to maintain the PES.
  - Allow for future domestic growth.
  - Give effect to the IIMA.

Implications: Jobs will increase from the baseline. The ecological implications are the same as for Sc C3.

The draft Water Resource Classes are provided in Table 11.4. The catchment configuration is provided in Table 11.4.

Table 11.4 Crocodile River system (X2): Draft Water Resource Classes

Green - Immediately applicable.
Blue - Applicable in the short term.
Pink - Applicable in the long term.
Orange - Applicable in the far long term.

IUA	Scenarios and Water Resource Class				
	PES	REC	C3	C62	C82
X2-1	II	**II**	**II**	**II**	**II**
X2-2	II	**II**	**II**	**II**	**II**
X2-3	I	**I**	**I**	**I**	**I**
X2-4	I	**I**	**I**	**I**	**I**
X2-5	I	**I**	**I**	**I**	**I**
X2-6	**II**	I	**II**	**II**	**II**
X2-7	II	**I**	**I**	**I**	**I**
X2-8	XXX[5]	**II**	**II**	**II**	**II**
X2-9	**II**	I	**II**	**II**	**II**
X2-10	II	**II**	**II**	**II**	**II**
X2-11	**II**	I	**II**	**II**	**II**
X2-12	II	**II**	**II**	**II**	**II**
X2-13	I	**I**	**I**	**I**	**I**

[5] xxx: The IUA does not comply to the criteria for a WMC III as there are large sections falling below a D EC.

Table 11.5 Crocodile River system (X2): Draft Water Resource Classes and Catchment Configuration

The red blocks indicate SQs which require non flow-related improvements to achieve the REC.

Note: The purple blocks indicate SQs where the catchment configuration, in terms of the Target EC, is different between the current state and future scenario.

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for: Im-mediate	Sc C3	Sc C62	Sc C82
X2-1	II	X21B-00898	Lunsklip	11.0	C/D	C/D	C/D	C/D
		X21B-00929	Gemsbokspruit	8.8	C/D	C/D	C/D	C/D
		X21B-00925	Lunsklip	21.5	C	C	C	C
		EWRC1	Crocodile	30.8	A/B	A/B	A/B	A/B
		EWRC2	Crocodile	30.1	B	B	B	B
		X21C-00859	Alexanderspruit	36.9	C	C	C	C
X2-2	II	EWRC3	Crocodile	58.3	B/C	C	C	C
		X21D-00957	Buffelskloofspruit	27.1	B/C	B/C	B/C	B/C
		X21E-00897	Buffelskloofspruit	14.6	B	B	B	B
X2-3	I	X21F-01100	Leeuspruit	12.9	C	C	C	C
		X21F-01092	Leeuspruit	1.0	C/D	C/D	C/D	C/D
		X21F-01091	Rietvleispruit	13.2	C	C	C	C
		EWRE1	Elands	55.6	B	B	B	B
X2-4	I	X21G-01090	Weltevredespruit	13.8	C	C	C	C
		X21G-01016	Swartkoppiespruit	13.8	C	C	C	C
		X21H-01060	Ngodwana*	20	B	B	B	B
		X21K-01007	Lupelule	20.0	B	B	B	B
X2-5	I	EWRE2	Elands	59	B	B	B	B
X2-6	II	X22B-00987	Crocodile	Linked to EWR C4[6]				
		X22B-00888	Crocodile					
		X22C-00946	Crocodile					
		X22J-00993	Crocodile					
X2-7	I	X22A-00824	Blystaanspruit	19.4	B	B	B	B
		X22A-00887	Beestekraalspruit	7.4	B/C	B/C	B/C	B/C
		X22A-00875	Houtbosloop	10.4	B	B	B	B
		X22A-00919	Houtbosloop	0.7	B/C	B/C	B/C	B/C
		X22A-00920		4.5	B	B	B	B
		X22A-00917	Houtbosloop	2.7	C	C	C	C
		X22A-00913	Houtbosloop	28.3	B	B	B	B
		X22C-00990	Visspruit	10.0	B/C	B/C	B/C	B/C
X2-8	II	X22D-00843	Nels	24.9	C	C	C	C

[6] The IUA results are represented by EWR C4 which is located in a different IUA but in the same MRU.

IUA	Water Resource Class	Nodes	River	River length (Km)	Target EC for:			
					Im-mediate	Sc C3	Sc C62	Sc C82
		X22D-00846		16.7	C	C	C	C
		X22F-00842	Nels	35.1	C	C	C	C
		X22E-00849	Sand	12.7	C	C	C	C
		X22E-00833	Kruisfonteinspruit	9.8	C	C	C	C
		X22F-00886	Sand	29.7	C	C	C	C
		X22F-00977	Nels	6.7	C/D	C/D	C/D	C/D
		X22C-01004	Gladdespruit	36.7	B/C	B/C	B/C	B/C
		X22H-00836	Wit	59.2	D	D	D	D
X2-9	II	X22K-01042	Mbuzulwane	10.0	B	B	B	B
		X22K-01043	Blinkwater	16.3	B	B	B	B
		X22K-01029	Blinkwater	3.4	C	C	C	C
		EWRC4	Crocodile	41.3	C	C	B/C	C
X2-10	II	X23B-01052	Noordkaap	7.2	C	C	C	C
		X23C-01098	Suidkaap	22.9	B/C	B/C	B/C	B/C
		EWRK7	Kaap	11.2	C	C	C	C
		X23E-01154	Queens	31.0	B/C	B/C	B/C	B/C
		X23F-01120	Suidkaap	28.6	C	C	C	C
X2-11	II	EWRC5	Crocodile	23	C	C	C	B/C
		EWRC6	Crocodile	99	C	C	C	C
X2-12	II	X24A-00826	Nsikazi	27.8	C	C	C	C
		X24A-00860	Sithungwane	12.4	A	A	A	A
		X24A-00881	Nsikazi	10.3	B	B	B	B
		X24B-00903	Gutshwa	19.1	D	D	D	D
		X24B-00928	Nsikazi	11.9	A/B	A/B	A/B	A/B
		X24C-00969	Mnyeleni	12.4	A	A	A	A
		X24C-00978	Nsikazi	21.2	B	B	B	B
X2-13	I	X24E-00973	Matjulu	17.3	B	B	B	B
		X24E-00922	Mlambeni	39.2	A/B	A/B	A/B	A/B
		X24G-00902	Mitomeni	21.9	A	A	A	A
		X24G-00876	Komapiti	16.0	A	A	A	A
		X24G-00844	Mbyamiti	19.8	A	A	A	A
		X24G-00823	Muhlambamadubo	21.0	A	A	A	A
		X24G-00820	Mbyamiti	28.9	A	A	A	A
		X24G-00904	Mbyamiti	5.2	A	A	A	A
		X24H-00882	Vurhami	36.6	A	A	A	A
		X24H-00892	Mbyamiti	28.8	A	A	A	A

*Note, the B EC is relevant US of Godwana Dam. The dam and the short river distance DS of the dam is in an E Category, but the management of the rest of the river upstream of the dam (20 km) must be in a B.

It is proposed to gazette the Water Resource Classes and catchment configuration as in Table 11.5 above for the immediate target ECs. RQOs were set for the short term ECs.

11.8.3 Sabie-Sand River systems

- The scenario immediately applicable:
  - Maintain the current ecological state and operation of the system.
  - Institute measures (non flow-related) to achieve the REC in the Sabie River upstream of the KNP and various tributaries (relevant for future scenarios as well).
  - May include the reinstatement of forestry in the Sand catchment.

Implications: No implications to users as this scenario represent the current baseline.This scenario will not however cater for an increase in domestic use in the Sabie River in the future. The REC in the Mutlumuvi River is not achieved under the current situation and the ecological status quo is maintained in this river.

- Long-term scenario / the scenario that may be applicable in future (Sc S71):
  - New dam development in the Mutlumuvi River.
  - Supply of the environmental flows supporting the REC in the Mutlumuvi River and downstream Sand River.
  - Assumed increase in return flows of 25% resulting from improved water supply to the Sand catchment.
  - Decreased transfer from the Sabie.

Implications: Significant economic improvement in GDP and jobs in the Sand River. Water for increased domestic growth in the Sabie River will be available. The REC will be maintained in all rivers except the Mutlumuvi River.

The draft Water Resource Classes are provided in Table 11.6. The catchment configuration is provided in Table 11.7.

Table 11.6 Sabie-Sand River system (X3): Draft Water Resource Classes

Green - Immediately applicable.
Blue - Applicable in the medium to long-term.

IUA	Catchment	Scenarios and Water Resource Class		
		PES	REC	ScS71
X3-1	Sabie	II	**I**	**I**
X3-2	Sabie	II	**I**	**I**
X3-3	Sabie	I	**I**	**I**
X3-4	Sabie	III	**III**	**III**
X3-5	Sabie	I	**I**	**I**
X3-6	Sabie	I	**I**	**I**
X3-7	Sand	III	**II**	**II**
X3-8	Sand	II	**II**	**II**
X3-9	Sand	I	**I**	**I**

Table 11.7 Sabie-Sand River system (X3): Draft Water Resource Classes and Catchment Configuration

The red blocks indicate SQs which require non flow-related improvements to achieve the REC.

The purple blocks indicate SQs where the catchment configuration, in terms of the Target EC, is different between the current state and future scenario.

IUA	Water Resource Class	Nodes	River	River length (Km)	Immediate	Sc S71
X3-1	I	X31A-00741	Klein Sabie	14.6	B/C	B/C
		X31A-00783		5.4	C	C
		X31A-00786		5.2	B	B
		X31A-00794		1.1	B	B
		X31A-00796		1.0	B	B
		X31A-00803		0.6	B/C	B/C
X3-2	I	EWR S1	Sabie	**57**	B	B
		X31B-00792	Goudstroom	8.8	B/C	B/C
		EWR S4	Mac-Mac	46.8	B	B
		EWR S2	Sabie		B	B
		X31E-00647a	Marite (US of dam)	19.9	B	B
		X31F-00695	Motitsi	42.8	B	B
X3-3	I	EWR S5	Marite	8.0	B/C	B/C
		EWR S3	Sabie		A/B	A/B
X3-4	III	X31D-00773	Sabani	19.8	C/D	C/D
		X31H-00819	White Waters	32.6	C	C
		X31J-00774	Noord-Sand	16.9	D	D
		X31J-00835	Noord-Sand	13.4	D	D
		X31K-00713	Bejani	17.7	D	D
		X31L-00657	Matsavana	12.8	C	C
		X31M-00673	Musutlu	40.3	B/C	B/C
		X31L-00664	Saringwa	28.9	C	C
		X31L-00678	Saringwa	16.6	B/C	B/C
X3-5	I	X33A-00731	Sabie		A/B	A/B
		X33A-00737	Sabie		A/B	A/B
		X33B-00784	Sabie		A/B	A/B
		X33B-00804	Sabie		A/B	A/B
		X33B-00829	Sabie		A/B	A/B
		X33D-00811	Sabie		A/B	A/B
		X33D-00861	Sabie		A/B	A/B
X3-6	I	X31K-00771	Phabeni	19.2	B	B
		X31M-00763	Nwaswitshaka	56.0	A	A
		X33A-00661	Nwatindlopfu	25.9	A	A
		X33A-00806	Nwatimhiri	35.5	A	A
		X33B-00694	Salitje	35.4	A	A
		X33B-00834	Lubyelubye	20.7	A	A
		X33C-00701	Mnondozi	46.9	A	A
		X33D-00864	Mosehla	19.9	A	A
		X33D-00894	Nhlowa	9.9	A	A
		X33D-00908	Shimangwana	8.3	A	A
		X33D-00911	Nhlowa	5.7	A	A

IUA	Water Resource Class	Nodes	River	River length (Km)	Immediate	Sc S71
X3-7	II	X32E-00629	Nwarhele	18.0	C	C
		X32E-00639	Ndlobesuthu	6.8	D/E	D/E
		EWR S6	Mutlumuvi		C	C
		X32F-00628	Nwarhele	6.5	C/D	C/D
X3-8	II	X32B-00551	Motlamogatsana	27.1	C	C
		EWR S7	Thulandziteka		C	C
		X32C-00558	Nwandlamuhari	15.1	C	C
		X32C-00564	Mphyanyana	11.9	C	C
		X32C-00606	Nwandlamuhari	1.2	C	C
		X32G-00549	Khokhovela	28.0	C	C
X3-9	I	X32H-00560	Phungwe	30.9	A	A
		EWR S8	Sand		B	B
		X32J-00651	Mutlumuvi	24.8	A	A

It is proposed to gazette the Water Resource Classes and catchment configuration as in Table 11.7 above for the immediate target ECs. RQOs were set for the short term ECs.

12 RIVER RESOURCE QUALITY OBJECTIVES

This chapter is an extract from report: DWS (2014d) - The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Resource Quality Objectives. Authored by Deacon AR, Kotze PJ, Louw MD, Mackenzie JA, Scherman P-A,. DWA Report, RDM/WMA05/00/CON/CLA/0414. December 2014.

12.1 BACKGROUND

12.1.1 Integrated steps applied in this study

The integrated steps for the National Water Classification System, the Reserve and RQOs are supplied in Table 12.1.

Table 12.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and Resource Units, and describe the status quo of the water resource(s) (completed).
2	Initiation of stakeholder process and catchment visioning (on-going).
3	Quantify the Ecological Water Requirements and changes in non-water quality ecosystem goods, services and attributes.
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	**Develop draft RQOs and numerical limits.**
7	**Gazette and implement the class configuration and RQOs.**

This summarises Step 6 and 7 focussing on an RQO summary as presented in the information supplied for input to the Gazette.

12.2 RESOURCE QUALITY OBJECTIVES

RQOs are numerical and/or descriptive statements about the biological, chemical and physical attributes that characterise a resource for the level of protection defined by its Class. The National Water Resource Strategy (NWRS) therefore stipulates that “Resource Quality Objectives might describe, among other things, the quantity, pattern and timing of instream flow; WQ; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota”.

Operational scenarios, Water Resource Classes and RQOs are inherently linked as operational scenarios inform the Water Resource Class and RQOs define and/or describe the Water Resource Class (Figure 12.1).

Figure 12.1 Links between RQOs and the Water Resource Class and operational scenarios

12.3 RESOURCE UNITS

As part of the Classification process, once the IUAs have been defined, RUs and biophysical nodes must be identified for different levels of EWR assessment and the setting of RQOs. RUs are sections of a river that frequently have different natural flow patterns, react differently to stress according to their sensitivity, and therefore require individual specifications of the Reserve appropriate for that reach. The guiding principle is that if the hydrology, geomorphic characteristics (i.e. geomorphic zone), physico-chemical attributes and river size remains relatively similar, a RU can be demarcated (DWAF, 2008a).

Management requirements (DWAF, 1999, volume 3) also play a role in the delineation. An example could be where large dams and/or transfer schemes occur. Furthermore, the type of disturbance/impact on the river plays a role to select homogenous river reaches from a biophysical basis under present circumstances. These are called MRUs and the purpose of distinguishing MRUs is to identify a management unit within which the EWR can be implemented and managed based on one set of identified flow requirements. MRUs are homogenous units which are sufficiently different from adjacent areas to warrant a separate EWR assessment being undertaken (Louw and Hughes, 2002). This means that an EWR site in the MRU, according to the EWR site selection criteria in context of the MRU, will provide for the whole MRU. Hydrological changes due to incremental runoff must obviously be taken into account (DWAF, 2008a).

Therefore an IUA can consist of RUs, MRUs or both.

Resource Units are delineated as follows:

- SQ reaches have been identified (DWA, 2013b) for the study area. These are surrogate for RUs in areas where further detailed RU determination will not be undertaken. These RUs are represented by desktop biophysical nodes (DWA, 2013b).
- For the purposes of RQOs, the SQs were combined to form RUs which represent a homogenous area of similar state and landuse. This process is followed in tributaries and rivers with no EWR sites which are usually lower priority areas and therefore do not include hotpots (DWA, 2013b)
- In key rivers which include hotspots (DWA, 2013b), a detailed RU assessment was undertaken to determine MRU. These also consist of a range of SQs, but the process and criteria used are more detailed than for the lower priority rivers. These MRUs were undertaken during Reserve studies (AfriDev, 2005a; DWAF, 2008a). Most MRUs are represented by key biophysical nodes (EWR sites) (DWA, 2013b).

RU priority is based on the outcome of the hotspot assessment (DWA, 2013b) (Step 1 of the integrated steps for the National Water Resource Classification System (NWRCS) and RQO determination; DWA (2007)) as well as available information and confidence in the information.

There are three main priority levels (Table 12.1) each with the broad type and detail of RQOs indicated.

Table 12.2 RU priority level and associated RQO description

RU priority level	RU priority level	Associated RQO
Low (1)	1a	Flow RQO. Habitat RQO in terms of PES and REC (EcoStatus).
	1b	Habitat RQO in terms of PES and REC (EcoStatus) (total river length usually in declared conservation areas).
Moderate (2)	2	Flow RQO. Habitat and biota RQO (broad).
High (3)	3a	Forms part of RU represented by an EWR site.
	3b	EWR site. Flow RQO related to preferred scenario. Detailed habitat and biota RQO (EcoSpecs).
	3WQ	User WQ RQOs required. Habitat and biota RQO will be at a priority level 2.

12.3.1 Priority of Resource Units

The allocated priority level of each RU consisting of SQ reaches, each represented by biophysical node is provided in Table 12.3 to 12.5.

Table 12.3 Komati River system (X1): Priority level of RQO RUs

RUs	SQ number	River	RU priority rating	RU priority breakdown
IUA X1-1				
RU K1	X11A-01300		**2**	
	X11A-01354			
	X11A-01358	Vaalwaterspruit	**3WQ**	2 for biota and habitat
	X11A-01248	Vaalwaterspruit	**3WQ**	
	X11A-01295	Vaalwaterspruit		
RU K2	X11B-01370	Boesmanspruit	**3WQ**	2 for biota and habitat
	X11B-01361			
	X11B-01272	Boesmanspruit		
IUA X1-2				
MRU Komati B	X11D-01219	Komati	**3**	3b, EWR K1
	X11D-01196	Komati		3b, EWR K1
	X11E-01157	Komati		3b, EWR K1
	X11F-01163	Komati		3b, EWR K1
	X11G-01142 EWR K1	Komati		3a
	X11G-01177	Komati		3b, EWR K1
	X11H-01140a	Komati, X11H-01140a		3b, EWR K1
IUA X1-3				
RU K3	X11C-01147	Witkloofspruit	**3WQ**	2 for biota and habitat
	X11D-01129	Klein-Komati		
	X11D-01137	Waarkraalloop		
RU K4	X11E-01237	Swartspruit	**3WQ**	2 for biota and habitat
RU K5	X11F-01133	Bankspruit	**2**	
	X11G-01143	Gemakstroom		
RU K6	X11G-01188	Ndubazi	**2**	
IUA X1-4				
MRU Komati G	X11J-01106 EWR G1	Mngubhudle	**3**	3a
	X11K-01179	Gladdespruit		3b, EWR G1
	X11K-01194	Gladdespruit		3b, EWR G1
RU K7	X11K-01165	Poponyane	**2**	

RUs	SQ number	River	RU priority rating	RU priority breakdown
	X11K-01199			
IUA X1-5				
MRU Komati C	X11H-01140b	X11H-01140b	**3**	3b, EWR K2
	X11K-01227	Komati		3b, EWR K2
	X12G-01200	Komati		3b, EWR K2
	X12H-01296	Komati		3b, EWR K2
	X12H-01258EWR K2	Komati		3a
	X12K-01316	Komati		3b, EWR K2
IUA X1-6				
MRU Komati T	X12E-01287EWR T1	Teespruit	**3**	3a
RU K8	X12A-01305	Buffelspruit	**2**	
	X12B-01246	Hlatjiwe		
	X12C-01242	Phophenyane		
	X12C-01271	Buffelspruit		
	X12D-01235	Seekoeispruit		
RU K9	X12H-01338	Sandspruit	**2**	
	X12H-01340			
	X12H-01318	Sandspruit		
	X12K-01333	Mlondozi		
	X12K-01332	Mhlangampepa		
RU K10	X12J-01202	Mtsoli	**1**	1a
IUA X1-7				
RU K 12	X14A-01173	Lomati	**1**	1a
	X14B-01166	Ugutugulo		1a
	X14F-01085	Mhlambanyatsi	**2**	
IUA X1-8				
MRU Komati M	X14G-01128	Lomati	**3**	3b, EWR L1
	X14H-01066 EWR L1	Lomati		3a
IUA X1-9				
RU K11	X13J-01214	Mgobode	**2**	
	X13J-01141	Mzinti		
	X13J-01205	Mbiteni		
MRU Komati D	X13J-01221	Komati	**3**	3b, EWR K3A
	X13J-01210	Komati		3b, EWR K3A
	X13J-01149	Komati		3b, EWR K3A
	X13J-01130 (EWR K3)	Komati		3a
IUA X1-10				
RUK13	X13K-01136	Mambane	**2**	
	X13K-01068	Nkwakwa		
	X13L-01000	Ngweti	**3WQ**	2
MRU Komati E	X13K-01114	Komati	**3WQ**	3b, EWR K3A
	X13K-01038	Komati		3b, EWR K3A
	X13L-01027	Komati		3b, EWR K3A
	X13L-00995	Komati		3b, EWR K3A

Table 12.4 Crocodile River system (X2): Priority level of RQO RUs

RUs	SQ number	River	RU priority rating	RU priority breakdown
IUA 1				
MRU Croc A	X21A-00930 (EWR C1)	Crocodile		3a
	X21B-00962 (EWR C2)	Crocodile		3a
RU C1	X21B-00929	Gemsbokspruit	**2**	
	X21B-00898	Lunsklip		
	X21B-00925	Lunsklip		
RU C2	X21C-00859	Alexanderspruit	**2**	
IUA 2				
RU C3	X21D-00957	Buffelskloofspruit	**2**	
RU C4	X21E-00897	Buffelskloofspruit	**2**	
MRU Croc B	X21D-00938	Crocodile	**3**	3b, EWR C3
	X21E-00947	Crocodile		3b, EWR C3
	X21E-00943 (EWR C3)	Crocodile		3a
IUA 3				
MRU Elan A	X21F-01046	Elands	**3WQ and 3**	3b, EWR ER1
	X21F-01081	Elands		3b, EWR ER1
	X21G-01037 (EWR ER 1)	Elands		3a
RU C7	X21F-01100	Leeuspruit	**3WQ**	2 for biota and habitat
	X21F-01091	Rietvleispruit	**2**	
	X21F-01092	Leeuspruit		
IUA 4 AND 5				
RU C8	X21G-01090	Weltevredespruit	**2**	
	X21G-01016	Swartkoppiespruit		
RU C10	X21K-01007	Lupelule	**2**	
RU C9	X21H-01060	Ngodwana	**2**	
MRU Elan B	X21G-01073	Elands	**3WQ and 3**	3b, EWR ER 2
	X21J-01013	Elands		3b, EWR ER 2
	X21K-01035 (EWR ER 2)	Elands		3a
	X21K-00997	Elands		3b, EWR ER 2
IUA 6 AND PART OF IUA 9				
MRU Croc C	X22B-00987	Crocodile	**3WQ and 3b**	3b, EWRC4
	X22B-00888	Crocodile		3b, EWRC4
	X22C-00946	Crocodile		3b, EWRC4
	X22J-00993	Crocodile		3b, EWRC4
	X22J-00958	Crocodile	**3WQ and 3b**	3b, EWRC4
	X22K-00981	Crocodile		
IUA 7				
MRU RU C5	X22A-00875	Houtbosloop	**2**	
	X22A-00887	Beestekraalspruit		
	X22A-00824	Blystaanspruit		
	X22A-00920			
	X22A-00919	Houtbosloop		
	X22A-00917	Houtbosloop		
RU C6	X22A-00913	Houtbosloop	**2**	
RU C11	X22C-00990	Visspruit	**2**	

RUs	SQ number	River	RU priority rating	RU priority breakdown
IUA 8				
RU C12	X22C-01004	Gladdespruit	**3WQ**	2 for biota and habitat
RU C13	X22D-00843	Nels	**2**	
	X22D-00846			
	X22E-00849	Sand		
	X22E-00833	Kruisfonteinspruit		
	X22F-00842	Nels		
	X22F-00886	Sand		
	X22F-00977	Nels	**2**	
RU C14	X22H-00836	Wit	**3WQ**	2 for biota and habitat
IUA 9				
RU C15	X22K-01042	Mbuzulwane	**2**	
	X22K-01043	Blinkwater		
	X22K-01029	Blinkwater		
MRU Croc D	X22K-01018 (EWR C4)	Crocodile	**3WQ and 3**	3a
IUA 10				
RU C16	X23B-01052	Noordkaap	**3WQ**	2 for biota and habitat
RU C17	X23C-01098	Suidkaap	**3WQ**	2 for biota and habitat
	X23E-01154	Queens		
	X23F-01120	Suidkaap		
MRU Kaap A	X23G-01057 (EWR C7)	Kaap	**3WQ and 3**	3a
IUA 11				
MRU Croc D	X24C-01033	Crocodile	**3WQ and 3b**	3b, EWR C6
MRU Croc E	X24H-00880	Crocodile	**3WQ and 3**	3b, EWR C6
	X24H-00934 (EWR C6)	Crocodile		3a
	X24D-00994 (EWR C5)	Crocodile		3a
	X24E-00982	Crocodile		3b, EWR C6
	X24F-00953	Crocodile		3b, EWR C6
IUA 12 AND 13				
RU C18	X24A-00826	Nsikazi	**2**	
RU C19	X24B-00903	Gutshwa	**3WQ**	2 for biota and habitat
RU C20	X24A-00860	Sithungwane	**1**	1b
	X24A-00881	Nsikazi		
	X24B-00928	Nsikazi		
	X24C-00969	Mnyeleni		
	X24C-00978	Nsikazi		
	X24E-00973	Matjulu		
	X24E-00922	Mlambeni		
	X24G-00902	Mitomeni		
	X24G-00876	Komapiti		
	X24G-00844	Mbyamiti		
	X24G-00823	Muhlambamadubo		
	X24G-00820	Mbyamiti		
	X24G-00904	Mbyamiti		
	X24H-00882	Vurhami		
	X24H-00892	Mbyamiti		

Table 12.5 Sabie and Sand River system (X3): Priority level of RQO RUs

RUs	SQ number	River	RU priority rating	RU priority breakdown
IUA 1 AND 2				
RU S2	X31A-00741	Klein Sabie	**2**	
MRU Sabie A	X31A-00778	Sabie	**3**	3b, EWR S1
	X31A-00799	Sabie		3b, EWR S1
	X31B-00756	Sabie		3b, EWR S1
	X31B-00757EWR S1	Sabie		3a
	X31D-00755EWR S2	Sabie		3a
	X31D-00772	Sabie		3b, EWR S2
RU S1	X31A-00783		**2**	
	X31A-00786			
	X31A-00794			
	X31A-00796			
	X31A-00803			
IUA 2 AND PART OF IUA 4				
RU S4	X31B-00792	Goudstroom	**2**	
	X31D-00773	Sabani		
MRU Mac A	X31C-00683EWR S4	Mac-Mac	**3**	3a
RU S8	X31E-00647a	Marite (US[1] of dam)	**2**	
	X31F-00695	Motitsi		
IUA 3				
Mar A	X31G-00728EWR S5	Marite	**3**	3a
	X31E-00647b	Marite (DS[2] of Dam)		3b, EWR S5
MRU Sabie B	X31K-00715EWR S3	Sabie	**3**	3a
	X31K-00750	Sabie		3b, EWR S3
	X31K-00752	Sabie		3b, EWR S3
	X31K-00758	Sabie		3b, EWR S3
	X31M-00681	Sabie		3b, EWR S3
	X31M-00747	Sabie		3b, EWR S3
	X31M-00739	Sabie		3b, EWR S3
IUA 4				
RU S5	X31H-00819	White Waters	**2**	
RU S6	X31J-00774	Noord-Sand	**3WQ**	2 for biota and habitat
	X31J-00835	Noord-Sand		
RU S9	X31K-00713	Bejani	**3WQ**	2 for biota and habitat
RU S10	X31L-00657	Matsavana	**2**	
	X31L-00664	Saringwa		
	X31L-00678	Saringwa		
RU S11	X31M-00673	Musutlu	**2**	
IUA 5				
MRU Sabie C	X33A-00731	Sabie	**3**	3b, EWR S3
	X33A-00737	Sabie		3b, EWR S3
	X33B-00784	Sabie		3b, EWR S3
	X33B-00804	Sabie		3b, EWR S3
	X33B-00829	Sabie		3b, EWR S3
	X33D-00811	Sabie		3b, EWR S3
	X33D-00861	Sabie		3b, EWR S3
IUA 6				

RUs	SQ number	River	RU priority rating	RU priority breakdown
RU S7	X33D-00864	Mosehla	1	1b
	X33D-00894	Nhlowa		1b
	X33D-00908	Shimangwana		1b
	X33A-00806	Nwatimhiri		1b
	X33B-00694	Salitje		1b
	X31M-00763	Nwaswitshaka		1b
	X33A-00661	Nwatindlopfu		1b
	X33B-00834	Lubyelubye		1b
	X33C-00701	Mnondozi		1b
	X33D-00911	Nhlowa		1b
	X31K-00771	Phabeni		1b
	X32H-00560	Phungwe		1a
	X32J-00651	Mutlumuvi		1b
IUA 7				
MRU Mut A	X32D-00605	Mutlumuvi	3	3b, EWR S6
	X32F-00597EWR S6	Mutlumuvi		3a
RU S13	X32E-00639	Ndlobesuthu	3WQ	
RU S12	X32F-00628	Nwarhele	2	
	X32E-00629	Nwarhele		
IUA 8				
MRU Sand A	X32A-00583EWR S7	Thulandziteka	3	3a
	X32C-00558	Nwandlamuhari		3b, EWR S7
	X32C-00606	Nwandlamuhari		3b, EWR S7
RU S14	X32B-00551	Motlamogatsana	3WQ	2 for biota and habitat
	X32C-00564	Mphyanyana	2	
RU S15	X32G-00549		2	
IUA 9				
MRU Sand B	X32H-00578	Sand	3	3b, EWR S8
	X32J-00602EWR S8	Sand		3a
	X32J-00730	Sand		3b, EWR S8
	X32G-00565	Sand		3b, EWR S8

12.4 SUMMARY OF RQO RESULTS

12.4.1 Hydrological RQOs

Table 12.6 to 12.8 provides an indication of the hydrological RQOs for rivers expressed in terms of flow at biophysical nodes and EWR sites. These summarised statistics are representative of the required flow regime in the river where the variability is dependent on the seasonal and temporal pattern of natural flow conditions. The mean monthly flows represent low flow requirements of a representative wet (February) and dry (October) month.

Table 12.6 RIVERS: Summary of key hydrological RQOs of the KOMATI RIVER system (X1) in the Inkomati catchment

RU	Biophysical node	River	Target EC	nMAR[1] (MCM)	Low flows (%nMAR)[2]	Total flows (%nMAR)	October (m^3/s)		Feb (m^3/s)	
							Mean of monthly flows at the indicated frequency[3].			
							90%	60/70%	90%	60/70%
IUA X1-1										
RU K1	X11A-01300		B	1.7	18.1	28.1	0.001	0.002	0.003	0.007
	X11A-01354		C	3.9	15.1	24.5	0.003	0.01	0.005	0.016
	X11A-01358	Vaalwaterspruit	C	6.6	17.3	26.8	0.011	0.014	0.018	0.026
	X11A-01248	Vaalwaterspruit	C	26.3	14.2	23.5	0.022	0.05	0.048	0.081
	X11A-01295	Vaalwaterspruit	C	15.4	18.2	27.2	0.012	0.035	0.023	0.058
RU K2	X11B-01370	Boesmanspruit	B	4.8	19	28.8	0.009	0.014	0.017	0.023
	X11B-01361		B/C	4.2	16	27	0.004	0.009	0.007	0.016
	X11B-01272	Boesmanspruit	C	51.4	17.3	26.8	0.051	0.133	0.083	0.191
IUA X1-2										
MRU Komati B	X11G-01142 EWR K1	Komati	C	158.6	16.1	27.5	0.254	0.374	0.618	0.779
IUA X1-3										
RU K3	X11C-01147	Witkloofspruit	C	11.4	13.5	22.1	0.015	0.022	0.025	0.041
	X11D-01129	Klein-Komati	C	21	19.2	27.4	0.027	0.056	0.107	0.122
	X11D-01137	Waarkraalloop	C	11.7	18.6	27.3	0.035	0.037	0.029	0.061
RU K4	X11E-01237	Swartspruit	B	14.8	25.6	35.5	0.049	0.057	0.067	0.111
RU K5	X11F-01133	Bankspruit	B	6.5	20.3	30.8	0.019	0.022	0.026	0.064
	X11G-01143	Gemakstroom	C	10.4	17.5	26.1	0.028	0.031	0.032	0.051
RU K6	X11G-01188	Ndubazi	B	17.4	24.9	34.9	0.055	0.063	0.067	0.145
IUA X1-4										
MRU Komati G	X11J-01106 EWR G1	Mngubhudle	D	29.5	19.9	26.9	0.041	0.063	0.122	0.205
RU K7	X11K-01165	Poponyane	C	13.7	14.7	22.7	0.01	0.012	0.047	0.071
	X11K-01199		D	2.4	15.1	22.3	0.002	0.004	0.004	0.006
IUA X1-5										
MRU Komati C	X12H-01258 EWR K2	Komati	C	545.6	9.3	18.3	0.599	0.82	1.156	1.649
IUA X1-6										
MRU Komati T	X12E-01287 EWR T1	Teespruit	C	56.4	22.6	35.3	0.206	0.272	0.294	0.349
RU K8	X12A-01305	Buffelspruit	B	32	31.2	39.9	0.085	0.168	0.195	0.261
	X12B-01246	Hlatjiwe	C	22.1	22.8	30.5	0.035	0.06	0.1	0.153
	X12C-01242	Phophenyane	B	6.3	28.7	37.5	0.016	0.024	0.032	0.041
	X12C-01271	Buffelspruit	B	71.1	31.7	40.5	0.261	0.367	0.495	0.789
	X12D-01235	Seekoeispruit	C	97	23.2	30.5	0.155	0.374	0.446	0.716
RU K9	X12H-01338	Sandspruit	B	4.4	27.9	36.7	0.035	0.056	0.069	0.12
	X12H-01340		B	4.8	30.6	39.5	0.022	0.031	0.031	0.043

RU	Biophysical node	River	Target EC	nMAR[1] (MCM)	Low flows (%nMAR)[2]	Total flows (%nMAR)	October (m³/s)		Feb (m³/s)	
							Mean of monthly flows at the indicated frequency[3].			
							90%	60/70%	90%	60/70%
	X12H-01318	Sandspruit	C	13.9	24.1	31.7	0.025	0.043	0.043	0.076
	X12K-01333	Mlondozi	B/C	22.4	25	33.5	0.052	0.091	0.103	0.143
	X12K-01332	Mhlangampepa	B	3.4	30.7	40	0.015	0.022	0.021	0.029
RU K10	X12J-01202	Mtsoli	B	66.5	15.9	33.5	0.189	0.206	0.227	0.39
IUA X1-7										
RU K 12	X14A-01173	Lomati	B/C	84.38	22.9	31.2	0.220	0.285	0.390	0.603
	X14B-01166	Ugutugulo	C	20.87	23.4	31.7	0.051	0.072	0.117	0.131
IUA X1-8										
MRU Komati M	X14H-01066 EWR L1	Lomati	C	294.3	11.7	17.3	0.502	0.664	0.989	1.168
IUA X1-9										
RU K11	X13J-01141	Mzinti	D	6.3	10.5	19.1	0.003	0.011	0.006	0.016
	X13J-01205	Mbiteni	D	5.9	8.6	17.6	0.005	0.007	0.007	0.011
MRU Komati D	X13J-01130 EWR K3A	Komati	D	1021.7	9.9	17.2	0.672	1.547	1.552	2.802
IUA X1-10										
RU K13	X13K-01136	Mambane	D	1.8	13.1	22.4	0.001	0.003	0.001	0.004
	X13K-01068	Nkwakwa	C/D	5.4	11.2	22.7	0.003	0.009	0.006	0.012
	X13L-01000	Ngweti	D	4.6	7.5	14.5	0.002	0.008	0.003	0.009
MRU Komati E	X13K-01114	Komati	D	1341.4	12.9	18.1	3.75	3.942	5.529	6.121
	X13L-00995	Komati	D	1356.6	7.2	11.1	0.485	0.5	0.481	2.956

1 nMAR is the natural Mean Annual Runoff in million cubic meters per annum.
2 %nMAR is flow required at the nodes expressed as a percentage of the natural MAR, Low flows and Total flows.
3 Percentage points on the monthly low flow frequency distribution continuum at the nodes, expressed as the percentage of the months (90% and 60% for biophysical nodes and 90% and 70% for EWR sites) that the flow should equal or exceed the indicated minimum values.

Table 12.7 RIVERS: Summary of key hydrological RQOs of the CROCODILE RIVER system (X2) in the Inkomati catchment

RU	Biophysical node	River	Target EC	Nmar[1] (MCM)	Low flows (%nMAR)[2]	Total flows (%nMAR)[3]	October (m³/s)		Feb (m³/s)	
							Mean of monthly flows at the indicated frequency[4]			
							90%	60/70%	90%	60/70%
IUA X2-1										
MRU Croc A	X21A-00930 EWR C1	Crocodile	A/B	15.6	24.36	30.13	0.033	0.059	0.121	0.205
	X21B-00962 EWR C2	Crocodile	B	76.1	30.88	35.48	0.246	0.373	0.673	1.162
RU C1	X21B-00929	Gemsbokspruit	C/D	3x.8	21.3	29.3	0.014	0.015	0.017	0.024
	X21B-00898	Lunsklip	C/D	9.6	19.8	27.7	0.031	0.034	0.026	0.058
	X21B-00925	Lunsklip	C	25.8	23.3	31.3	0.062	0.109	0.192	0.201
RU C2	X21C-00859	Alexanderspruit	C	28.8	23.6	31.5	0.069	0.134	0.172	0.188
IUA X2-2										

RU	Biophysical node	River	Target EC	Nmar[1] (MCM)	Low flows (%nMAR)[2]	Total flows (%nMAR)[3]	October		Feb	
							(m^3/s)		(m^3/s)	
							Mean of monthly flows at the indicated frequency[4]			
							90%	60/70%	90%	60/70%
RU C3	X21D-00957	Buffelskloofspruit	**B/C**	16.88	25	32.6	0.032	0.064	0.069	0.116
RU C4	X21E-00897	Buffelskloofspruit	**B**	8.39	25.5	35.3	0.03	0.043	0.047	0.067
MRU Croc B	X21E-00943 (EWR C3)	Crocodile	**B/C**	194	15.86	47.09	0.456	0.808	0.676	1.083
IUA X2-3										
MRU Elan A	X21G-01037 ER 1	Elands	**B**	60.00	10.39	47.12	0.100	0.177	0.293	0.613
RU C7	X21F-01100	Leeuspruit	**C**	11.88	30.8	39.5	0.065	0.069	0.065	0.098
	X21F-01091	Rietvleispruit	**C**	3.31	27.1	35.5	0.017	0.019	0.030	0.032
	X21F-01092	Leeuspruit	**C/D**	11.88	23.60	31.20	0.065	0.068	0.043	0.064
IUA X2-4										
RU C8	X21G-01090	Weltevredespruit	**C**	5.53	23.6	32.1	0.028	0.029	0.017	0.027
	X21G-01016	Swartkoppiespruit	**C**	11.36	24.4	32.6	0.06	0.065	0.035	0.061
RU C10	X21K-01007	Lupelule	**B**	29.4	25	35.3	0.051	0.07	0.143	0.257
RU C9	X21H-01060	Ngodwana	**B**	59.64	12.8	22.1	0.04	0.052	0.103	0.242
X2-5										
MRU Elan B	X21K-01035 ER 2	Elands	**B**	217.19	4.97	43.07	0.369	0.502	1.429	2.090
X2-6										
MRU Croc C	X22B-00987	Crocodile	Linked to EWR C4[7]							
	X22B-00888	Crocodile								
	X22C-00946	Crocodile								
	X22J-00993	Crocodile								
IUA X2-7										
RU C5	X22A-00875	Houtbosloop	**B**	6.92	30.6	39	0.024	0.033	0.051	0.074
	X22A-00887	Beestekraalspruit	**B/C**	3.72	25.9	33.9	0.013	0.021	0.027	0.032
	X22A-00824	Blystaanspruit	**B**	21	32.2	40.6	0.072	0.095	0.142	0.219
	X22A-00920		**B**	1.69	30.8	39.4	0.007	0.011	0.015	0.017
	X22A-00919	Houtbosloop	**B/C**	10.64	30.3	38.7	0.037	0.064	0.078	0.109
	X22A-00917	Houtbosloop	**C**	14.8	31.4	39.8	0.054	0.076	0.111	0.149
RU C6	X22A-00913	Houtbosloop	**B**	75.26	33	41.3	0.336	0.376	0.566	0.821
RU C11	X22C-00990	Visspruit	**B/C**	3.36	20	31.1	0.005	0.012	0.007	0.016
IUA X2-8										
RU C12	X22C-01004	Gladdespruit	**B/C**	16.26	12.5	23.1	0.018	0.022	0.021	0.037
RU C13	X22D-00843	Nels	**C**	20.58	21.9	29.6	0.034	0.059	0.072	0.12
	X22D-00846		**C**	13.78	24.1	31.9	0.078	0.082	0.052	0.082
	X22E-00849	Sand	**C**	8.66	19.8	27.8	0.019	0.027	0.021	0.043
	X22E-00833	Kruisfonteinspruit	**C**	11.2	18.7	26.6	0.022	0.032	0.027	0.07
	X22F-00842	Nels	**C**	74.94	11.22	19	0.064	0.087	0.100	0.184
	X22F-00886	Sand	**C**	48.9	19.4	27.4	0.092	0.179	0.135	0.238

[7] The IUA results are represented by EWR C4 which is located in a different IUA but in the same MRU.

RU	Biophysical node	River	Target EC	Nmar[1] (MCM)	Low flows (%nMAR)[2]	Total flows (%nMAR)[3]	October (m^3/s) Mean of monthly flows at the indicated frequency[4]		Feb (m^3/s) Mean of monthly flows at the indicated frequency[4]	
							90%	60/70%	90%	60/70%
	X22F-00977	Nels	C/D	125.41	16.8	24.1	0.401	0.539	0.615	0.767
IUA X2-9										
RU C15	X22K-01042	Mbuzulwane	B	1.19	28.6	38.4	0.005	0.007	0.005	0.01
	X22K-01043	Blinkwater	B	5.93	24.2	34.9	0.025	0.027	0.025	0.037
	X22K-01029	Blinkwater	C	4.9	16.7	25.8	0.004	0.012	0.008	0.02
MRU Croc D	X22K-01018 EWR C4	Crocodile	C	824.8	9.07	31.93	0.772	1.426	2.44	4.137
IUA X2-10										
RU C16	X23B-01052	Noordkaap	C	50.91	26.9	34.4	0.212	0.246	0.253	0.396
RU C17	X23C-01098	Suidkaap	B/C	61.75	32.6	39.5	0.025	0.027	0.025	0.037
	X23E-01154	Queens	B/C	39.54	23.4	32.7	0.121	0.146	0.169	0.22
	X23F-01120	Suidkaap	C	109.79	24.1	31	0.321	0.482	0.698	0.979
MRU Kaap A	X23G-01057 EWR C7	Kaap	C	179.5	6.18	19.23	0.069	0.144	0.349	0.559
IUA X2-11										
MRU Croc E	X24H-00934 EWR C6	Crocodile	C	1165.6	9.65	19.55	0.76	0.898	3.083	4.276
	X24D-00994 EWR C5	Crocodile	C	1117.4	10.93	23.96	1.616	2.047	2.7	4.408
IUA X2-12										
RU C18	X24A-00826	Nsikazi	C	1.97	24.1	33.9	0.004	0.009	0.004	0.011
RU C19	X24B-00903	Gutshwa	D	25.41	16.2	24.4	0.05	0.09	0.116	0.136
X2-13										
RU C20	X24A-00881	Nsikazi	B	11.68	29.5	40.6	0.027	0.056	0.034	0.077
	X24B-00928	Nsikazi	A/B	42.39	31.8	44	0.236	0.351	0.261	0.319
	X24C-00978	Nsikazi	B	52.25	30.7	40.5	0.05	0.194	0.318	0.401

1 nMAR is the natural MAR in million cubic meters per annum.
2 %nMAR is flow required at the nodes expressed as a percentage of the natural MAR, Low flows and Total flows.
3 The monthly flow requirements for EWR C3 and C6 represent the total flow defined by the current operating rule where the revised PES low flows and releases for water users defines the minimum requirements for the respective EWR sites.
4 Percentage points on the monthly low flow frequency distribution continuum at the nodes, expressed as the percentage of the months (90% and 60% for biophysical nodes and 90% and 70% for EWR sites) that the flow should equal or exceed the indicated minimum values.

Table 12.8 RIVERS: Summary of key hydrological RQOs of the SABIE AND SAND RIVER system in the Inkomati catchment (X3)

RU	Biophysical node	River	Target EC	nMAR[1] (MCM)	Low flows (%nMAR)[2]	Total flows (%nMAR)[3]	October (m^3/s) Mean of monthly flows at the indicated frequency[4]		Feb (m^2/s) Mean of monthly flows at the indicated frequency[4]	
							90%	60/70%	90%	60/70%
IUA X3-1										
RU S2	X31A-00741	Klein Sabie	B/C	14.62	16.9	25.8	0.046	0.05	0.046	0.083
RU S1	X31A-00783		C	12.12	26.1	33.8	0.034	0.049	0.065	0.098
	X31A-00786		B	4.65	39	47.7	0.026	0.029	0.039	0.051
	X31A-00794		B	Small SQ catchment areas (less than 3 km^2) and hence no						

RU	Biophysical node	River	Target EC	nMAR[1] (MCM)	Low flows (%nMAR)[2]	Total flows (%nMAR)[3]	October (m^3/s) Mean of monthly flows at the indicated frequency[4]		Feb (m^2/s)	
							90%	60/70%	90%	60/70%
	X31A-00796		B	hydrology modelled (small flows and inaccurate at this resolution).						
	X31A-00803		B/C							
IUA X3-2										
MRU Sabie A	X31B-00757 EWR S1	Sabie	B	132	12.88	54	40.91	0.189	0.320	0.393
	X31D-00755 EWR S2	Sabie	B	261.7	11.14	63.35	24.21	0.360	0.535	0.638
RU S4	X31B-00792	Goudstroom	B/C	12.21	31	38.9	0.035	0.058	0.075	0.111
	X31D-00773	Sabani	C/D	19.23	16.3	19.5	0.03	0.063	0.068	0.105
MRU Mac A	X31C-00683 EWR S4	Mac-Mac	B	65.8	14.35	45.07	0.16	0.047	0.459	1.133
RU S8	X31E-00647a	Marite (US of dam)	B	79.88	29.2	38.7	0.231	0.336	0.493	0.71
	X31F-00695	Motitsi	B	43.91	25.6	35.2	0.101	0.159	0.172	0.206
IUA X3-3										
Mar A	X31G-00728 EWR S5	Marite	B/C	156.4	28.32	63.94	0.68	0.88	0.75	1
MRU Sabie B	X31K-00715 EWR S3	Sabie	A/B	493.7	9.71	37.94	0.581	0.955	1.489	2.848
IUA X3-4										
RU S5	X31H-00819	White Waters	C	28.94	25.9	31.4	0.063	0.173	0.098	0.202
RU S6	X31J-00774	Noord-Sand	D	45.08	9.3	16	0.053	0.066	0.086	0.123
	X31J-00835	Noord-Sand	D	12.01	24.2	31.3	0.081	0.086	0.025	0.057
RU S9	X31K-00713	Bejani	D	2.38	16.9	25.7	0.001	0.007	0.002	0.009
RU S10	X31L-00657	Matsavana	C	3.84	4.3	16.8	0	0	0.003	0.004
	X31L-00664	Saringwa	C	10.89	13.5	24.5	0.022	0.027	0.016	0.041
	X31L-00678	Saringwa	B/C	3.24	18.2	30.8	0.003	0.009	0.005	0.013
RU S11	X31M-00673	Musutlu	B/C	1.8	10.6	19	0.001	0.001	0.002	0.005
IUA X3-7										
MRU Mut A	X32F-00597 EWR S6	Mutlumuvi	C	45.0	22.21	28.46	0.0016	0.042	0.111	0.193
RU S12	X32F-00628	Nwarhele	C/D	14.77	23.3	31.3	0.02	0.041	0.027	0.07
	X32E-00629	Nwarhele	C	10.58	20.2	28.6	0.039	0.043	0.031	0.052
IUA X3-8										
MRU Sand A	X32A-00583 EWR S7	Thulandziteka	B	28.9	11.14	39.66	0.025	0.047	0.086	0.138
	X32C-00558	Nwandlamuhari	C							
	X32C-00606	Nwandlamuhari	C							
RU S14	X32B-00551	Motlamogatsana	C	15.36	17.9	25.7	0.015	0.026	0.025	0.058
	X32C-00564	Mphyanyana	C	3.1	1.6	10.5	0	0	0	0
RU S15	X32G-00549		C	3.94	10.4	17	0.001	0.005	0.003	0.009
IUA X3-9										
RU S16	X32H-00560	Phungwe	A	7.59	15.7	26.1	0.01	0.021	0.016	0.027
MRU Sand B	X32J-00602 EWR S8	Sand	B	133.6	3.36	24.71	0.028	0.088	0.235	0.605

1 nMAR is the natural MAR in million cubic meters per annum.

2 %nMAR is flow required at the nodes expressed as a percentage of the natural MAR, Low flows and Total flows.
3 The monthly flow requirements for EWR S5 represents the total flow defined by current operating rule where the PES low flows and releases for water users defines the minimum requirements for the respective EWR site.
4 Percentage points on the monthly low flow frequency distribution continuum at the nodes, expressed as the percentage of the months (90% and 60% for biophysical nodes and 90% and 70% for EWR sites) that the flow should equal or exceed the indicated minimum values.

12.4.2 Habitat, biota and WQ RQOs

Table 12.9 to12.11 provides the habitat, biota and WQ RQOs for each IUA of high priority RUs in the respective river systems. RQOs and the target ECs are provided for each component and/or indicator.

Table 12.9 RIVERS: RQOs for WQ, geomorphology, riparian vegetation, macro-invertebrates and fish in HIGH priority RUs of the KOMATI RIVER (X1) system in the Inkomati catchment

Component/ Indicator	Target EC	RQOs
IUA X1-2; MRU KOMATI B (EWR K1) (Komati River)		
Geomorphology	C	Maintain the current EC and geomorphological structure.
Fish	C	Maintain target EC of C and fish species richness of eleven species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic *Amphilius uranoscopus* (AURA) and the large semi-rheophilic *Labeobarbus marequensis*(BMAR).
Invertebrates	B/C	Community is representative of a medium-sized foothill stream assemblage. Maintain the EC, good stones-in-current (SIC) and marginal vegetation (MV), 2 high flow velocity species.
Riparian vegetation	C	Maintain current EC. Maintain vegetation cover (woody and non-woody) between 70 - 90%. Perennial invasive alien species kept in check. No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	B	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.02 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 42 mS/m (aquatic ecosystems: driver).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR[1] for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X1-4; MRU KOMATI G (EWR G1) (Gladdespruit River)		
Geomorphology	D	Maintain the current EC and geomorphological structure.
Fish	D	Maintain target EC of D and fish species richness of eleven species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (AURA) and*Chiloglanis pretoriae*(CPRE).
Invertebrates	D	Community is representative of a small mountain stream assemblage. Maintain the EC, good SIC and MV, 2 moderate flow velocity species.
Riparian vegetation	D	Maintain D. Maintain vegetation cover (woody and non-woody) above 50%. Perennial invasive alien species kept in check. No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	C	Ensure that turbidity/clarity or Total Suspended Solids (TSS) levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver).
		Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.02 mg/L PO4-P (aquatic ecosystems: driver).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).

Component/ Indicator	Target EC	RQOs
		Ensure that As levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.020 mg/L As (aquatic ecosystems: driver).
		Ensure that (free) Cn levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.004 mg/L Cn (aquatic ecosystems: driver).
IUA X1-5; MRU KOMATI C (EWR K2) (Komati River)		
Geomorphology	**C**	Maintain the current EC and geomorphological structure.
Fish	**C**	Maintain target EC of C and fish species richness of nineteen species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (AURA) and the large semi-rheophilic (BMAR).
Invertebrates	**C**	Community is representative of a medium mountain stream assemblage. Maintain the EC, good SIC and MV, 2 high flow velocity species.
Riparian vegetation	**C**	Maintain current EC. Maintain vegetation cover (woody and non-woody) between 50 - 80%. Perennial invasive alien species kept in check. No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	**B/C**	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.02 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 42 mS/m (aquatic ecosystems: driver).
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
IUA X1-5; MRU KOMATI T (EWR T1) (Teewaterspruit River)		
Geomorphology	**C**	Maintain the current EC and geomorphological structure.
Fish	**C**	Maintain target EC of C and fish species richness of nineteen species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (AURA) and the large semi-rheophilic (BMAR).
Invertebrates	**C**	Community is representative of a mediummountain stream assemblage. Maintain the EC, good SIC and MV, 2 high flow velocity species.
Riparian vegetation	**C**	Maintain current EC. Maintain vegetation cover (woody and non-woody) above 30%. Perennial invasive alien species kept in check (less than 20%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	**C**	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
IUA X1-8; MRU KOMATI M (EWR L1) (Lomati River)		
Geomorphology	**D**	Maintain the current EC and geomorphological structure.
Fish	**C**	Maintain target EC of C and high fish species richness of thirty-six species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic *Chiloglanis anoterus* (CANO) and the large semi-rheophilic (BMAR).
Invertebrates	**C**	Community is representative of a medium-sized Lowveld riverassemblage. Maintain the EC, good SIC, sand and gravel habitat, and MV, 1 high flow velocity species.
Riparian vegetation	**B/C**	Maintain current EC. Maintain vegetation cover (woody and non-woody) between 50 - 80%. Perennial invasive alien species kept in check (less than 10%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ:	**B/C**	Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver).

Component/ Indicator	Target EC	RQOs
		Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
		Ensure that nutrient levels (phosphate) are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that nutrient levels (Total Inorganic Nitrogen - TIN) are within Acceptable limits: 50th percentile of the data must be less than 1.0 mg/L TIN (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X1-9; MRU KOMATI D (EWR K3) (Komati River)		
Geomorphology	DE	Maintain the current EC and geomorphological structure.
Fish	C/D	Maintain target EC of C/D and high fish species richness of thirty-five species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic *Barbus eutaenia* (BEUT) and the large semi-rheophilic (BMAR).
Invertebrates	D	Community is representative of a larger-sized Lowveld river assemblage. Maintain the EC, good SIC, sand and gravel habitat, and MV, 1 high flow velocity species.
Riparian vegetation	D	Maintain a D EC. Maintain vegetation cover (woody and non-woody) between 50 - 75%. Perennial invasive alien species kept in check (less than 15%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	D	Ensure that electrical conductivity (salt) levels are within Tolerable limits: 95th percentile of the data must be less than or equal to 85 mS/m (aquatic ecosystems: driver).
		Ensure that nutrient levels (phosphate) are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that nutrient levels (TIN) are within Acceptable limits: 50th percentile of the data must be less than 1.0 mg/L TIN (aquatic ecosystems: driver).
		Ensure that periphyton levels are within Acceptable limits: 50th percentile of the data must be less than 21 mg/m^2 (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0-130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).

1 TWQR = Target WQ Range (DWAF, 1996a).

Table 12.10 RIVERS: RQOs for WQ, geomorphology, riparian vegetation, macro-invertebrates and fish in HIGH priority RUs of the CROCODILE RIVER system (X2) in the Inkomati catchment

Component/ Indicator	Target EC	RQOs
IUA X2-1; MRU CROC A (EWR C1) (Crocodile River)		
Geomorphology	B	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the reach as an alluvial meandering channel type. PES score from the GAI level IV should equal or exceed 85%.
Fish	A	Maintain target EC of A and low fish species richness of one species. Suitable vegetated habitats should be available for small semi-rheophilic *Barbus anoplus*(BANO).
Invertebrates	B	Community is representative of a small mountain stream assemblage. Maintain

Component/ Indicator	Target EC	RQOs
		the EC, good SIC and MV, 5 high flow velocity species.
Riparian vegetation	A	Maintain current EC. Maintain woody vegetation cover below 10%. Maintain non-woody cover between 80% and 100%. Maintain reed cover below 5%. Perennial invasive alien species kept in check (less than 1%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	A	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (intermediate) use: Meet the TWQR of 0 - 1000 counts per 100 ml (DWAF, 1996b).
		IUA X2-1; MRU CROC A (EWR C2) (Crocodile River)
Geomorphology	B	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the reach as an alluvial meandering channel type. PES score from the GAI level IV should equal or exceed 85%.
Fish	B	Maintain target EC of B and fish species richness of eleven species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (AURA) and (CPRE).
Invertebrates	B	Community is representative of a small mountain stream assemblage. Maintain the EC, good SIC and MV, 5 high flow velocity species.
Riparian vegetation	A/B	Maintain current EC. Maintain woody vegetation cover below 5%. Maintain non-woody cover between 80% and 100%. Maintain reed cover below 5%. Perennial invasive alien species kept in check (less than 5%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	C	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (intermediate) use: Meet the TWQR[1] of 0 - 1000 counts per 100 ml (DWAF, 1996b).
		IUA X2-2; MRU CROC B (EWR C3) (Crocodile River)
Geomorphology	C	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the reach as an alluvial meandering channel type. PES score from the GAI level IV should equal or exceed 64%.
Fish	B	Maintain target EC of C and fish species richness of six species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (AURA) and (CPRE).
Invertebrates	C	Community is representative of a medium-sized foothill stream assemblage. Maintain the EC, good SIC and MV, 5 high flow velocity species.
Riparian vegetation	C	Maintain current EC. Maintain woody vegetation cover between 20 - 70%. Maintain non-woody cover between 30% and 90%. Maintain reed cover below 10%. Perennial invasive alien species kept in check (less than 15%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	C	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).
		Ensure that toxics are within Ideal limits or A categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
		IUA X2-9; MRU CROC D (EWR C4) (Crocodile River)

Component/ Indicator	Target EC	RQOs
Geomorphology	B/C	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 81%.
Fish	B	Maintain target EC of B and fish species richness of twenty species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CPRE) and the large semi-rheophilic (BMAR).
Invertebrates	C	Community is representative of a larger-sized Lowveld river assemblage. Maintain the EC, good SIC, sand and gravel habitat, and MV, one high flow velocity species.
Riparian vegetation	C	Maintain current EC. Maintain woody vegetation cover between 20 - 70%. Maintain non-woody cover above 30%. Maintain reed cover between 10 - 20%. Perennial invasive alien species kept in check (less than 20%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	C	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
		IUA X2-11; MRU CROC E (EWR C5) (Crocodile River)
Geomorphology	C/D	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 60%.
Fish	C	Maintain target EC of C and high fish species richness of thirty five species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CPRE) and the large semi-rheophilic (BMAR).
Invertebrates	C	Community is representative of a large, wide Lowveld river assemblage. Maintain the Category C, good SIC, sand and gravel habitat, and MV, 1 moderate flow velocity species.
Riparian vegetation	C	Maintain current EC. Maintain woody vegetation cover between 20 - 70%. Maintain non-woody cover above 40%. Maintain reed cover above 10% along the channel. Perennial invasive alien species kept in check (less than 10%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	C	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (aquatic ecosystems: driver, EWR C6.
		Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 70 mS/m (aquatic ecosystems: driver).
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.
		Ensure that temperatures stay within Acceptable limits: A moderate change to instream temperatures should occur infrequently, i.e. vary by no more than 2ºC. Highly temperature sensitive species will occur in lower abundances (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within the Chronic Effects Value (CEV) limits: 95th percentile of the data must be within the CEV for toxics or the B Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).

Component/ Indicator	Target EC	RQOs
		IUA X2-11; MRU CROC E (EWR C6) (Crocodile River)
Geomorphology	C	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 66%.
Fish	C	Maintain target EC of C and high fish species richness of thirty-four species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic *Chiloglanis paratus*(CPAR) and the large semi-rheophilic (BMAR).
Invertebrates	C	Community is representative of a large, wide Lowveld river assemblage. Maintain the EC, good SIC, sand and gravel habitat, and MV, one moderate flow velocity species.
Riparian vegetation	C	Maintain current EC. Maintain woody vegetation cover between 5 - 60%. Maintain non-woody cover above 30% in the marginal zone. Maintain reed cover between 10 - 90% along the channel. Maintain absence of perennial invasive alien species. No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	C	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver, EWR C6.
		Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 70 mS/m (aquatic ecosystems: driver).
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.
		Ensure that temperatures stay within Acceptable limits: A moderate change to instream temperatures should occur infrequently, i.e. vary by no more than 2ºC. Highly temperature sensitive species will occur in lower abundances (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within the CEV limits: 95th percentile of the data must be within the CEV for toxics or the B Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
		IUA X2-10; MRU KAAP A (EWR C7) (Kaap River)
Geomorphology	B	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 86%.
Fish	C	Maintain target EC of C and fish species richness of eleven species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CPRE) and (BEUT) and the large semi-rheophilic (BMAR).
Invertebrates	B	Community is representative of a medium-sized Lowveld river assemblage. Maintain the Category B, good SIC and MV, 3 high flow velocity species.
Riparian vegetation	C/D	Maintain current EC. Maintain woody vegetation cover between 20 - 70%. Maintain non-woody cover above 30%. Maintain reed cover between 10 - 90% along the channel. Perennial invasive alien species kept in check (less than 30%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	B	Ensure that nutrient levels are within Tolerable limits: The 50th percentile of the data may be at 0.125 mg/L PO_4-P (aquatic ecosystems: driver). The 50th percentile of the data must be ≤ 4.0 mg/L TIN-N (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 200 mS/m (Aquatic ecosystems: driver). Note this is a naturally salinised system.
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).

Component/ Indicator	Target EC	RQOs
		Ensure that As levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.020 mg/L As (aquatic ecosystems: driver).
		Ensure that (free) Cn levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.004 mg/L Cn (aquatic ecosystems: driver).

1 TWQR = Target WQ Range (DWAF, 1996a).

Table 12.11 RIVERS: RQOs for WQ, geomorphology, riparian vegetation, macro-invertebrates and fish in HIGH priority RUs of the SABIE AND SAND RIVER (X3) system in the Inkomati catchment (X3)

Component/ Indicator	Target EC	RQOs
IUA X3-2; MRU SABIE A (EWR S1) (Sabie River)		
Geomorphology	**B**	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 83%.
Fish	**B**	RQO will be immediately applicable if the non-flow related measures are addressed. This will result in an improvement in the fish assemblage (reduced sedimentation of rocky substrate, improved indigenous vegetative habitats). Fish species richness of eight species must be maintained. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic *Varicorhinus nelspruitensis* (VNEL).
Invertebrates	**B**	Community is representative of a small mountain stream assemblage. Maintain the EC, good SIC and MV, 1 high flow velocity species. For an improvement in the PES additional key taxa for the improved situation: Oligoneuridae and Prosopistomatidae.
Riparian vegetation	**B**	RQO will be immediately applicable if the non-flow related measures are addressed. This will result in the woody cover improving and reed cover decreasing. Perennial invasive alien species should be less than 10%. No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	**A/B**	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR[1] for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-2; MRU SABIE A (EWR S2) (Sabie River)		
Geomorphology	**B**	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 85%.
Fish	**B**	RQO will be immediately applicable if the non-flow related measures are addressed. This will result in an improvement in the fish assemblage (reduced sedimentation of rocky substrate, improved indigenous vegetative habitats).Maintain fish species richness of eight species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic (VNEL).
Invertebrates	**B**	Community is representative of a small mountain stream assemblage. RQO will be immediately applicable if the non-flow related measures are addressed. This will result in an improvement with increased South African Scoring System version 5 (SASS V) and Macro Invertebrate Response Assessment Index (MIRAI – Thirion,

Component/ Indicator	Target EC	RQOs
		2007) scores as well as additional taxa that will occur (Trichorythidae and Libellulidae)
Riparian vegetation	B	RQO will be immediately applicable if the non-flow related measures are addressed. This will result in the woody cover improving and reed cover decreasing. Perennial invasive alien species should be less than 10%. No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	B	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). For an improvement in the PES ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (aquatic ecosystems: driver)
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-3; MRU SABIE B (EWR S3) (Sabie River)		
Geomorphology	B	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 84%.
Fish	B	Maintain target EC of B and fish species richness of twenty six species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic (BMAR).
Invertebrates	B	Community is representative of a medium-sized foothill stream assemblage. Maintain the EC, good SIC and MV, 2 high flow velocity species.
Riparian vegetation	A/B	Maintain current EC. Maintain woody vegetation cover between 20 - 40%. Maintain non-woody cover between 30 - 90%. Maintain reed cover between 20 - 40% along the channel. Perennial invasive alien species kept in check (less than 5%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	B	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-2; MRU MAC A (EWR S4) (MacMac River)		
Geomorphology	A	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 93%.
Fish	B/C	Maintain target EC of B/C and fish species richness of twenty species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic (VNEL).
Invertebrates	A/B	Community is representative of a small mountain stream assemblage. Maintain the EC, good SIC and MV, 2 high flow velocity species.

Component/ Indicator	Target EC	RQOs
Riparian vegetation	A/B	Maintain current EC. Maintain woody vegetation cover between 20 - 80%. Maintain non-woody cover between 30 - 60% in the marginal zone. Maintain the absence of reed cover. Perennial invasive alien species kept in check (less than 5%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	A/B	Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver).
IUA X3-3; MRU MAR A (EWR S5) (Marite River)		
Geomorphology	C	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 65%.
Fish	B/C	Maintain target EC of B/C and fish species richness of twenty-six species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic (BMAR).
Invertebrates	B/C	Community is representative of a medium-sized foothill stream assemblage. Maintain the EC, good SIC and MV, 2 high flow velocity species.
Riparian vegetation	B/C	Maintain current EC. Maintain woody vegetation cover between 70 - 80%. Maintain non-woody cover between 40 - 50% in the marginal zone. Maintain reed cover between 20 - 30% along the channel. Perennial invasive alien species kept in check (less than 15%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	B	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).
		Meet faecal coliform and E.coli targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-7; MRU MUT A (EWR S6) (Mutlumuvi River)		
Geomorphology	C	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 71%.
Fish	C	Maintain target EC of C and fish species richness of twenty six species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic (BMAR).
Invertebrates	B/C	Community is representative of a medium-sized Lowveld river assemblage. Maintain the EC, good SIC, sand and gravel habitat, and MV, two moderate flow velocity species.
Riparian vegetation	C	Maintain current EC. Maintain woody vegetation cover between 20 - 70% along the banks. Maintain reed cover between 10 - 90% along the channel. Perennial invasive alien species kept in check (less than 20%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	B/C	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the

Component/ Indicator	Target EC	RQOs
		TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or CEV limits or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-8; MRU SAND A (EWR S7) (Thulandziteka River)		
Geomorphology	**C/D**	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 61%.
Fish	**C**	Maintain target EC of C and fish species richness of twenty-nine species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic (BMAR).
Invertebrates	**B/C**	Community is representative of a medium-sized Lowveld river assemblage. Maintain the EC, good SIC, sand and gravel habitat, and MV, one high flow velocity species.
Riparian vegetation	**C**	Maintain current EC. Maintain woody vegetation cover between 20 - 70% along the banks. Maintain reed cover between 10 - 90% along the channel. Perennial invasive alien species kept in check (less than 20%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	**C**	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO4-P (aquatic ecosystems: driver).
		Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 42 mS/m (aquatic ecosystems: driver).
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-9; MRU SAND B (EWR S8) (Sand River)		
Geomorphology	**C**	Maintain the bed material size distribution within the active channel in order to maintain the available physical habitats. Maintain the channel/reach type. PES score from the GAI level IV should equal or exceed 71%.
Fish	**B**	Maintain target EC of B and high fish species richness of thirty-five species. Suitable habitats should be adequate for especially the primary indicator fish species, namely the small rheophilic (CANO) and the large semi-rheophilic (BMAR).
Invertebrates	**B**	Community is representative of a medium-sized Lowveld river assemblage. Maintain the EC, good SIC, sand and gravel habitat, and MV, one moderate flow velocity species.
Riparian vegetation	**B**	Maintain current EC. Maintain the absence of terrestrial woody species in the channel. Maintain reed cover between 20 - 80% along the channel. Perennial invasive alien species kept in check (less than 10%). No increase of riparian zone fragmentation. Maintain riparian taxon richness.
WQ	**B**	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver).
		Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).

1 TWQR = Target WQ Range (DWAF, 1996a).

12.4.3 WQ RQOs in High WQ priority RUs other than EWR sites

Table 12.12 – 12.14 provides the WQ RQOs for each IUA of high priority RUs (other than EWR sites) in the respective river systems.

Table 12.12 RIVERS: Summary of key WQ RQOs in HIGH WQ priority RUs of the KOMATI RIVER system (X1) in the Inkomati catchment

RUs	SQ number	WQ RQOs
IUA X1-1		
RU K1	X11A-01358	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure pH levels stay within Acceptable limits: A small change from the Ideal range is allowed, i.e. a 5th percentile of 5.9 - 6.5, and a 95th percentile of 8.0 - 8.8 (aquatic ecosystems: driver). Ensure that toxics are within Ideal limits or A Categories or TWQR[1]: 95th percentile of the data must be within the TWQR[1] for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Ensure that sulphate levels are within Acceptable limits: 95th percentile of the data must be less than 30 mg/L (industrial cat 3: drivers; DWA, 2012). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
	X11A-01248	
	X11A-01295	
RU K2	X11B-01370	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure pH levels stay within Acceptable limits: A small change from the Ideal range is allowed, i.e. a 5th percentile of 5.9 - 6.5, and a 95th percentile of 8.0 - 8.8 (aquatic ecosystems: driver). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Ensure that sulphate levels are within Acceptable limits: 95th percentile of the data must be less than 30 mg/L (industrial cat 3: drivers; DWA, 2012). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
	X11B-01361	
	X11B-01272	
IUA X1-3		
RU K3	X11C-01147	Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure pH levels stay within Acceptable limits: A small change from the Ideal range is allowed, i.e. a 5th percentile of 5.9 - 6.5, and a 95th percentile of 8.0 - 8.8 (aquatic ecosystems: driver). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Ensure that sulphate levels are within Acceptable limits: 95th percentile of the data must be less than 30 mg/L (industrial cat 3: drivers; DWA, 2012).
	X11D-01129	
	X11D-01137	
RU K4	X11E-01237	Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver).
RU K13	X13L-01000	Ensure that electrical conductivity (salt) levels are within Tolerable limits: 95th percentile of the data must be less than or equal to 85 mS/m (aquatic ecosystems: driver). Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver).

RUs	SQ number	WQ RQOs
		Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
MRU Komati E	X13K-01114 X13K-01038 X13L-01027 X13L-00995	Ensure that electrical conductivity (salt) levels are within Tolerable limits: 95th percentile of the data must be less than or equal to 85 mS/m (aquatic ecosystems: driver). Ensure that temperatures stay within Acceptable limits: A moderate change to instream temperatures should occur infrequently, i.e. vary by no more than 2ºC. Highly temperature sensitive species will occur in lower abundances (aquatic ecosystems: driver). Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity. Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within the CEV limits: 95th percentile of the data must be within the CEV for toxics or the B Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b) (aquatic ecosystems: driver).

1 TWQR = Target WQ Range (DWAF, 1996a).

Table 12.13 RIVERS: Summary of key WQ RQOs in HIGH WQ priority RUs of the CROCODILE RIVER system (X2) in the Inkomati catchment

RUs	SQ number	WQ RQOs
IUA X2-3		
MRU Elan A	X21F-01046 X21F-01081 X21G-01037 ER 1	Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A Categories or TWQR1: 95th percentile of the data must be within the TWQR[1] for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Ensure that pH stays within Ideal limits: 5th and 95th percentiles of pH data must be between 6.5 and 8.0 (aquatic ecosystems: driver). Ensure that Cr-VI levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.014 mg/L Cr-VI (aquatic ecosystems: driver). Ensure that Mn levels are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR of 0.180 mg/L Mn (aquatic ecosystems: driver).
RU C7	X21F-01100	Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Ensure that pH stays within Ideal limits: 5th and 95th percentiles of pH data must be between 6.5 and 8.0 (aquatic ecosystems: driver). Ensure that Cr-VI levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.014 mg/L Cr-VI (aquatic ecosystems: driver). Ensure that Mn levels are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR of 0.180 mg/L Mn (aquatic ecosystems: driver).
IUA X2-4		

<table>
<tr><th>RUs</th><th>SQ number</th><th>WQ RQOs</th></tr>
<tr><td rowspan="2">MRU Elan B</td><td>X21G-1073</td><td rowspan="2">Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.</td></tr>
<tr><td>X21J-01013</td></tr>
<tr><th colspan="3">IUA X2-5</th></tr>
<tr><td rowspan="2">MRU Elan B</td><td>X21K-01035 ER 2</td><td rowspan="2">Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.</td></tr>
<tr><td>X21K-00997</td></tr>
<tr><th colspan="3">IUA X2-6 AND PART OF IUA X2-9</th></tr>
<tr><td rowspan="8">MRU Croc C</td><td>X22B-00987</td><td rowspan="6">Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver).
Meet faecal coliform and E.coli targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
Ensure that Mn levels are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR of 0.180 mg/L Mn (aquatic ecosystems: driver).
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.</td></tr>
<tr><td>X22B-00888</td></tr>
<tr><td>X22C-00946</td></tr>
<tr><td>X22J-00993</td></tr>
<tr><td>X22J-00958</td></tr>
<tr><td>X22K-00981</td></tr>
<tr><td>X22J-00958</td><td rowspan="2">Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver).
Meet faecal coliform and E.coli targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).</td></tr>
<tr><td>X22K-00981</td></tr>
<tr><th colspan="3">IUA X2-8</th></tr>
<tr><td>RU C12</td><td>X22C-01004</td><td>Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
Ensure that Mn levels are within Ideal limits or A categories or TWQR: 95th percentile of the data must be within the TWQR of 0.180 mg/L Mn (aquatic ecosystems: driver).
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.</td></tr>
<tr><td>RU C14</td><td>X22H-00836</td><td>Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).
Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver).
Meet faecal coliform and E.coli targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).</td></tr>
</table>

RUs	SQ number	WQ RQOs
		Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X2-10		
RU C16	X23B-01052	Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.
RU C17	X23C-01098 X23E-01154 X23F-01120	Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Ensure that As levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.020 mg/L As (aquatic ecosystems: driver). Ensure that (free) Cn levels are within Ideal limits or A Categories: 95th percentile of the data must be less than 0.004 mg/L Cn (aquatic ecosystems: driver).
IUA X2-11		
MRU Croc D	X24C-01033	Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 85 mS/m (aquatic ecosystems: driver). Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity.
IUA X2-12 AND X2-13		
RU C19	X24B-00903	Ensure that electrical conductivity (salt) levels are within Acceptable limits: 95th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver). Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver). Meet faecal coliform and E.coli targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).

1 TWQR = Target WQ Range (DWAF, 1996a).

Table 12.14 RIVERS: Summary of key WQ RQOs in HIGH WQ priority RUs of the SABIE AND SAND RIVER system (X3) in the Inkomati catchment

RUs	SQ number	WQ RQOs
IUA X3-4		
RU S6	X31J-00774	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate

RUs	SQ number	WQ RQOs
	X31J-00835	change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A Categories or TWQR[1]: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
RU S9	X31K-00713	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-5		
MRU Sabie C	X33A-00731 X33A-00737 X33B-00784 X33B-00804 X33B-00829 X33D-00811 X33D-00861	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P. Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 42 mS/m (aquatic ecosystems: driver). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b).
IUA X3-7		
RU S13	X32E-00639	Ensure that nutrient levels are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that periphyton chl-a levels are within Tolerable limits: 50th percentile of the data must be less than or equal to 84 mg/m^2 (aquatic ecosystems: driver). Ensure that electrical conductivity (salt) levels are within Ideal limits: 95th percentile of the data must be less than or equal to 42 mS/m (aquatic ecosystems: driver). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
IUA X3-8		
RU S14	X32B-00551	Ensure that nutrient levels are within Acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that turbidity/clarity or TSS levels stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads; or <10% change from background TSS levels (aquatic ecosystems: driver). Meet faecal coliform and *E.coli* targets for recreational (full contact) use: Meet the TWQR of 0 - 130 counts per 100 ml (DWAF, 1996b). Ensure that toxics are within Ideal limits or A Categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A Category in DWAF (2008b). Numerical limits can be found in DWAF (1996a) and DWAF (2008b).

1 TWQR = Target WQ Range (DWAF, 1996a).

12.4.4 Wetland RQOs

Table 12.15 to 12.17 provides the habitat and biota RQOs for HIGH priority wetlands in each IUA. The locality of the wetlands is linked to the river RU and biophysical nodes. The target EC is provided for the relevant wetlands in the Resource Unit. All target ECs are set to maintain the PES and are therefore immediately applicable. It must be noted, that although these wetlands can be of high priority, the level of RQOs provided are at MODERATE level due to lack of detailed information such as baseflow conditions and as none of the scenarios will impact on the wetlands.

Note that the following RQOs for the wetlands are standard and relevant for all RUs:

- Maintain species composition and vegetative cover.
- No increase in the cover or abundance of woody alien invasive species.
- No increase in wetland fragmentation.

Table 12.15 WETLANDS: Summary of key RQOs in MODERATE priority RUs of the KOMATI RIVER system (X1) in the Inkomati catchment

RUs	SQ number	Target EC	Wetland RQO
X1-1			
RU K1	X11A-01354	**C**	Maintain C EC. Cessation of land use encroachment on pans, seeps and channeled valley bottom wetland.
	X11A-01248	**C**	
RU K2	X11B-01272	**B/C**	Improve to B/C by increasing buffer zones where wetlands are not artificial. Cessation of land use encroachment on non-artificial channeled valley bottom wetlands.
X1-3			
RU K3	X11C-01147	**C**	Maintain C EC. Cessation of land use encroachment on pans, seeps and non-artificial channeled valley bottom wetlands.
	X11D-01129	**C**	
RU K4	X11E-01237	**B**	Maintain wetland EC of B/C. Cessation of land use encroachment on channeled valley bottom wetlands.
RU K5	X11G-01143	**C**	Maintain wetland EC of C. Cessation of land use encroachment on seeps.
X1-6			
RU K8	X12A-01305	**B**	Cessation of land use, urban and forestry encroachment on seeps and channeled valley bottom wetlands.
	X12C-01271	**B**	
	X12D-01235	**B/C**	
X1-9			
RU K11	X13J-01205	**D**	Maintain wetland EC of D. Cessation of land use and agricultural encroachment on floodplain and non-artificial channeled valley bottom wetlands.

Table 12.16 WETLANDS: Summary of key RQOs in MODERATE priority RUs of the CROCODILE RIVER system (X2) in the Inkomati catchment

RUs	SQ number	REC	Wetland RQO
IUA X2-1			
MRU Croc A	X21A-00930	**B/C**	Off-channel wetlands generally in better condition, as well as those in Verloren Valei Nature Reserve. Other wetlands, improve to a B by improving wetland buffers, remove alien woody species in wetlands, no more dams and rehabilitate those not in use, reduce amount of dams if possible. Cessation of land use and forestry encroachment on wetlands

RUs	SQ number	REC	Wetland RQO
RU C1	X21B-00929	**C**	See above.
	X21B-00898	**C**	
RU C2	X21C-00859	**C**	Improve to a C by improving buffer zones for wetlands especially with reference to agriculture. Cessation of land use and forestry encroachment on natural wetlands.
IUA X2-3			
MRU Elan A	X21F-01046	**B/C**	Improve to a B/C by removing agriculture from wetland areas. Cessation of land use and agricultural encroachment on natural wetlands (seeps and channelled valley bottom).
IUA X2-8			
RU C12	X22C-01004	**B/C**	Improve to a B/C by removing agriculture from wetland areas. Cessation of land use and forestry encroachment on natural wetlands (seeps and channelled valley bottom).
RU C14	X22H-00836	**D**	Maintain EC of a D. Cessation of farm dam construction
IUA X2-10			
RU C17	X23E-01154	**B/C**	Maintain EC of a B/C. Cessation of forestry encroachment on seeps.

13 GROUNDWATER RESOURCE QUALITY OBJECTIVES

This chapter is an extract from report: DWS (2014e) -The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Resource Quality Objectives: Groundwater. Authored by Martin Holland. DWS Report, RDM/WMA05/00/CON/CLA/0514. December 2014.

13.1 BACKGROUND

The catchments of the Inkomati are predominantly (> 60%) underlain by igneous and metamorphic crystalline basement rocks comprising of the Northern Basement Rocks (i.e. Nelspruit Suite) and the Barberton Supergroup. The Inkomati aquifers comprise of five groundwater regions as defined by Vegter (2000) and are predominantly characterised by their geological settings. Within each of these regions a number of aquifer types can be differentiated namely:

- Intergranular (weathered) and Fractured Aquifers
- Fracture Aquifer
- Intergranular (alluvial) aquifers

Based on the borehole yield classification insignificant to minor aquifers are present in large parts of the Inkomati. Moderate intergranular aquifer zones are associated with river courses, valleys or open plains and although not specifically mapped, they do occur locally throughout the Inkomati. The Malmani dolomite formations cutting across the Inkomati forms a moderate Karst aquifer.

Based on the collated borehole datasets obtained from the National Groundwater Archive (NGA) average water levels range from 7 to 25 m below surface with average borehole yields of 0.4 to 3.1 l/s.

The 'Great Escarpment' is an important recharge area and groundwater provides significant baseflow to the head waters of surface drainages. The lower reaches of the Inkomati lack on the other hand groundwater baseflow and many major rivers have a low probability of being groundwater-fed. Mean annual groundwater recharge varies from 100 to 150 mm in the higher rainfall areas along the central escarpment regions to 10 to 25 mm in the low rainfall and lower lying easternmost portion of the Inkomati.

According to the Inkomati WMA Internal Strategic Perspective (ISP) groundwater use amounts to 27.5 Million m^3/a based on the Water Use Authorisation and Registration Management System (WARMS) database (2004), while estimated use based on the Groundwater Resource Assessment II (GRA II) dataset amount to only 13.3 Million m^3/a (DWAF, 2004). The current study approach took also cognisance of the GRA II and WARMS 2013 datasets to achieve a more balanced estimate of groundwater use. The total groundwater use for the Inkomati was subsequently estimated to 52.3 Mm*3*/a.

Approximately 800 groundWQ samples (latest analysis per station) were collated from the NGA and Water Management System (WMS) datasets. A deterioration of the groundWQ (salinity) in the Inkomati from west to east, following essentially the average annual rainfall, is obvious. Several samples show major ion concentrations (i.e. Mg, Na, Cl, and F) and subsequently electric conductivities elevated to Class II drinking water qualities. This can mostly be related to evaporative concentration of elements in discharge areas or low recharge values, while the occurrence of fluoride is primarily controlled by geology.

Historical mining activities have resulted in the presence of abandoned adits, shafts, mine reside deposits and other infrastructure scattered across the area, although the impact of these on groundWQ is thought to be rather local in nature. Other potential threats to groundWQ include sub-standard sewage treatment plants and agricultural activities. Due to the growing population, the increase in the use of septic tanks, pit and bucket latrines, poses a direct risk to the groundWQ in terms of nitrate and bacterial or viral concentrations.

13.2 GROUNDWATER CLASSIFICATION

13.2.1 Groundwater units

The delineation of Groundwater Units (GUs) is based on hydrogeological criteria and might not necessarily correlate to quaternary surface water catchments or surface water units of analysis. However, it must be kept in mind during the delineation of groundwater units of analysis, that a Class, Reserve and RQOs have to be set for each unit; linkages with other components have to be considered; and that each unit will have to be managed. As a result, the delineation is largely based on management considerations while attention is given to hydrogeological criteria. As a result, the current delineation of GUs for the Inkomati was based on the following criteria:

- Surface water units of analysis as part of this project.
- The four main Inkomati sub-catchments were considered, namely the Komati, Crocodile, Sabie-Sand and the undeveloped X4 sub-catchment in the KNP.

A total of nineteen GUs were delineated across the main river systems (Figure 13.1).

13.2.2 Summary

The Komati sub-catchment comprises of seven GUs. Groundwater use is substantially higher within the lower parts of the Komati sub-catchment with a registered groundwater use of over 6 Mm^3/a. These volumes need to be verified with follow-up studies but may well relate to either an over registration or wrongly entered information into WARMS. The aquifers of the Komati sub-catchment are by far not utilised to their potential. Overall groundWQ in the Upper Komati sub-catchment is regarded as good with most samples complying with the recommended drinking WQ standards. Coal mining poses a threat to the quality of the groundwater if compliance to environmental legislation is not enforced. Groundwater level fluctuations from the observed hydrographs vary between 1 and 3 m. No declining trend due to abstraction is observed from the hydrographs.

The Crocodile sub-catchment comprises of six GUs. Groundwater use is dominated by irrigation and forestry. Numerous rural communities occur within the region dependant on groundwater for water supply. Groundwater use in relation to recharge and available resources is minimal throughout the sub-catchment. The overall groundWQ in the Crocodile sub-catchment is regarded as good with most samples complying with the recommended drinking WQ standards. Slightly elevated sulphate concentrations compared to the population are seen in some samples. These locally impacted groundWQ might be related to the industrial activities occurring along the Elands River. Groundwater level fluctuations from the observed hydrographs vary between 1 and 4 m. No declining trend due to over abstraction is observed from the hydrographs.

The Sabie-Sand sub-catchment comprises of five GUs. Groundwater use is predominantly for domestic use specifically in the Middle Sabie and Bushbuckridge areas. The aquifers of the Sabie-Sand sub-catchment are by far not utilised to their potential. The upper Sabie-Sand sub-catchment provides a groundwater contribution to surface flow from springs and seeps along the escarpment, as well as from the dolomitic formation which extends across the headwaters of the of the Sabie River. The overall groundWQ in the Sabie-Sand sub-catchment is regarded as good with most samples complying with the recommended drinking WQ limits. A slightly poorer WQ is observed in the Lower Sabie-Sand region, mainly due to elevated electrical conductivity, Total Dissolved Salt (TDS), Sodium and Chloride values. This can again be related to evaporative concentration of elements in discharge areas, and low recharge values. Although not yet above recommended drinking water guideline limits, elevated Nitrate concentrations within suggest potential anthropogenic influences on the groundWQ related to inappropriate on-site sanitation, wastewater treatment including sewage sludge disposal or livestock concentration (animal feedlots) at watering points near boreholes. Water levels show a general seasonal fluctuation and no declining trend due to abstraction is observed from the hydrographs.

In summary, groundwater use in relation to recharge and available resources (harvest potential) is minimal throughout Inkomati (Figure 13.2). Numerous groundwater level monitoring datasets depict and increasing trend suggesting that the system is no under significant stress due to over abstraction. Increasing domestic and other industries water requirements could be met from groundwater. The groundWQ of the Inkomati is generally of potable use; however, some boreholes do show elevated nitrate concentrations.

13.3 RESOURCE QUALITY OBJECTIVES

13.3.1 Approach and prioritisation

The process followed to develop groundwater RQOs can be summarised as follows:

- Collate and synthesize groundwater data (i.e. GRA II, DWS monitoring data and WARMS information) for each quaternary catchment in each groundwater unit in order to establish:
  - Borehole yields.
  - Groundwater levels.
  - Groundwater harvest and exploitation potential.
  - Existing groundwater (use) abstraction rates.
  - GroundWQ.
  - Baseflow potential.
  - Recharge.

The groundwater RQOs and appropriate numerical limits are based on what information is available and estimations using hydrogeological reasoning. It is understood that the Inkomati is not regarded as a high groundwater priority area and the status quo was largely based on a desktop assessment. In many cases not sufficient monitoring was available or collated to derive detailed RQOs. Where possible, existing monitoring networks were taken into account in setting the RQOs. Although, the Resource Unit Prioritisation Tool can be applied for rivers, wetlands and estuaries, currently no methodology exists for prioritising groundwater Resource Units (DWA, 2011b). As a result no official criteria and rating guideline was applied for the Inkomati RQO but prioritisation was based on the following main indicators:

- **Importance for users**: Some aquifers in the Inkomati provide significant services for the environment and other users. The importance for users was evaluated with respect to the current and possible future use by the different water sectors.
- **Threat posed to users/receptors**: Depending on the pattern and scale of groundwater abstraction as well as the land use within the resource units the different aquifers might be at risk of over-abstraction (indicated by aquifer stress and decline in water level) and or pollution (indicated by decline in WQ), both of were considered in the prioritisation.

- **Practical considerations**: RQOs can only be implemented and enforced if they can be measured. Hence, the focus was on identifying resource units with a sufficient groundwater monitoring network and existing baseline data to allow for comparison with data collected in the future.
- **Level of surface water – groundwater interaction**: Depending on the aquifer type and its interaction with surface water bodies it has greater or lesser relevance for maintaining the hydrological integrity and WQ of the ecosystem. The aquifer types occurring in the GU and their contribution to surface water low flows were considered, as these could impact on possible management options.

A summary of the criteria used for identifying groundwater priority areas is listed in Table 13.1 to Table 13.3. A number of water level monitoring boreholes occur throughout the Inkomati. However, the monitoring of groundWQ (collated through the DWS - WMS) is limited and should be expanded or, if possible, ceased monitoring sites should be re-instated. Figure 13.3 also shows the spatial distribution of nitrate concentrations from the collated status quo assessment indicating that numerous boreholes exceed the recommended drinking WQ limit of 11 mg/l (SANS 241: 2011).

Table 13.1 Priority groundwater units for the Komati River system

Description	GUs	Quat	Importance for users	Threat to posed users/receptors	Practical consideration	SW-GW Interaction	Over-riding indictors	Recommendation
Komati Highveld	GU1-1	X11B	Groundwater use is predominantly for mining, while some groundwater is used for forestry and domestic use.	High potential for AMD within the coal mining region.	No DWS water level monitoring. Limited quality data.	Medium baseflow probability.	GroundWQ.	Establish appropriate monitoring protocols (water levels and quantity). Collate mine monitoring data. Increase groundwater allocation.
Escarpment Komati	GU1-3	X11H X11J	Groundwater use is predominantly for mining and forestry.	Groundwater abstraction within close proximity to major rivers is likely to impact on baseflow in the region.	No DWS water level monitoring. Limited quality data.	Significant source of baseflow.	Baseflow.	Establish appropriate monitoring protocols (water levels). Increase groundwater allocation. Potential large scale abstraction within the proximity of a river should be assessed based on the local aquifer characteristics.
Middle Komati	GU1-5	X12F X12H	Domestic groundwater use/rural water supply.	Risk of over-abstraction and or pollution.	Available DWS water level monitoring (X12H. Limited quality data.	High baseflow probability.	Groundwater use. Quality	Verify groundwater use volume. Expand monitoring programme. Collate mine monitoring data. Increase groundwater allocation.
		X12K	Groundwater use is predominantly for mining domestic use.	Potential for AMD within the gold mining region.	No DWS water level monitoring. Limited quality data.			
Lower Komati	GU1-6	X13J X14G X14H	Domestic groundwater use/rural water supply.	Risk of over-abstraction and or pollution.	Available DWS water level monitoring (X13J). Limited quality data.	High baseflow probability.	Groundwater use. Quality	Verify groundwater use volume. Expand monitoring programme. Increase groundwater allocation.

1 Surface water – groundwater.

Table 13.2 Priority groundwater units for the Crocodile River system

Description	GUs	Quat.	Importance for users	Threat to posed users/receptors	Practical consideration	SW-GW Interaction	Over-riding indictors	Recommendation
Escarpment Dolomites	GU2-3	X21H X21J X21K	Groundwater use is predominantly for mining and forestry.	Groundwater abstraction within close proximity to major rivers is likely to impact on baseflow in the region/potential for AMD within the gold mining.	Available DWS water level monitoring (X21J). Limited quality data.	Significant source of baseflow.	Baseflow. Quality	Establish appropriate monitoring protocols (water levels). Set groundwater baseflow contribution protection zones. Increase groundwater allocation. Potential large scale abstraction within the proximity of a river should be assessed based on the local aquifer characteristics.
Middle Crocodile	GU2-4	X22H X22J X22K	Domestic groundwater use.	Risk of over-abstraction and or pollution.	Available DWS water level monitoring (X22J). Limited quality data.	Significant baseflow probability.	Groundwater use. Quality	Verify groundwater use volume/ Expand monitoring programme/ Increase groundwater allocation. Potential large scale abstraction within the proximity of a river should be assessed based on the local aquifer characteristics.
		X24A X24B X24C	Domestic groundwater use. Rural water supply.	Risk of over-abstraction and or pollution.	Available DWS water level monitoring. Limited quality data.	Medium baseflow probability.	Groundwater use. Quality	Verify groundwater use volume. Expand monitoring programme. Increase groundwater allocation.
Barberton Region	GU2-5	X23B X23F X23G	Groundwater use is predominantly for mining and rural water supply	High potential for AMD within the gold mining region.	No DWS water level monitoring.	Significant baseflow probability.	Quality	Establish appropriate monitoring protocols (water levels and quantity). Increase groundwater allocation. Potential large scale abstraction within the proximity of a river should be assessed based on the local aquifer characteristics.

Table 13.3 Priority groundwater units for the Sabie-Sand River system

Description	GUs	Quat.	Importance for users	Threat to posed users/receptors	Practical consideration	SW-GW Interaction	Over-riding indictors	Recommendation
Upper Sabie	GU3-1	X31A	Domestic groundwater use. Rural water supply.	Groundwater abstraction within close proximity to major rivers is likely to impact on baseflow in the region. Risk of over-abstraction and or pollution.	No DWS water level monitoring. Quality data.	Significant baseflow probability.	Baseflow. Quality	Establish appropriate monitoring protocols (water levels). Set groundwater baseflow contribution protection zones. Potential large scale abstraction within the proximity of a river should be assessed based on the local aquifer characteristics.
Middle Sabie	GU3-2	X31G X31K X31L	Domestic groundwater use. Rural water supply.	Risk of over-abstraction and or pollution.	No DWS water level monitoring. Quality data.	Low to medium baseflow probability.	Groundwater use. Quality (some poor quality boreholes with elevated nitrates exist).	Verify groundwater use volume. Expand DWS water level monitoring.
Upper Sand	GU3-3	X32A X32B X32C X32D X32E X32F X32G	Domestic groundwater use. Rural water supply.	Risk of over-abstraction and or pollution.	Available DWS water level monitoring. Quality data.	Low to medium baseflow probability.	Groundwater use. Quality (some poor quality boreholes with elevated nitrates exist).	Verify groundwater use volume. Expand DWS water level monitoring.
Middle Sand	GU3-4	X31M X32H	Domestic groundwater use. Rural water supply.	Risk of over-abstraction and or pollution.	No DWS water level monitoring. Quality data.	Low baseflow probability.	Groundwater use. Quality (some poor quality boreholes with elevated nitrates exist).	Verify groundwater use volume. Expand DWS water level monitoring.

13.3.2 Groundwater RQOs

Based on the prioritisation, an assessment of the 11 GUs resulted in the groundwater RQOs shown in Table 13.4 to Table 13.6. The relevant RQO parameters used included water level, baseflow and WQ. The setting of water quantity related RQOs (i.e. water level and baseflow) is aimed at maintaining water levels within natural seasonal fluctuations ensuring sufficient yield for all users and to improve or maintain groundwater discharge to support low flow river requirements. The setting of WQ related RQOs is aimed at maintaining the groundWQ in relation to its background/present level, or ensuring compliance with WQ standards for domestic use, as this is the more stringent requirement for the variety of users in the GU.

Table 13.4 Summary of RQOs for Groundwater in the Komati River system

IUA	GU	Component	Narrative RQO	Indicator/Measure	Numerical Criteria
X1-2 and X1-3	GU1-3	Quantity	Groundwater flow directions in the resource unit should not be reversed from it natural flow directions towards the drainage systems.	Continuous flow measurement at EWR G1.	19.9 % nMAR[1]
X1-6 and X1-5	GU1-5			Continuous flow measurement at EWR T1.	22.6 % nMAR[1]
X1-8 and X1-9	GU1-6			Continuous flow measurement at EWR K3 and EWR L1.	9.9 and 11.7 % nMAR[1]
X1-6 and X1-5	GU1-5	Aquifer	No negative trend between peak drawdowns during dry seasons. Seasonal fluctuation to stay within natural range.	Water level - Depth to Groundwater Level at active monitoring boreholes using Groundwater Monitoring Guidelines*.	
X1-8 and X1-9	GU1-6				
All	All prioritised GUs	Quality	GroundWQ should be based on background groundWQ. Sites that exceed the water use requirement[#] should not be allowed to deteriorate in WQ.	Background WQ per borehole/spring using Groundwater Monitoring Guidelines* Bi-annual monitoring.	WQ should not be allowed to deteriorate significantly from background WQ[3].
X1-1	GU1-1		Salinity levels should not increase. Concentrations must be maintained at levels to support domestic and ecological water users.	Salts - Electrical Conductivity. Bi-annual monitoring.	Electrical Conductivity ≤ 40 mS/m (based on quality dataset).
X1-6 and X1-5	GU1-5		Nitrate values in the GU must be maintained to support domestic water users.	Nutrients – Nitrate (as Nitrogen). Bi-annual monitoring.	Nitrate (as N)< 4 mg/l in recharge area (based on quality dataset).
X1-8 and X1-9	GU1-6		Nitrate values in the GU must be maintained to support domestic water users.	Nutrients – Nitrate (as Nitrogen). Bi-annual monitoring.	Nitrate (as N)< 5 mg/l in recharge area (based on quality dataset).

Table 13.5 Summary of RQOs for Groundwater in the Crocodile River system

IUA	GUs	Component	RQO	Indicator/Measure	Numerical Criteria
X2-2 and X2-4	GU2-3	Quantity	Groundwater flow directions in the resource unit should not be reversed from it natural flow directions towards the drainage systems.	Continuous flow measurement at EWR C3 and ER1.	30.1 and 4.97 % nMAR[1].
X2-7, X2-5, X2-6, X2-8 and X2-9	GU2-4			Continuous flow measurement at EWR C4.	9.07 % nMAR[1].
X2-10	GUA2-5			Continuous flow measurement at EWR C7.	6.18 % nMAR[1].
X2-2 and X2-4	GU2-3	Aquifer	No negative trend between peak drawdowns during dry	Water level - Depth to Groundwater Level at active monitoring boreholes	
X2-7, X2-5,	GU2-4				

IUA	GUs	Component	RQO	Indicator/Measure	Numerical Criteria
X2-6, X2-8 and X2-9			seasons. Seasonal fluctuation to stay within natural range.	using Groundwater Monitoring Guidelines*.	
X2-10	GU2-5				
All	All prioritised GUs	Quality	GroundWQ should be based on background groundWQ. Sites that exceed the water use requirement# should not be allowed to deteriorate in WQ.	Background WQ per borehole/spring using Groundwater Monitoring Guidelines*.	WQ should not be allowed to deteriorate significantly form background WQ[3].
X2-2 and X2-4	GU2-3		Salinity levels should not increase.	Salts - Electrical Conductivity. Bi-annual monitoring.	Electrical Conductivity ≤ 55mS/m (based on quality dataset).
X2-7, X2-5, X2-6, X2-8 and X2-9	GU2-4		Nitrate values must be maintained to support domestic water users.	Nutrients – Nitrate (as Nitrogen). Bi-annual monitoring.	Nitrate values in the recharge area should not increase to >3mg/l.
X2-10	GUA2-5				
X2-10	GUA2-5		Salinity levels should not increase. Concentrations must be maintained at levels to support domestic and ecological water users.	Salts - Electrical Conductivity. Bi-annual monitoring.	Electrical Conductivity ≤ 60 mS/m (based on quality dataset).

Table 13.6 Summary of RQOs for Groundwater in the Sabie-Sand River system

IUA	GUs	Component	RQO	Indicator/Measure	Numerical Criteria
X3-1 and X3-2	GU3-1	Quantity	Groundwater flow directions in the resource unit should not be reversed from it natural flow directions towards the drainage systems.	Continuous flow measurement at EWR 1 and EWR 4.	12.88 and 14.35 % nMAR[1].
X3-2, X3-4, X3-3 and X3-6	GU3-2			Continuous flow measurement at EWR 5 and EWR 3.	28.32 and 9.71 % nMAR[1].
X3-7 and X3-8	GU3-3			Continuous flow measurement at EWR 7 and EWR 6.	11.14 and 13.38 % nMAR[1].
X3-1 and X3-2	GU3-1	Aquifer	No negative trend between peak drawdowns during dry seasons. Seasonal fluctuation to stay within natural range.	Water level - Depth to Groundwater Level at active monitoring boreholes using Groundwater Monitoring Guidelines*.	
X3-7 and X3-8	GU3-3				
All	All prioritised GUs	Quality	GroundWQ should be based on background groundWQ. Sites that exceed the water use requirement# should not be allowed to deteriorate in WQ.	Background WQ per borehole/spring using Groundwater Monitoring Guidelines*.	WQ should not be allowed to deteriorate significantly from background WQ[3]
X3-1 and X3-2	GU3-1		Nitrate values must be maintained to support domestic water users.	Nutrients – Nitrate (as Nitrogen). Bi-annual monitoring.	Nitrate values in the recharge area should not increase to >2mg/l.
X3-2, X3-4, X3-3 and X3-6	GU3-2				Nitrate (as N)<8mg/l in recharge area (based on quality dataset).
X3-7 and X3-8	GU3-3				
X3-4	GU3-4				Nitrate (as N)<6mg/l in recharge area (based on quality dataset).

* - A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa, DWAF (2008c).
# - South African WQ Guidelines, DWAF (1996).
1 - %nMAR is flow required at the nodes expressed as a percentage of the natural MAR, Low flows.
2 - Unlike in a dam, seasonal fluctuations of groundwater levels in an aquifer are dependent on the location of measurement (e.g. recharge versus discharge areas, with lower variations expected in the proximity of a discharge area like a river), the recharge rate (dependent amongst others on the properties of overlying soils at this point) as well as the porosity of the aquifer as this point

(withhigher porosity aquifers showing lower variations). From a scientific point of view it is recommended that more than one numerical fluctuation limits for GU be used

3 - It is generally recognised that the groundwater chemistry evolves along a flow path, e.g. from a fresh low mineralised bicarbonate water in recharge areas to an older, higher mineralised water (water type dependent on amongst other factors the underlying geology) in discharge areas, where it is often undergoes additional concentration increases due to evapotranspiration. Additional factors influencing the groundWQ over relatively short distances include the occurrence of preferential flow paths (along fractures) or the proximity to pollution sources. The background quality observed at one monitoring site is therefore not necessarily applicable as a background value for another monitoring location.

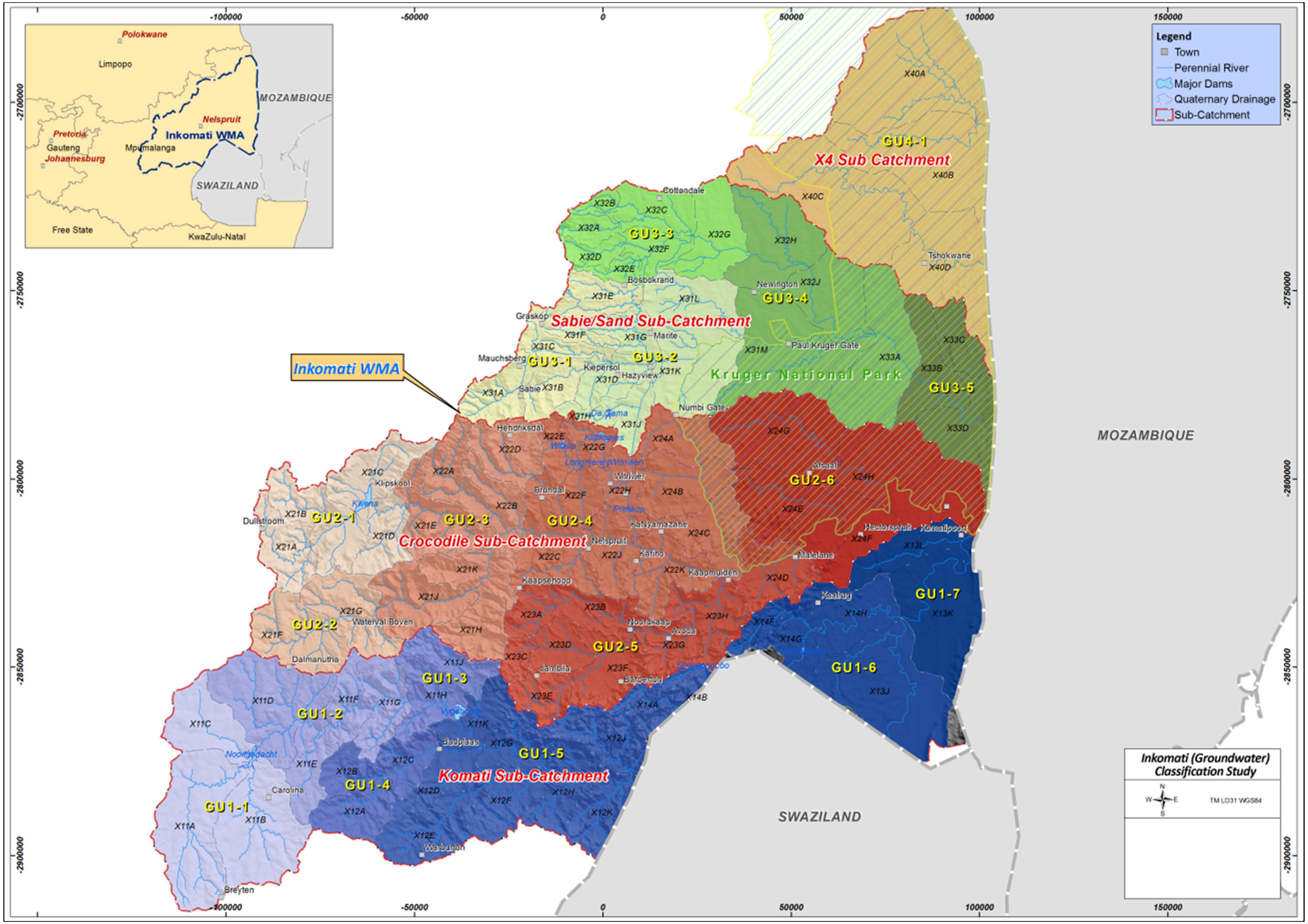


Figure 13.1 Delineated GUs for the catchments of the Inkomati

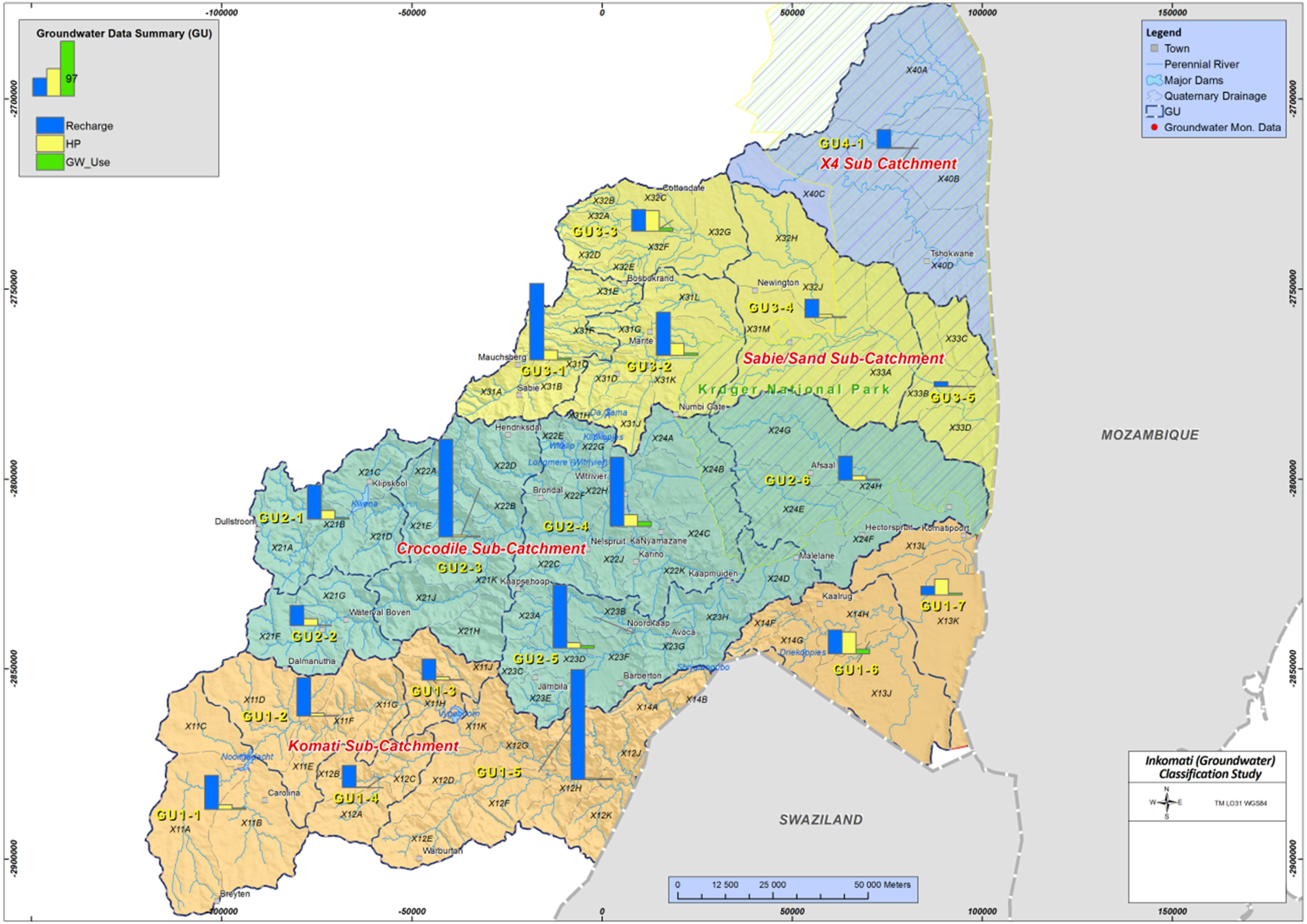


Figure 13.2 Groundwater use versus recharge and harvest potential

Figure 13.3 DWS Inkomati groundwater monitoring network

14 IMPLEMENTATION CONSIDERATIONS

This chapter is an extract from report: DWS (2015) -The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Implementation of the Classes and RQOs.Authored by MD Louw, S Mallory, P Scherman, P van Rooyen. Prepared by*:* Rivers for Africa eFlows Consulting (Pty) Ltd. DWS Report, RDM/WMA05/00/CON/CLA/0215. May 2015.

The chapter describes the principles and aspects to consider for implementing the NWRCS including the actions needed as well as a timeline to give effect to the RQOs. Monitoring to measure whether the RQOs are being achieved is also provided.

14.1 IMPLEMENTATION BUILDING BLOCKS AND COMPONENTS

The RQO implementation plan consists of three components:

- Firstly activities ensuring that the RQOs determined are adhered too (e.g. releasing or transferring water usually from storage).
- Secondly, monitoring (measuring) various aspects in order to determine whether or not the required RQOs are met or the resulting ecological health objectives are achieved.
- Lastly, if the intended outcomes are not observed from the monitoring process, adaptive management needs to take place in order to rectify the situation such that the desired RQOs are met. The figure below presents a simplified schematic of these three components, indicating a circular flow of information.

This is best demonstrated through what is needed for the flow RQOs:

- Activity: Release flow from a dam according to set rules.
- Monitoring: Record the flow at flow gauges and compare against EWR flow EWR at a downstream site.
- Adaptive Management: Inform operator to increase flow if target levels are not achieved.

Where the above cycle would typically be carried out at weekly or monthly frequencies a similar process would be followed for ecological variables, however, the cycle period could be annually of once every three years.

Important aspects that should be managed as part of this cycle are the flow of information including recorded (raw) data and information such as reports, meeting proceedings and decisions. This is to build up a history (record) of the implementation process as well as identify "lessons learned" to strengthen success and improve or adjust activities to achieve the desired results.

Some of the activities needed to fulfil the requirements of the RQO implementation plan relate to functions that are currently performed by different Directorates in DWS or even other institutions. Coordination among these institutions is essential. In addition to this, the uptake of particular responsibilities relating to these actions need to be formalised and added to their respective business plans. For example, institutions that will typically be involved are water users (e.g. Water Authority Associations and Municipalities) and DWS water resource operating personnel and active conservation bodies. This coordination may be formalised in an appropriate structure similar to a System Operating Forum (SOF) (as set up by DWS in various catchments across the country). All these role players need to contribute to the plan by, for example, sharing information and executing their assigned activities.

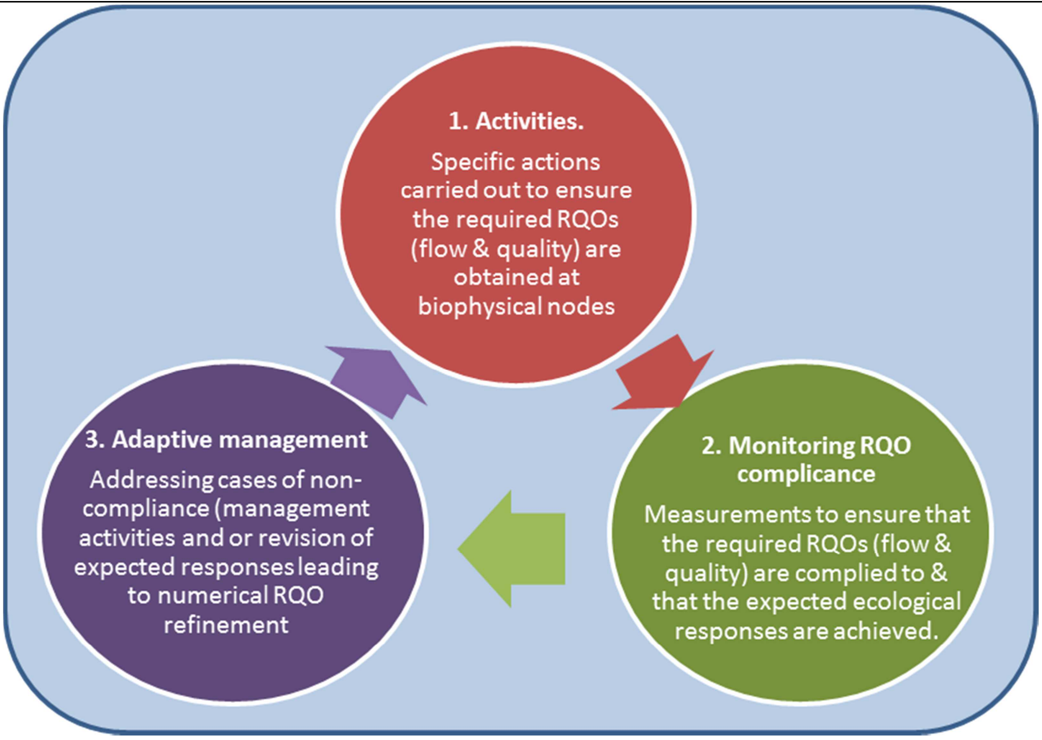


Figure 14.1 Core building blocks of the implementation plan

A RQO implementation plan must function within the existing environment of water resource management as well as existing monitoring programmes. While the regulation and control of the required RQOs are the responsibility of DWA's CD: WE, certain aspects that could cause violations of the required RQOs may relate to legislation managed and implemented by other Directorates within DWA, or even other Government Departments. Examples of this are pollution, abstraction and erosion control. It is not the intention of the implementation plan to either duplicate or replace existing legislation and/or institutions that already manage aspects affecting the RQOs, but to rather harness these and inform the relevant authorities that can take action using existing Acts and legislation. The plan should therefore allow for the linkages that will initiate the appropriate actions to enforce compliance in accordance with procedures already in place.

Implementation of the RQOs to achieve the Water Resource Class (hereafter referred to as the Class) basically consists of the following components:

- Implementing the operating rules in terms of the key driver (hydrology) to ensure that the discharges required by users and the ecology are met in time and place. This may consist of operation of dams, abstractions and other infrastructure as well as management through licensing and implementation of restrictions amongst other measures.
- Compliance hydrological monitoring based largely on the continuous monitoring at a network of gauges.
- Implementing WQ source control measures through operation and management of WWTW for example. If dam releases are relevant factors such as releases through multi-level outlets to maintain WQ would be relevant.
- Compliance WQ monitoring based largely on monitoring at gauges and other key points as well as monitoring through implementing agents and municipalities (often by the developers themselves as part of license conditions) amongst others. WQ RQOs at EWR sites and associated RUs are described through Ecological Specifications (EcoSpecs) and Thresholds of Potential Concern (TPCs).
- Implementation of catchment and non-flow related measures to achieve the Class: In some cases, non-flow (other than quality) related measures are required to achieve the Class's

catchment configuration. Although these measures may not be the responsibility of DWS to implement and manage, the RQOs are provided at a broad level. These measures most often relate to protection of the riparian buffer zone, alien vegetation control and control of erosion and sedimentation.

- Response monitoring of biota and habitat to determine whether the expected responses described as part of the Reserve and Classification assessments are being achieved. The responses are described at different levels of detail depending on the available information and priority level of the different river reaches. Generally the biota and habitat RQOs are described through EcoSpecs and TPCs where detailed numerical information is available at high priority river reaches (RUs) which contain EWR sites. Also note that the response monitoring is dependant on information on the hydrology and WQ compliance monitoring.

Note that the Reserve is encapsulated within the Class and RQOs. The Class and catchment configuration provides the associated EcoStatus for every river reach in the system. The EWRs associated with the accepted Class become the Ecological Reserve. The hydrology, WQ, habitat and biota RQOs therefore include the Reserve requirements. The response monitoring above directly refers to the monitoring of the EcoStatus and therefore by default the Ecological Reserve.

14.2 PROPOSED IMPLEMENTATION PLAN TO GIVE AFFECT TO THE RQOs

In its most basic form the implementation plan tries to answer the following three questions:

- **What** activities are required? i.e. the actions and work that has to be performed and at what intensity or level of detail these should be carried out;
- **When** should the activities take place? i.e. the frequency of work of activity; and
- **Who** is responsible for ensuring the work or activity are carried out?

It was recognised that the implementation plan should take account of the varying characteristics of the river reaches across the Komati, Crocodile and Sabie River systems, availability and need for monitoring information, the ability (currently and in the future) to regulate flow in the river reaches as well as the existing water resource management activities taking place or being planned.

The overarching approach to be followed in the execution of the implementation plan is that a sequence of activities needs to be introduced to accommodate proposed future infrastructure developments, rollout of ongoing water resource management activities such as the verification of the lawful water use as well as seeking alignment with the progressive implementation of the DWS Reconciliation Strategy and the strategies of the District Municipalities. The implementation plan has been divided into two phases, namely, operation to maintain the status quo and operation to meet recommended EWRs at key points which are currently not being met.

The tables below lists all the activities required for RQO implementation.

Table 14.1 Activities milestones and related processes: Komati River system

ID	Activity	Description
1	**Resource Quality Objectives & Class.**	
2	Legal Notice.	Published in Gazette and comment period.
3	Promulgation.	Approved by Minister of Water and Sanitation.
4	**Apply KOBWA and IUCMA operating models**	Existing decision support system.
5	Align KOBWA and the IUCMA models.	Ongoing discussion with between the IUCMA and KOBWA to align models.
6	**Monitoring.**	
7	Flow (continuous recordings).	Maintain flow gauges.
8	WQ (continuous from current activities).	▪ Maintain current DWS WQ monitoring activities. ▪ Identify and maintain monitoring programmes other than DWS. Ensure these data are captured in the DWS WMS database.
9	WQ.	Initiate and maintain additional WQ monitoring points as specified.
10	Fish and macro-invertebrates (every 2 - 3 years).	Standard fish and macro-invertebrate surveys and an update of the FRAI[1] and MIRAI to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.
11	Diatoms (twice a year).	Diatom analysis to feed into the WQ monitoring programme.
12	Riparian vegetation (every 3rd year).	Specific surveys to determine whether TPCs have been exceeded as well as an update of the VEGRAI[2] to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.
13	Groundwater monitoring.	▪ Water level monitoring: Monthly to quarterly at existing and (new) monitoring boreholes. ▪ Abstraction monitoring (for large groundwater users): Continuous or aggregated monthly to annually. ▪ Baseflow monitoring continuously at gauging stations and aggregated monthly to provide annual volumes. ▪ GroundWQ monitoring: quarterly at existing and (new) monitoring sites.
14	**Institutional arrangements.**	
15	Establish RQO implementation structures (committee).	Design and establish the institutional structures. This could be in the form of a standalone committee or may be linked to other initiatives.
16	Develop reporting procedures, method and communication products.	This must be linked to the monitoring information and should be concise focussing on reporting compliance with meeting the RQOs.
17	Meetings / compliance reports / adaptive measures.	Application of what is defined in Item 19.
18	**Review RQO and Implementation Plan.**	
19	Evaluate effectiveness of activities and monitoring.	Key activity to ensure the RQO implementation remains relevant.
20	Review RQOs and recommend changes	Recommend when RQOs need to be revised.
21	**Related Parallel Water Resource Management Processes.**	
22	Operating Analysis.	
23	Update: Water requirements, maintenance schedules, operational risk analysis.	The information must feed into the IUCMA model.

ID	Activity	Description
24	Komati Joint Operations Forum (KJOF).	IUCMA to continue representation on KJOF. Item 16 meetings could be combined with the KJOF meetings.
25	Develop a Reconciliation Strategy for the Komati Basin.	

1 Fish Response Assessment Index (Kleynhans, 2007) 2 Vegetation Response Assessment Index (Kleynhans *et al*., 2007)

Table 14.2 Activities milestones and related processes: Crocodile River system

ID	Activity	Description
1	**Resource Quality Objectives & Class.**	
2	Legal Notice.	Published in Gazette and comment period.
3	Promulgation.	Approved by Minister of Water and Sanitation.
4	**Apply the IUCMA Crocodile real-time operating models.**	Existing decision support system.
5	Update the model with latest water use information.	While updating the model, continue applying the current version of the model.
6	**Monitoring.**	
7	Flow (continuous recordings).	Maintain flow gauges.
8	WQ (continuous from current activities).	▪ Maintain current DWS WQ monitoring activities. ▪ Identify and maintain monitoring programmes other than DWS. Ensure these data are captured in the DWS WMS database.
9	WQ.	Initiate and maintain additional WQ monitoring points as specified.
10	Fish and macro-invertebrates (every 2 - 3 years).	Standard fish and macro-invertebrate surveys and an update of the FRAI and MIRAI to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.
11	Diatoms (twice a year).	Diatom analysis to feed into the WQ monitoring programme.
12	Riparian vegetation (every 3rd year).	Specific surveys to determine whether TPCs have been exceeded as well as an update of the VEGRAI to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.
13	Groundwater monitoring.	▪ Water level monitoring: Monthly to quarterly at existing and (new) monitoring boreholes. ▪ Abstraction monitoring (for large groundwater users): Continuous or aggregated monthly to annually. ▪ Baseflow monitoring continuously at gauging stations and aggregated monthly to provide annual volumes. ▪ GroundWQ monitoring: quarterly at existing and (new) monitoring sites.
14	**Institutional arrangements.**	
15	Establish RQO implementation structures (committee).	Design and establish the institutional structures. This could be in the form of a standalone committee or may be linked to other initiatives.
16	Develop reporting procedures, method and communication products.	This must be linked to the monitoring information and should be concise focussing on reporting compliance with meeting the RQOs.
17	Meetings / compliance reports / adaptive measures.	Application of what is defined in Item 19.
18	**Review RQO and Implementation Plan.**	
19	Evaluate effectiveness of activities and monitoring.	Key activity to ensure the RQO implementation remains relevant.

ID	Activity	Description
20	Review RQOs and recommend changes.	Recommend when RQOs need to be revised.
21	**Related Parallel Water Resource Management Processes.**	
22	Operating Analysis.	
23	Update: water requirements, maintenance schedules, operational risk analysis.	The information must feed into the IUCMA Croc Real-time model.
24	Crocodile River Operations Committee (CROC-OC)	IUCMA to continue with regular CROC-OC meeting.
25	**Implement the Mbombela Reconciliation Strategy.**	DWS to form a Reconciliation Implementation Committee to implement strategies.

Table 14.3 Activities milestones and related processes: Sabie-Sand River system

ID	Activity	Description
1	**Resource Quality Objectives & Class.**	
2	Legal Notice.	Published in Gazette and comment period.
3	Promulgation.	Approved by Minister of Water and Sanitation.
4	**Apply the IUCMA Sabie real-time operating models.**	Existing decision support system.
5	Update the model with latest water use information.	While updating the model, continue applying the current version of the model.
6	Form a Sabie Operational Committee.	Although the Sabie Real-time model is being run on a weekly basis, a stakeholder forum is required.
7	**Monitoring.**	
8	Flow (continuous recordings).	Maintain flow gauges.
9	WQ (continuous from current activities).	▪ Maintain current DWS WQ monitoring activities. ▪ Identify and maintain monitoring programmes other than DWS. Ensure these data are captured in the DWS WMS database.
10	WQ.	Initiate and maintain additional WQ monitoring points as specified.
11	Fish and macro-invertebrates (every 2 - 3 years).	Standard fish and macro-invertebrate surveys and an update of the FRAI and MIRAI to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.
12	Diatoms (twice a year).	Diatom analysis to feed into the WQ monitoring programme.
13	Riparian vegetation (every 3rd year).	Specific surveys to determine whether TPCs have been exceeded as well as an update of the VEGRAI to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.
14	Groundwater monitoring.	▪ Water level monitoring: Monthly to quarterly at existing and (new) monitoring boreholes. ▪ Abstraction monitoring (for large groundwater users): Continuous or aggregated monthly to annually. ▪ Baseflow monitoring continuously at gauging stations and aggregated monthly to provide annual volumes. ▪ GroundWQ monitoring: quarterly at existing and (new) monitoring sites.
15	**Institutional arrangements.**	
16	Establish RQO implementation structures (committee).	Design and establish the institutional structures. This could be in the form of a standalone committee or may be linked to other initiatives.

ID	Activity	Description
17	Develop reporting procedures, method and communication products.	This must be linked to the monitoring information and should be concise focussing on reporting compliance with meeting the RQOs.
18	Meetings / compliance reports / adaptive measures.	Application of what is defined in Item 19.
19	**Review RQO and Implementation Plan.**	
20	Evaluate effectiveness of activities and monitoring.	Key activity to ensure the RQO implementation remains relevant.
21	Review RQOs and recommend changes.	Recommend when RQOs need to be revised.
22	**Related Parallel Water Resource Management Processes.**	
23	Operating Analysis	
24	Update: water requirements, maintenance schedules, operational risk analysis.	The information must feed into the IUCMA Sabie Real-time model.
25	Sabie River Operations Forum.	IUCMA to set up a Sabie River Operations forum.
26	**Develop a Reconciliation Strategy for the Sabie-Sand catchment.**	DWS to develop a Reconciliation Strategy for the Sabie-Sand catchment.

14.3 IMPLEMENTATION PLAN MANAGEMENT COMMITTEE

It is recommended that an Implementation Plan Management Committee (IPMC) be formulated in order to roll out the implementation plan. This should be done by the IUCMA. Since there are already several forums and committees in the Inkomati, it is suggested that the proposed functions of the IPMC be adopted by these existing forums and committees.

The committee will be responsible for implementing the plan in order to achieve the RQOs. As part of this, the committee will be responsible for operating decision support tools. The meeting will discuss monitoring results obtained in the previous year, as well as set goals and targets to achieve the RQOs for the upcoming year.

The committee will also be responsible for ensuring that all the required monitoring takes place. Should non-compliance become an issue, the committee should perform adaptive management in order to correct the problem. This can involve linking with other mechanisms and legislation.

The proposed way forward with regard to the formation of IPMCs is described separately for each major catchment comprising the Inkomati.

14.3.1 Komati IPMC

KOBWA has established and maintained the Komati Joint Operations Forum (KJOF). The decision support model used by KOBWA in support of the KJOF is an enhancement of the Water Resources Yield Model. The model is kept largely up to date by KOBWA. A major shortcoming though is that KOBWA does not take cognisance of the actual operating of the upper Komati Catchment. This will need to be resolved by the IUCMA.

It is suggested that the KJOF be used as an IPMC. The KJOF should also be expanded to include the activities of the upper Komati Catchment, especially the Nooitgedacht and Vygeboom dams and their catchments. Should KOBWA be unable or unwilling to do this then the IUCMA will need to form a separate forum to take on the functions of the IPMC.

14.3.2 Crocodile IPMC

The Crocodile IPMC can fall under the Crocodile River Operations Forum (CROC-OC) forum which is already functioning well as a committee to ensure compliance with the EWR and cross border flows. The real-time model which provides decision support to the committee was developed through a joint DWS/IUCMA Project. The model is kept up to date by the IUCMA.

This forum meets about every three months. It is suggested that a sub-committee of the CROC-OC be formed to take on the responsibilities of the IPMC.

14.3.3 Sabie-Sand IPMC

While a real-time operational model is in place (developed through DWS and the IUCMA), a Sabie Operational Committee needs to be formed. As for the CROC-OC, it is suggested that the IPMC consist of a sub-committee of the Sabie Operational Committee (when and if formed).

The real-time DSS is operated and maintained by the IUCMA. This model has been successful in ensuring compliance with the EWR in the Sabie Catchment. More attention needs to be given to the Sand River Catchment considering the rapid rural development taking place.

14.4 DECISION SUPPORT SYSTEMS

A crucial aspect of the implementation plan is the DSS required to perform simulations and assist in managing the releases and/or restrictions for meeting the EWRs. Four Decision Support System (DSS) currently exist within the Inkomati, three of which are operated by the IUCMA and the fourth by KOBWA. The DSS set up for the Crocodile and Sabie Catchment are so-called ‘real-time’ models which are run every week. These two models were developed by DWS in conjunction with the IUCMA and include new modelling concepts such as real-time naturalisation (which is key to EWR implementation and compliance monitoring) and runoff predictions.

The KOBWA model applied to the Komati River Basin is an enhanced version of the DWS Water Resources Yield Model. This is an ‘annual’ operational model and is generally only run once a year to assist KOBWA and stakeholders to decide on whether or not to apply restrictions. Two major shortcomings of the KOBWA model are:

a) It does not use the latest hydrological dataset produced by DWS as part of the Inkomati Water Availability Assessment Study (IWAAS) (DWA, 2009c) or later enhancements to the hydrology by their own consultants.
b) The KOBWA model fails to take into account the actual situation in the upper Komati Catchment in terms of actual water use by Eskom, compensation releases and pumping into the catchment from the Usuthu catchment. Instead the KOBWA model is based on the allocation as set out in the Komati Basin Treaty.

In order to deal with the shortcoming of the KOBWA model, the IUCMA has developed a model similar to that used in the Crocodile and Sabie Catchments with which to carry out EWR implementation and compliance monitoring in the Komati Catchment when and if required. This model uses the latest hydrology and includes the actual operating rules of the upper Komati (as opposed to the KOBWA model which uses the allocations contained in the Komati Treaty). The IUCMA model is generally run once a month while the KOBWA model is run once a year.

14.5 DOCUMENTATION

It is necessary to keep record of the implemented actions, monitoring and adaptive management and it is suggested that this take place on an annual basis. The annual implementation plan document will typically include a summary of the previous years' monitoring results. Desired and achieved flows will be included and where deviations have occurred, explanations of the adaptive management or corrective measurements should be given. System changes that took place in the previous year should also be well documented, as well as specific dam operational aspects.

14.6 MONITORING

Effective implementation of the Classes and RQOs relies on the availability of relevant monitoring information for tracking progress, evaluating compliance and to identify if and when revisions of the specified stipulation (target criteria) need to be considered. Monitoring requirements are therefore a key component of the plan as outlined in the subsequent sections.

14.6.1 Hydrological compliance monitoring

The DWS has approximately 39 functional flow gauges on the online HYDSTRA database for the Inkomati. There are also numerous flow gauges which have been closed over the years. It is important that flow monitoring takes place at the EWR sites. In the initial stages of implementing the plan, the key gauges should be activated, preferably on the IUCMA real time system. Where applicable, gauges that are no longer monitored should be reinstated. Monitoring exists for two main purposes namely:

- Monitoring to confirm whether the required flows at a certain point are being achieved.
- Monitoring to activate a specific action (request for release) should the flows be non- compliant.

Groundwater monitoring timing is as follows:

- Water level monitoring: Water level monitoring is required monthly to quarterly.
- Abstraction monitoring: Abstraction monitoring is by nature continuous, or aggregated monthly to annually.
- Baseflow monitoring: Baseflow monitoring is undertaken continuously at gauging stations and aggregated monthly to provide annual volumes. During wet periods, baseflow can be derived from hydrograph separations.
- GroundWQ monitoring: WQ is required quarterly.

A groundwater monitoring plan has been provided that indicates what type of monitoring is essential and the priority.

14.6.2 WQ compliance monitoring

The monitoring is specific to the High Priority RUs i.e. RUs with a 3 priority rating; and should therefore be applied at EWR sites and at WQ hotspots (designated Priority Rating - 3WQ) (DWS, 2014d). Two different types of frequency of monitoring are described as follows:
Level 1 Monitoring Programme: Level 1 monitoring refers to monitoring that is undertaken at a higher frequency (yearly or monthly or as specified by the current DWS monitoring programme) than more detailed Level 2 monitoring (3-yearly), which also include response indicators. The Level 1 monitoring focuses on WQ and diatoms and are specific to High Priority sites (so EWR and 3WQ sites for WQ monitoring) but could be applied at any of the RUs with Moderate Priority Ratings (2) where WQ has been identified as an indicator (DWS, 2014d).

A Level 1 Monitoring programme for WQ and diatom sampling providing the actions, temporal and spatial scales have been provided below.

Table 14.4 WQ and diatom Level 1 monitoring programme

Indicator	Monitoring action	Temporal scale (frequency and timing)	Spatial scale
All variables measured as standard by DWS as a minimum requirement. Note that temperature and dissolved oxygen should be monitored at all EWR sites as no baseline currently exists for these parameters and they are strongly linked to biotic responses. No data or numeric DWS guidelines exist for turbidity. Turbidity should be measured as specified and a turbidity database developed.	Include additional variables in the formal DWS monitoring programme as indicated by WQ RQOs, specifically periphyton chlorophyll-a and diatoms. Include toxics monitoring if specifically mentioned; otherwise cover only if indicated by biotic response (conducted as part of Level 2 monitoring).	1. Monthly, or as determined by current DWS monitoring programme per monitoring point. 2. Institute bi-monthly monitoring <u>if required</u> at High Priority WQ sites with no WQ gauging weir in place. 3. Institute monthly monitoring of standard suite of DWS variables <u>if required</u> at Moderate Priority RUs where WQ has been identified as an indicator and an existing WQ gauging weir is in place. If not, institute bi-monthly monitoring as outlined in point 2.	1. Relevant WQ monitoring point at gauging weir. 2. Institute a monitoring point downstream of a High Priority WQ site or at the lower end of a Moderate Priority RU where WQ has been identified as an indicator, if no WQ gauging weir is in place for use.
Diatoms	Collect baseline data to develop EcoSpecs and TPCs.	Six monthly.	All EWR sites and sites were WQ hotspots have been identified.

Although it is recommended that Level 1 monitoring be conducted at all High Priority and some Moderate Priority sites, it is understood that the pressure on resources may require prioritization of sites for monitoring purposes. This is particularly important if an information database has to be built before the implementation of RQOs can take place. Prioritisation may be for a range of reasons, e.g. EWR S2 and C6 require WQ monitoring as these are important ecological sites and the data is needed to explain what may be seen biologically, while the Leeuspruit (X21F-01100) is prioritised because of the poor WQ state at this site. Prioritisation of sites is therefore conducted for the EWR sites and High priority 3WQ sites. Moderate priority sites where WQ is an indicator and WQ improvement is needed to achieve the REC, were also evaluated during the prioritisation process and provided in this report.

Level 2 monitoring should be applied on a regular basis at the EWR sites (High Priority RUs). Monitoring should include WQ, diatoms and hydrology as outlined in the previous sections as well as other indicators. Therefore, whereas Level 1 monitoring focuses on WQ and diatoms as well as the continuous hydrological gauging and some woody vegetation monitoring; Level 2 focuses on the more detailed work at a lower frequency required for biota and habitat. It is acknowledged that resources may not be available to undertake this work (even at a lower frequency) at all EWR sites (High priority RUs).

14.6.3 Habitat and biota monitoring

There are current initiatives in DWS with the revitalising of the River Health Programme and the use of the Rapid Habitat Assessment Method (RHAM) (DWA, 2009d) in determining and measuring EcoSpecs at a rapid level. It is recommended that this monitoring dictates the level required and the methods to be followed.

Habitat and biota monitoring should be applied as part of Level 2 monitoring. This implies detailed monitoring at a lower frequency than Level 1. It is acknowledged that resources may not be available to undertake this work (even at a lower frequency) at all EWR sites (High priority RUs). Therefore EWR sites have been prioritised as part of the scenario evaluation and by taking into account the position of the EWR site in the catchment as well as the length of river the site represents. For example, monitoring at the most downstream site will often be the most useful as all impacts and changes of upstream developments will impact on these sites.

The order of priority EWR sites for monitoring is provided below.

Table 14.5 Order of priority EWR sites for monitoring in the Komati River system

Priority	EWR sites	Comment
1	EWR K3	Most downstream site and reflects all impacts downstream of Maguga Dam.
2	EWR K2	Within a nature reserve and reflects all impacts of upstream dams.
3	EWR L1	Only site that illustrates impacts of Driekoppies Dam. However, it must be noted that current operation will not change to improve the ecology.
4	EWR K1	Only site that illustrates impacts of power generation.
5	EWR G1	Most important for measuring responses to WQ issues.
6	EWR T1	No large scale developments upstream apart from rural settlements.

Table 14.6 Order of priority EWR sites for monitoring in the Crocodile River system

Priority	EWR sites	Comment
1	EWR C6	Most downstream site in the main Crocodile River and will reflect all upstream impacts, specifically the management for extensive irrigation farming downstream of Nelspruit.
2	EWR C5	Similar reasoning as above. Further upstream and in Malelane - can therefore be important for detecting WQ impacts from Malelane and extensive townships further upstream and along tributaries.
3	EWR C4	In the Crocodile River and downstream of Nelspruit. Therefore important for detecting WQ issues from the upstream urban areas.
4	EWR C1	Lower priority than the above three sites as limited developments upstream and in upper part of catchment. However, the EWR site is downstream of Dullstroom, and is in a very good PES. It is therefore very important to ensure that the category does not drop as this IUA is in a Class I and monitoring here for especially WQ impacts are important.
5	EWR C2	Situated further downstream than EWR C1 but reasoning similar to the above.
6	EWR C3	Situated downstream of Kwena Dam but current operation is unlikely to change in the short term. Any changes to the operation will warrant the priority for monitoring to increase.
7	EWR C7	Situated in the Kaap River and reflects all upstream impacts.

Table 14.7 Order of priority EWR sites for monitoring in the Sabie-Sand River system

Priority	EWR sites	Comment
1	EWR S3	Most downstream site in the Sabie River as well as in a Class I. Monitoring essential to ensure that the river stays in a Class I as demand for further water use is increasing. Also the flagship River in the KNP.
2	EWR S8	Most downstream site in the KNP and same reasoning as above. Due to the lack of hydrological gauging, it is essential that the biological monitoring takes place.
3	EWR S1	The upper Sabie River has, according to anecdotal and limited monitoring information, been degrading slowly. As it supports the downstream Class I

Priority	EWR sites	Comment
		river (EWR S3) and is situated downstream of Sabie town and ideally situated to detect any WQ problems, it is rated third. Furthermore, non flow-related actions are required to improve the river and to ensure that it achieves Class I state if these anthropogenic impacts are addressed.
4	EWR S2	See above.
5	EWR S4	Within the Mac Mac River and currently in an excellent state. Monitoring is required to ensure that no forestry activities or activities from Graskop compromise this state.
6	EWR S6	Situated in the Mutlumuvi River and due to the very limited monitoring of any drivers, the biological monitoring should be undertaken. Currently no further development is being planned, therefore it is low on the priority list. If however dam development is initiated, the priority would be a 1.
7	EWR S7	Situated in the Upper Sand or Thulandziteka River. It was not used in the ecological consequences evaluation due to the low confidences in drivers and responses at this site (lack of available data). Unless hydrological gauging and WQ monitoring is initiated, priority for habitat and biological monitoring would be low.
8	EWR S5	Downstream of Inyaka Dam and although very high priority for hydrological compliance monitoring, the biological monitoring priority is low. If the current operation of Inyaka Dam changes, the priority must increase and the baseline updated.

In the table below, a monitoring programme for Level 2 is provided for riparian vegetation, fish and macro-invertebrates.

Table 14.8 Level 2 monitoring programme at EWR sites

Indicator	Monitoring action	Temporal scale (frequency and timing)	Spatial scale
Riparian vegetation			
Woody vegetation within the riparian zone, both terrestrial and indigenous riparian	1) Field assessments using VEGRAI level 4. 2) Fixed point photographs.	Every three years, same month for subsequent surveys.	All EWR sites.
Reeds			
Alien vegetation			
Non-woody vegetation including sedges, grasses, and dicotyledonous forbs, but excluding reeds or palmiet			
Overall PES for riparian vegetation			
Fish			
Species richness and specific indicator fish species with a preference for specific habitat features (such as substrate) or being intolerant to specific impacts (such as WQ deterioration, flow reduction) (see EcoSpecs (DWS, 2014d))	Field assessment (electrofishing).	At least every four years, but more frequently where possible.	All EWR sites (K1, G1, K2, T1, L1, K3, C1 to C7, S1 to S8) and preferably at least one additional site per SQ reach that EWR site fall in. (In some cases one site will be sampled in each SQ reach of the primary rivers (Sabie, Crocodile and Komati).
Macro-invertebrates			

Indicator	Monitoring action	Temporal scale (frequency and timing)	Spatial scale
Composition and abundance	Field assessment (SASS5) (high priority).	Every two years.	All EWR sites as above.

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16 APPENDIX A: VISIONING SUMMARY

Catchment visioning is a requirement of the RQO process and has been included in Task 2 of the integrated process. Visioning is part of step 2 of the RQO steps and is not a requirement of the NWCS steps. Logically however, it fits into Classification as the determination of the Water Resource Class as part of the NWCS is linked to visioning. Visioning therefore takes place during step 2 of the integrated steps which form the basis of the project plan for this study. It is necessary that visioning takes place during the beginning of the study as it can inform the design of the scenarios within Integrated Water Resources Management (i.e., step 4 in the integrated steps). Visioning is done for each Integrated Unit of Analysis as these units are catchments or linear stretches of river that can be managed as a unit.

During the first PSC meeting where stakeholders were present, the status quo in the catchment for various aspects (ecology, economy, water resources, EGSA) was presented and the reasons for the status provided. Preliminary IUAs were also presented. Stakeholders were required to indicate what their catchment vision are and how they would like the status quo to change. At the end of the study, this vision will be defined through the selected Water Resource Classes as well as recommended future scenarios.

The questionnaire provided to stakeholders is provided below as well as the information received in table format.

16.1 VISIONING QUESTIONNAIRE

Implementation of the Water Resources Classification System and Determination of the Resource Quality Objectives for Significant Water Resources in the Inkomati Water Management Area
20 August 2013

Please complete the form below preferably during the PSC meeting as supporting document to the visioning process. If you require completing this after the meeting on 20 August 2013 please return the completed for to Anelle Lötter (contact details on next page). Also find on the 2nd page of this form some criteria/questions/issues that you can consider in answering the questions below.

Title		**First name**	
Initials		**Surname**	
Organisation			
Address			
		Postal code	
Tel no		**Fax no**	
E-mail			
Field of interest			
In which Integrated Unit of Analysis (IUA) do you live? (Mark with an X)			

<table>
<tr><td>Komati X1-1</td><td>Komati X1-2</td><td>Komati X1-3</td><td>Komati X1-4</td><td>Komati X1-5</td><td>Komati X1-6</td><td>Komati X1-7</td><td>Komati X1-8</td><td>Komati X1-9</td><td>Komati X1-10</td></tr>
<tr><td>Croc X2-1</td><td>Croc X2-2</td><td>Croc X2-3</td><td>Croc X2-4</td><td>Croc X2-5</td><td>Croc X2-6</td><td>Croc X2-7</td><td>Croc X2-8</td><td>Croc X2-9</td><td>Croc X2-10</td><td>Croc X2-11</td><td>Croc X2-12</td><td>Croc X2-13</td></tr>
<tr><td>Sabie-Sand X3-1</td><td>Sabie-Sand X3-2</td><td>Sabie-Sand X3-3</td><td>Sabie-Sand X3-4</td><td>Sabie-Sand X3-5</td><td>Sabie-Sand X3-6</td><td>Sabie-Sand X3-7</td><td>Sabie-Sand X3-8</td><td>Sabie-Sand X3-9</td></tr>
<tr><td colspan="13">Is the current state of the water resource in terms of ……………………………………. acceptable?</td></tr>
<tr><td colspan="6">YES</td><td colspan="7">NO</td></tr>
<tr><td colspan="3">If <u>no</u>, what would you like to be changed?</td><td colspan="10"></td></tr>
<tr><td colspan="3">Why do you need changes?</td><td colspan="10"></td></tr>
<tr><td colspan="3">What are the possible consequences of the changes?</td><td colspan="10"></td></tr>
<tr><td colspan="3">What are your water resource issues in this IUA? (see next page)</td><td colspan="10"></td></tr>
</table>

Your water resource issues can relate to issues of:

- policy and legislation (e.g. lack of clarity, concern about pricing strategies etc);
- resources (e.g. scarcity, threats to or increasing demands on water resources, etc);
- administration (e.g. delays, roles and responsibilities, etc);
- capacity/empowerment (e.g. inadequate extension services, education, sense of ownership); or
- technology (e.g. water saving, best practices, etc).

Please indicate if there is an improvement or deterioration in any of the issues that you mention.

Aspects that you may consider when completing the form:

- Economic and social objectives;
- Economic empowerment of the poor;
- Maximise job creation i.e. labour intensive activities in order to provide for the most people;
- Maximise capital growth and in this way contribute to development;
- Social upliftment of the poor including provision of water services;
- Maximise economic development through first world activities - from agriculture to industry;
- Aim for water conservative uses;
- Promote and develop recreation and tourism;
- Conservation of biodiversity;
- Maintain overall present ecological status of the catchment or IUA;
- Improve overall present ecological status of the entire catchment or IUA;
- Allow deterioration of present ecological status of the entire catchment or IUA for purposes of development;
- Protect certain areas the ecological status of which need to be maintained or improved; and
- Allow deterioration of the present ecological status of certain areas for the purpose of development.

Catchment	IUA	Main river system/proposed IUA name
Komati Catchment	X1-1	Catchment upstream of Nooitgedacht Dam
	X1-2	Komati River between Nooitgedacht and Vygeboom Dam
	X1-3	All tributaries between Nooitgedacht and Vygeboom Dam excluding the main Komati River
	X1-4	Gladdespruit Catchment
	X1-5	Komati River downstream of Vygeboom Dam to Swaziland
	X1-6	All tributaries downstream of Vygeboom Dam in IUA X1-6 excluding the Gladdespruit
	X1-7	Lomati Catchment upstream of Swaziland
	X1-8	Lomati Catchment downstream of Driekoppies Dam
	X1-9	Komati Catchment downstream of Swaziland to the Lomati River confluence
	X1-10	Komati Catchment downstream of the Lomati River
Crocodile Catchment	X2-1	Crocodile Catchment upstream of Kwena Dam
	X2-2	Crocodile River downstream of the Kwena Dam to the Elands River
	X2-3	Elands Catchment upstream of the Weltevredespruit (excluded)
	X2-4	Elands River downstream of IUA X2-3 to the Ngodwana confluence, including the Weltevredenspruit the Ngodwana River upstream of the Ngodwana Dam and the Lupelele River
	X2-5	Elands River downstream of the Ngodwana River
	X2-6	Crocodile River to the Nels River confluence
	X2-7	Houtbos and Visspruit Rivers
	X2-8	Nels, Wit, and Gladdespruit Rivers
	X2-9	Crocodile River to the Kaap Confluence (incl Blinkwater trib)
	X2-10	Kaap Catchment
	X2-11	Crocodile River from the Kaap confluence to the Komati River
	X2-12	Nsikasi River
	X2-13	Northern tributaries of the Crocodile River located in the KNP
Sabie/Sand Catchment	X3-1	Sabie Catchment upstream of the Klein Sabie (included) confluence
	X3-2	Sabie River downstream of IUA X3-1 to the Marite confluence incl the Goudstroom, MacMac, Motitse and Marite upstream of Inyaka Dam
	X3-3	Marite and Sabie River downstream of Inyaka Dam to the Sand confluence
	X3-4	Sabaan, Noord-Sand, Bejani, Saringwa, Musutlu Rivers
	X3-5	Sabie River downstream of the Sand confluence to the KNP border
	X3-6	Southern and northern tributaries of the Sabie in the KNP downstream of the Sand confluence including the Phabeni
	X3-7	Mutlumuvi Catchment
	X3-8	Sand Catchment to the Khokhovela (included) confluence
	X3-9	Sand Catchment downstream of the Khokovela confluence
	X4	Nwanedzi/Nwaswitsontso catchment (X4 secondary catchment)

Please complete by 31 August 2013 and return to: Anelle Lötter - Tel: 012 667-4860, Fax: 012 667-6129, E-mail: anelle@jaws.co.za

16.2 VISIONING RESPONSE AND RESULTS

Results of the discussions held in the break-away sessions at the 1st PSC on 20 August 2013 to develop a vision for the Inkomati.

	Name and organisation representing	IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the consequences of the changes?	What are your water resource issues in this IUA?
1.	Mr Robin Petersen, SANParks	X2-13	No – not in terms of biodiversity and conservation as well as water quality and quantity.	The water quality and quantity of the Crocodile River is important, tributaries are fine and in an 'A' condition.	To improve the state of the river in terms of the biodiversity context for the Crocodile River. Water quality experienced is related to algal blooms.	▪ Pristine river - all biodiversity could be protected which will lead to a sustainable future. ▪ Promotion of tourism.	Resource – demand for water could cause a decrease in flows and decrease the quality of water.
2.	Ms Mutondwa Gladys Makhado, Department of Water Affairs - RDM	X2-1 to X2-13	No – not in terms of water quality.	▪ The small farms found in the area, especially livestock farms expose nutrients which run off in the water resource. ▪ The farmers need to clean the water before it is discharged into the water resources. ▪ Mining needs to reduce the discharge into the water resources.	▪ For improved water quality. ▪ Farmers pose a threat to water resources in terms of water quality and degrade the water resource. ▪ There is a need to manage the catchment as an integrated catchment from headwaters.	▪ Improved water quality.	Resources (increasing demands on the water resource and administration).
3	Ms Happy Maleme, Department of Water Affairs - RDM	X2-1 to X2-13	No – not in terms of water quality and quantity.	▪ Improved operation of waste water treatment works. ▪ Some interventions need to take place as far as old mining activities are concerned.	If the operation of waste-water treatment works is improved and managed, our water resource can have an improved water quality.	▪ Sustainability of ecological biota and habitat. ▪ Development of an improved management plan for existing mines to reduce future contamination.	Water quality due to return flows from upstream users, urban areas, gold mining, waste water treatment works etc.
4.	Mr Clemens Kiessig, Barbeton Mines Pty Ltd	X2-10	Yes – in terms of mining.				
5.	Miss Amrita Lamba, School of Oriental and African Studies (SOAS) University of London,UKZN/ICMA	X2-11	No – not in terms of water governance.				▪ Policy and legislation. ▪ Administration. ▪ Capacity and empowerment
6.	Mrs Debbie Turner, White River Conservation Board (plus four minor irrigation boards and the Crocodile Catchment Forum)	X2-8	No – not in terms of irrigation and stock watering.	Control of pollution from Waste Water Treatment Works (WWTW).	Long term pollution needs to be corrected.	Cleaner water.	▪ Allocation for agriculture in White River Valley insufficient for purpose. ▪ Long term contamination from White River. ▪ Waste Water Treatment Works affects water quality.
7.	Mrs Mia Ackermann, Sappi Ngodwana	X2-4 & X2-5	No – not in terms of water quality.	▪ Improved delivery times from important decision makers, (ie) government regarding	▪ Need to make strategic decisions, which have	Improved decision-making and improved economic modelling.	▪ Policy and legislation. ▪ Resource availability. ▪ Conversion of existing

	Name and organisation representing	IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the consequences of the changes?	What are your water resource issues in this IUA?
				setting quality objectives. ▪ Clear guidelines on alternatives to meeting quality objectives. ▪ Also require increased availability of DWA in application process.	significant implications on business and the macro-economy. ▪ Delayed feedback from government compromises sound economic modelling.		lawful uses for alternative end-uses. ▪ Poor administration.
8.	Mr Andrew Rossaak, Sand River Irrigation Board	X2-8	No – in terms of water quality.	▪ Reduced pollution like e-coli which impacts irrigation water quality. ▪ Improved compliance.	Food safety- as the fresh produce is used for human consumption.	▪ Improved irrigation quality and lower human risk. ▪ Fair and equitable use and access to quality water.	Policy, resource and compliance (All have shown potential to improve but have not done so).
9.	Mrs Vutlhari Matsane, ICMA	X2-6	No – in terms of quantity.	Availability to all.			Resources.
10.	Dr Paul Mensah, Rhodes University and ICMA	X2-11	No – in terms of water quality.	Properly managed by an Integrated Water Quality Management Plan (IWQMP)	For proper management.	People cooperate to manage the problem.	Poor administration.
11.	Mr Marius Kolesky, ICMA	X2-9	No – in terms of water quality.	Flow improvement during winter	Better availability	Water available in periods when historically not available.	Resources.
12.	Mr Yakeen Atwaru, DWA	X2-10	No – in terms of ecology.	Improvement in the ecological condition.	To ensure sustainable ecological functioning and improved water quality for downstream users.	Improved ecological functioning - better contribution to goods and services.	▪ Resources. ▪ Capacity. ▪ Technology.
13.	Miss Gugu Precious Motha, ICMA	X2-11	Yes – in terms of agriculture.				▪ Capacity. ▪ Empowerment. ▪ Policy and Legislation. ▪ Concerned about the pricing strategy.
14.	Mr Smale Lanios Malapane, Kgarudi KRP5465-Mapulane Mogane Tribe	X1-5 and X3-1 to X3-5	Yes.				
15.	Mrs Ronelle Putter, Croc River Water Irrigation Board/ White Waters Water Irrigation Board	X2-1; X2-2; X2-6; X2-7; X2-8; X2-9; X2-11; X2-13 and X3-4	No – in terms of water quality.	Waste from municipalities and informal settlements.	▪ Low flow times. ▪ Quality very poor downstream.	▪ Domestic-illnesses; ▪ Agriculture- European standards and quality of food production.	▪ Policy and Legislation. ▪ Resources (very important). ▪ Poor administration. ▪ Capacity and empowerment.
16.	Mr Dawie van Rooy, Crocodile Major Irrigation Board	X2-11	No.	Water quality.	Water quality impacting on people and business.	▪ Water quality deteriorated a lot in the past 8 years. ▪ Health. ▪ Export of fruits.	▪ Capacity of municipalities. ▪ Application of legislation of mines.
17.	Mr Joseph Mabunda, ICMA	X3-1; X3-4; X3-7; X3-8	No – in terms of aquatic ecosystems and degradation.	Improved regulation of sand mining that degrades aquatic eco-systems and water quality.	Improved enforcement.	▪ Improved eco-system services. ▪ International agreements (turbidity issue by Mozambique).	▪ Water quality. ▪ Water management.

	Name and organisation representing	IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the consequences of the changes?	What are your water resource issues in this IUA?
18.	Miss Assa Thibela, ICMA	X3-3	No – in terms of water resource pollution.	The state of water resource is unhealthy because a waste water treatment plant has been built next to the dam.	There are no measurable ways in this area.	It can be stopped or engage with the Bushbuckridge Municipality.	▪ Illegal sand mining. ▪ Illegal dumping- negative interference with the resource.
19.	Ms Nomsa Kubayi, ICMA	X3-1; X3-2; X3-6; X3-7; and X3-9	No.	Water resource pollution.	To avoid contamination (Malaria and Diarrhoea)	Awareness creation on Integrated Water Resource Management (IWRM)	▪ Increasing demand and technological problems. ▪ Water rights issues. ▪ Pollution. ▪ Illegal abstraction.
20.	Mr Greg Beyers, TSB Sugar & Greenviro Management	X1-8; X1-9; X1-10; X2-1 to X2-13; X3-7 and X3-8	Yes – in terms of sugar mills and industrial.				▪ Assurance of supply.
21.	Dr Harry Biggs	X3-3	No – in terms of quality and quantity.	The likelihood that the (laudable) plan can be 'implemented', be higher.	To reach sustainable status through effective action at all of the multiple levels required.	An emergent result: real improvement.	▪ Well outlined for this and other IUAs in your study, though I accept there will be addition of detail by stakeholders as asked - I have none now.

General comments raised in the Komati break-away group:

- There are issues of existing and future mining licences (future scenarios) to be considered.
- There is a need to include a multiplier effect on electricity.
- Reallocating of Eskom water for increased domestic use.
- The need to include climate change aspect into future scenarios.
- Modelling of Acid Mine Drainage.
- Consider transfer from Lesotho (operating rule).
- Coal mine exist in X1-9.
- Governance and policy assessment.

17 APPENDIX B: REPORT COMMENTS

Page &/ or section	Report statement	Comments	Changes made?	Author comment
Comments received from Mohlapa, Sekoele on 29 June 2015				
Extensive editorial comments		All addressed	Yes	