DEPARTMENT OF WATER AFFAIRS

CHIEF DIRECTORATE: RESOURCE DIRECTED MEASURES

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

ECOLOGICAL WATER REQUIREMENTS

Report Number: RDM/WMA05/00/CON/CLA/0114

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

ECOLOGICAL WATER REQUIREMENTS: DRAFT

Report Number: RDM/WMA5/00/CON/CLA/0114

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REPORT SCHEDULE

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First draft	*March 2014*	

EXECUTIVE SUMMARY

BACKGROUND

The Chief Directorate: Resource Directed Measures (CD: RDM) of the Department of Water Affairs (DWA) 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 Inkomati WMA. IWR Water Resources was appointed as the Professional Service Provider (PSP) to undertake this study. This study entails Classification and setting of RQOs. Embedded in the National Water Resources Classification System (NWRCS) is the determination of the Reserve. Each of these three processes consists of distinctive steps which overlap. Integrated steps were designed and are provided below.

In summary, this task refers to Integrated step 3: Quantify EWRs and changes in non-water quality ecosystem services. The main emphasis consists of the EcoClassification and Ecological Water Requirement (EWR) determination at various biophysical nodes in the system.

This document summarises the EcoClassification and Ecological Water Requirement results of the following Reserve studies undertaken in the study area between 2004 and 2010:

- *2003 – 2005 Elands River Reserve Study.*
- *2004 – 2006 Komati Reserve Study*
- *2007 - 2010 Inkomati Reserve Study*

EWR SITES

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 Catchment (X2) and Sabie-Sand Catchment (X3).*
- *Two EWR sites were selected on the Elands River in the Crocodile Catchment (X2).*
- *Seven EWR sites were selected in the Komati Catchment (X1)*

Details of the EWR sites selected during the 2006 EWR study

EWR Site number	EWR Site name	River	Co-ordinates		Management Resource Unit
			Latitude	Longitude	
Sabie-Sand Catchment (X3)					
EWR 1	Upper Sabie	Sabie	25 04.424	30 50.924	Sabie A
EWR 2	Aan de Vliet	Sabie	25 01.675	31 03.099	Sabie A
EWR 3	Kidney	Sabie	24 59.256	31 17.572	Sabie B.1
EWR 4	MacMac	Mac Mac	25 00.800	31 00.243	Mac A
EWR 5	Marite	Marite	25 01.077	31 07.997	Mar A
EWR 6	Mutlumuvi	Mutlumuvi	24 45.352	31 07.923	Mut A
EWR 7	Tlulandziteka	Tlulandziteka	24 40.829	31 05.188	Sand A
EWR 8	Sand	Sand	24 58.045	31 37.641	Sand B, RAU B.1
Crocodile Catchment (X2)					
EWR 1	Valeyspruit	Crocodile	25 29.647	30 08.656	Croc A
EWR 2	Goedenhoop	Crocodile	25 24.555	30 18.955	Croc A
EWR 3	Poplar Creek	Crocodile	25 27.127	30 40.865	Croc B
EWR 4	KaNyamazane	Crocodile	25 30.146	31 10.919	Croc D (RUA Croc D.1)
EWR 5	Malelane	Crocodile	25 28.972	31 30.464	Croc E

EWR Site number	EWR Site name	River	Co-ordinates		Management Resource Unit
			Latitude	Longitude	
EWR 6	*Nkongoma*	*Crocodile*	*25 23.430*	*31 58.467*	*Croc E*
EWR 7	*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*
Komati Catchment (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*

ECOCLASSIFICATION RESULTS (LEVEL IV)

The Komati Catchment 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.

Summary of the EcoClassification results

EWR 1 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: 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 2 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 3 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 4 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, water quality 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

EWR 5 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 6 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 7 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 1: Upper Sabie (Sabie River)

EIS: High
Rare and endangered fish and vegetation species. Fish species present that are intolerant to flow and flow related water quality 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 2: Aan de Vliet (Sabie River)

EIS: High
Rare and endangered fish and vegetation species. Species present intolerant to flow and flow related water quality 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 3 Kidney (Sabie River)

EIS: Very High
Rare and endangered species, taxon richness and species intolerant to flow and flow related water quality 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 4 Mac Mac (Mac Mac River)

EIS: High
Rare and endangered fish and vegetation species. Species present intolerant to flow and flow related water quality 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 water quality 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 5 Marite (Marite River)

EIS: High.
Rare, endangered and unique biota. Species richness high and species intolerant to flow and flow related water quality 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 6 Mutlumuvi (Mutlumuvi River)

EIS: High
Rare, endangered and unique biota. Taxon species richness high and species intolerant to flow and flow related water quality 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 7 Tlulandziteka (Tlulandziteka River)

EIS: Moderate
Rare and endangered species, high taxon richness, species intolerant to flow and flow related water quality 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 8 Lower Sand (Sand River)

EIS: High
Rare and endangered species, high taxon richness and species intolerant to flow and flow related water quality 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 water quality 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 areas 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 water quality 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 water quality 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 water quality. 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 water quality changes.

PES: D

Combination of flow and non-flow related impacts. The main impacts are related to reduced low flows due to forestry, water quality 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 water quality 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

EWR RESULTS AT EWR SITES (KEY BIOPHYSICAL NODES)

The 2006 Komati EWR results were updated using the updated natural and present day hydrology. 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 Catchment

EWR site	nMAR	PMAR	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM	MCM	MCM		MCM	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(% nMAR)
Crocodile												
EWR 1	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
EWR 2	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
EWR 3	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.						
EWR 4	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
EWR 5	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
EWR 6	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
EWR 7	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												
EWR 1	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
EWR 2	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
EWR 3	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
EWR 4	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
EWR 5	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
EWR 6	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
EWR 7	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
EWR 8	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 Catchment												
K1	158.62	108.46	68.38	B/C PES, REC	27.38	17.30			16.30	10.20	43.68	27.50
K2	545.56	318.64	58.41	C PES	50.87	9.30			49.00	9.00	99.87	18.30

EWR site	nMAR	PMAR	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM	MCM	MCM		MCM	(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(% nMAR)
K3	1021.67	489.84	47.95	D REC	101.10	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	294.31	229.53	77.99	C PES, REC	34.46	11.70			16.50	5.60	50.96	17.30

ECOCLASSIFICATION RESULTS AT THE DESKTOP BIOPHYSICAL NODES

The PES and Ecological Importance (EI) - Ecological Sensitivity (ES) (PESEIS; DWA, 2013b)) study results were used to determine the PES and REC. These results are summarised below and includes the Integrated Environmental Importance (IEI) of the nodes.

X1 (Komati): Summary of results for the desktop biophysical nodes

SQ number	River	PES	EIS	REC
X11A-01300		B	2.6	B
X11A-01354		C	2.5	C
X11A-01358	Vaalwaterspruit	C	2.6	C
X11A-01295	Vaalwaterspruit	C	2.4	C
X11A-01248	Vaalwaterspruit	C	2.8	C
X11B-01370	Boesmanspruit	B	2.9	B
X11B-01361		B/C	2.8	B/C
X11B-01272	Boesmanspruit	C	3.1	B/C
X11C-01147	Witkloofspruit	C	3.8	C
X11D-01129	Klein-Komati	C	2.9	C
X11D-01137	Waarkraalloop	C	2.8	C
X11D-01219	Komati	C/D	2.6	C/D
X11D-01196	Komati	C	2.6	C
X11E-01237	Swartspruit	C	3.8	B
X11E-01157	Komati	B/C	3.0	B/C
X11F-01133	Bankspruit	B	3.2	B
X11G-01188	Ndubazi	B/C	3.0	B
X11G-01143	Gemakstroom	C	2.9	C
X11K-01165	Poponyane	C	2.6	C
X11K-01199		D	2.1	D
X11K-01179	Gladdespruit	C	2.7	C
X11K-01194	Gladdespruit	C	2.7	C
X12A-01305	Buffelspruit	C	3.8	B
X12B-01246	Hlatjiwe	C	2.8	C
X12C-01242	Phophenyane	B	3.1	B
X12C-01271	Buffelspruit	B	3.0	B
X12D-01235	Seekoeispruit	C	3.1	B/C
X12E-01287	Teespruit	C	3.7	B
X12H-01338	Sandspruit	B	3.2	B
X12H-01340		B	3.0	B
X12H-01318	Sandspruit	C	2.8	C
X12J-01202	Mtsoli	B	4.0	B
X12K-01333	Mlondozi	C	3.1	B/C
X12K-01332	Mhlangampepa	B	3.5	B
X12K-01316	Komati	D	2.8	D

SQ number	River	PES	EIS	REC
X13A-01337	Maloloja	A	3.5	A
X13J-01141	Mzinti	D	3.3	D
X13J-01205	Mbiteni	D	2.5	D
X13J-01221	Komati	D	2.7	D
X13K-01136	Mambane	D	2.9	D
X13K-01068	Nkwakwa	C/D	3.1	C/D
X13K-01114	Komati	D	2.9	D
X13L-01000	Ngweti	D	2.8	D
X13L-0995	Komati	D	2.7	D
X14B-01166	Ugutugulo	C	3.4	B/C

X2 (Crocodile): Summary of results for the desktop biophysical nodes

SQ number	River	PES	EIS	REC
X21A-01008		C/D	2.0	C
X21B-00929	Gemsbokspruit	C/D	4.1	C
X21B-00898	Lunsklip	C/D	4.1	C
X21B-00925	Lunsklip	C	3.0	C
X21C-00859	Alexanderspruit	C	3.8	C
X21D-00957	Buffelskloofspruit	C	3.1	B/C
X21D-00938	Crocodile	C	2.9	C
X21E-00897	Buffelskloofspruit	B	3.2	B
X21E-00947	Crocodile	B	3.0	B
X21F-01046	Elands	C	3.8	C
X21F-01100	Leeuspruit	C	2.6	C
X21F-01096	Dawsonsspruit	A	1.6	A
X21F-01091	Rietvleispruit	C	2.4	C
X21F-01092	Leeuspruit	C/D	2.3	C/D
X21F-01081	Elands	C	2.5	C
X21G-01090	Weltevredespruit	C	2.8	C
X21G-01016	Swartkoppiespruit	C	3.3	C
X21H-01060	Ngodwana	C	3.2	B
X21J-01013	Elands	C	3.1	B/C
X21K-01007	Lupelule	B	3.2	B
X21K-00997	Elands	C	2.8	C
X22A-00875	Houtbosloop	B/C	3.2	B
X22A-00887	Beestekraalspruit	B/C	3.0	B/C
X22A-00824	Blystaanspruit	B/C	3.2	B
X22A-00920		B	2.4	B
X22A-00919	Houtbosloop	B/C	2.8	B/C
X22A-00917	Houtbosloop	C	2.6	C
X22A-00913	Houtbosloop	C	3.4	B
X22C-00990	Visspruit	B/C	2.8	B/C
X22C-01004	Gladdespruit	C	3.8	B/C
X22D-00843	Nels	C	2.8	C
X22D-00846		C	2.7	C
X22E-00849	Sand	C	2.4	C
X22E-00833	Kruisfonteinspruit	C	2.2	C
X22F-00842	Nels	C	3.1	B/C
X22F-00886	Sand	C	3.0	C
X22F-00977	Nels	C/D	3.3	C/D

SQ number	River	PES	EIS	REC
X22H-00836	Wit	D/E	3.8	D
X22K-01042	Mbuzulwane	B	2.7	B
X22K-01043	Blinkwater	B	3.1	B
X22K-01029	Blinkwater	C	2.7	C
X23B-01052	Noordkaap	D	3.5	C
X23C-01098	Suidkaap	C	3.5	B/C
X23E-01154	Queens	C	3.8	B/C
X23F-01120	Suidkaap	C	2.8	C
X24A-00826	Nsikazi	C	3.3	C
X24A-00860	Sithungwane	A	3.3	A
X24A-00881	Nsikazi	B	3.2	B
X24B-00903	Gutshwa	D	3.3	D
X24B-00928	Nsikazi	A/B	3.4	A/B/
X24C-00978	Nsikazi	B	3.7	B

X3 (Sabie/Sand): Summary of results for the desktop biophysical nodes

SQ number	River	PES	EIS	REC
X31A-00741	Klein Sabie	C	3.0	B/C
X31A-00783		C	2.4	C
X31A-00786		B	3.3	B
X31A-00794		B	2.9	B
X31A-00796		B	2.9	B
X31A-00803		B/C	2.3	B/C
X31B-00792	Goudstroom	B/C	2.7	B/C
X31D-00773	Sabani	C/D	2.8	C/D
X31E-00647	Marite (US of dam)	B/C	3.4	B
X31F-00695	Motitsi	C	3.5	B
X31H-00819	White Waters	C	3.1	B/C
X31J-00774	Noord-Sand	D	2.9	D
X31J-00835	Noord-Sand	D	2.9	D
X31K-00713	Bejani	D	3.7	D
X31K-00771	Phabeni	B	3.0	B
X31L-00657	Matsavana	C	2.8	C
X31L-00664	Saringwa	C	2.9	C
X31L-00678	Saringwa	B/C	3.3	B/C
X31M-00673	Musutlu	B/C	3.3	B/C
X32B-00551	Motlamogatsana	C	3.4	C
X32C-00558	Nwandlamuhari	C	2.9	C
X32C-00564	Mphyanyana	C	2.9	C
X32C-00606	Nwandlamuhari	C	2.9	C
X32E-00629	Nwarhele	C/D	3.3	C
X32F-00628	Nwarhele	C/D	2.8	C/D
X32G-00549	Khokhovela	C	3.2	C
X32H-00560	Phungwe	A	3.4	A

EWR RESULTS AT THE DESKTOP BIOPHYSICAL NODES

The Revised Desktop Reserve Model (RDRM) 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 (10^6 m^3)		REC	Long-term requirements			
						Low flows		Total flows	
			Natural	PD		10^6 m^3	MAR	10^6 m^3	MAR
Inkomati River Catchment									
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%
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 Catchment									

IUA	SQ node	River name	MAR ($10^6 m^3$)		REC	Long-term requirements			
			Natural	PD		Low flows		Total flows	
						$10^6 m^3$	MAR	$10^6 m^3$	MAR
X2-1	X21A-01008		na	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%
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 River Catchment									

IUA	SQ node	River name	MAR ($10^6 m^3$)		REC	Long-term requirements			
						Low flows		Total flows	
			Natural	PD		$10^6 m^3$	MAR	$10^6 m^3$	MAR
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%
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%

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

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TERMINOLOGY AND ACRONYMS

CD: RDM	*Chief Directorate: Resource Directed Measures*
DEM	*Digital Elevation Model*
DRM	*Desktop Reserve Model*
DWA	*Department of Water Affairs*
EC	*Ecological Category*
EGSA	*Ecosystem Goods, Services and Attributes*
EWR	*Ecological Water Requirement*
FD	*Fast Deep fish habitat*
FRAI	*Fish Response Assessment Index*
FROC	*Frequency of Occurrence*
FS	*Fast Shallow fish habitat*
GIS	*Geographical Information System*
Gz	*Geomorphological zone*
IEI	*Integrated Environmental Importance*
IFR	*Instream Flow Requirements*
IUA	*Integrated Unit of Analysis*
IWAAS	*Inkomati Water Availability Assessment Study*
KNP	*Kruger National Park*
LB	*Left Bank*
LL	*Large limnophilics*
LR	*Large rheophilics*
LSR	*Large semi-rheophilics*
MAR	*Mean Annual Runoff*
MIRAI	*Macro Invertebrate Response Assessment Index*
MRU	*Management Resource Unit*
NFEPA	*National Freshwater Ecosystem Priority Areas*
NRU	*Natural Resource Unit*
NWRCS	*National Water Resources Classification System*
PD	*Present Day*
PES	*Present Ecological State*
PESEIS	*Present Ecological State and Ecological Importance -Ecological Sensitivity*
PSP	*Professional Service Provider*
Quat	*Quaternary catchment*
RAU	*Reserve Assessment Unit*
RB	*Right Bank*
RDRM	*Revised Desktop Reserve Model*
REC	*Recommended Ecological Category*
RHP	*River Health Programme*
RQO	*Resource Quality Objective*
RU	*Resource Units*
SPATSIM	*Spatial and Time Series Information Modelling*
SQ	*Sub-quaternary (may also be termed a quinary)*
SRTM	*Shuttle Remote Topography Mission*
VEGRAI	*Vegetation response Assessment Index*
WMA	*Water Management Area*
WQSU	*Water Quality Sub Unit*
WRC	*Water Research Commission*
WRUI	*Water Resource Use Importance*

1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Resource Directed Measures (CD: RDM) of the Department of Water Affairs (DWA) 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 Inkomati WMA. IWR Water Resources was appointed as the Professional Service Provider (PSP) to undertake this study.

1.2 INTEGRATED STEP 3: QUANTIFY EWRS AND CHANGES IN NON-WATER QUALITY ECOSYSTEM SERVICES

This study entails Classification and setting of RQOs. Embedded in the National Water Resources Classification System (NWRCS) is the determination of the Reserve. Each of these three processes consists of distinctive steps which overlap. Integrated steps were designed and are provided below.

Table 1.1 Integrated steps combining the NWRC, RQO and Reserve processes

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	*Identification and evaluate scenarios within the integrated water resource management process.*
5	*Evaluate the scenarios with stakeholders.*
6	*Develop draft RQOs and numerical limits.*
7	*Gazette and implement the class configuration and RQOs.*

This report documents Step 3 (red above), i.e. quantifying the Ecological Water Requirements (EWR). In summary, this task consists of the EcoClassification and EWR determination at various biophysical nodes in the system. EWR results are available from previous studies at key biophysical nodes (EWR sites) and these studies are summarised below as well as additional work required for application during the NWRCS.

1.2.1 2007 - 2010 Inkomati Reserve Study

This study is the most recent comprehensive Reserve study that was undertaken and focussed on the Sabie-Sand Catchment (X3) and the Crocodile Catchment (X2). The work was undertaken at 15 EWR sites of which eight are situated in the Sabie-Sand and seven in the Crocodile. As this work was finalised during 2010 (DWA, 2010), the methods used are current and based on updated hydrology which was derived from the Inkomati Water Availability Assessment Study (IWAAS) completed by the Department of Water Affairs in 2009 (DWA, 2009a,b). No further work is required at these EWR sites and the results are summarised in this report.

1.2.2 2003 – 2005 Elands River Reserve Study

This study was undertaken during 2003 – 2005 at Comprehensive level in the Elands River catchment, Mpumalanga Province. This study was a follow on the Intermediate Reserve determination study which was conducted for the Elands River during 2000 – 2002 as this study *did not consider scenarios. The purpose of the study was to establish the ecological specifications for Resource Quality Objectives (RQOs) which should be met in the Elands River (Hill, 2005). Two EWR sites were selected in the Elands River mainstem. EcoClassification and EWR flow requirement methods were followed as outlined in DWAF (2004).*

1.2.3 2004 – 2006 Komati Reserve Study

This study was done during 2004 - 2006 and addressed the EWRs at seven EWR sites with one situated in Swaziland. It was recognised that the hydrology used for the EWR study (AfriDev, 2005a) was out dated. Reserve results are generated as an EWR rule which is a flow duration table. The natural simulated hydrology is used to generate the final output. If the hydrology changes, then the final EWR output is invalid, especially if changes are significant. Therefore, the basis of the EWRs (dry and wet drought and maintenance EWRs) has to be used to generate new EWR rules based on the original habitat requirements. The problem is further exacerbated as the EWR data and the scenarios that were developed towards the end of the study were not stored in the correct format within the Spatial and Time Series Information Modelling (SPATSIM) framework and therefore adjustments and changes required for future scenario evaluation cannot be made (DWA, 2013a). The existing results therefore have to be updated within SPATSIM using the updated hydrology (DWA, 2009c).

Furthermore, the models used to determine the Present Ecological State (PES) within the EcoClassification process were in its infancy and some of the models were not designed yet. The scenarios evaluation process (Step 4) of the NWRCS uses these models to predict the change in Ecological Category (EC) from the (PES). It was also therefore necessary to update the EcoClassification models using the 2004 - 2006 results as well as considering any additional recent information. If the ECs are different than those determined during this period, statements must be made whether this is just an artefact of using an updated model, and/or whether the state has changed since 2004 - 2006.

The EcoClassification process will therefore be undertaken based on existing data at six of the EWR sites. M1 situated in Swaziland is not considered further as Swaziland does not form part of the study area for the NWRCS. The EWR results at these six sites will be converted using the updated hydrology.

1.2.4 EWR assessment for the desktop biophysical nodes

Apart from the EWR sites, EWR estimates have to be made at 217 desktop biophysical nodes. The PES for these nodes are available from the PESEIS 2011 (DWA, 2013b) study (referred to as PES (11) and was used accordingly. The Recommended Ecological Category (REC) had to be determined (DWA, 2013c) and the EWRs estimated for these nodes. The determination of the REC and the EWR estimates (at desktop level) therefore had to be undertaken as part of this study.

1.2.5 Step 3 subtasks

This task consists of the following subtasks:

- **Task D3.1. Setting up the system model and provision of natural and present day data**
  As indicated in the section above, the hydrology has been revised as part of the IWAAS and will be used for the EWR assessment.
- **Task D3.2. EWRs for key biophysical nodes**

EWRs were set at six EWR sites (key biophysical nodes) during the comprehensive 2004 - 2006 study on the Komati River. These EWRs had to be revised based on the new hydrology during this study. The PES also had to be revised.

- **Task D3.3. EWRs for desktop biophysical nodes.**

  As the previous comprehensive Reserve studies focussed on the EWRs at the EWR sites, EWRs must now be estimated at desktop biophysical nodes which are representative of the whole catchment.

- **Task D3.4. Consequences of Ecosystem Goods, Services and Attributes (EGSA) at sites where the REC is an improvement of the PES**

  During Task D1, the REC for all the biophysical nodes was established. The Ecosystem Services were also identified at these sites. At sites where the REC is set to improve the PES, the links (response) to the identified Services are identified.

- **Task D3.5. EWR report**

  This report.

This task provides the information for the next step, i.e. Step D4: Identification and evaluation of operational scenarios to identify consequences.

1.3 REPORT STRUCTURE

The report outline is provided below.

Chapter 1: Introduction

This Chapter provides general background to the project Task.

Chapter 2: Summary of EWR results at EWR sites (Key biophysical nodes): Sabie-Sand (X3) Catchment

The Chapter summarises certain aspects of the 2007 - 2010 Reserve study undertaken by Rivers for Africa during April 2007 and March 2010. The focus of this Chapter is on the Resource Units and EWR sites selected during the study.

Chapter 3: Summary of EWR results at EWR sites (Key biophysical nodes): Crocodile (X2) Catchment

The Chapter summarises certain aspects of the 2007 - 2010 Reserve study undertaken by Rivers for Africa during April 2007 and March 2010. Also included are the same details for the Elands River Catchment. The focus of this Chapter is on the Resource Units and EWR sites selected during the study.

Chapter 4: Summary of EWR results at EWR sites (Key biophysical nodes): Komati (X1) Catchment

The Chapter summarises certain aspects of the 2004 - 2006 Reserve study undertaken by AfriDev Consultants. The focus of this Chapter is on the Resource Units and EWR sites selected during the study.

Chapter 5: Revised EcoClassification results: EWR sites (Key biophysical nodes): Komati (X1) Catchment

EcoClassification results per EWR site are provided comparing the 2005 Reserve results with 2014 results achieved by using updated data and current EcoClassification models.

Chapter 6: EWR results at EWR sites

The focus of this chapter is on the revision of the Komati EWR results. The updated results were generated by using the measured hydraulic cross-sections and hydraulic modelling data at EWR sites and the updated hydrology to populate the Revised Desktop Reserve Model (RDRM) (Hughes et al., 2012) in SPATSIM. The results for the low flows are provided per EWR site and the high flows are summarised for all the EWR sites. A summary of the results compared to the natural MAR (NMAR) is also provided.

Chapter 7: Desktop biophysical nodes: Resource Units, locality and EcoClassification

The Sub-Quaternary river reaches (SQs) forms the basis of the PES (11) (DWA, 2013b) assessment and are therefore surrogates for desktop level Resource Units. Desktop biophysical nodes are listed and a summary of results for the desktop biophysical nodes are provided.

Chapter 8: Desktop biophysical nodes: EWR estimation and results

This chapter provides the general approach used during this study to estimate the EWRs at the biophysical nodes using the Revised Desktop Reserve Model (RDRM) which includes the links and relationships between hydrology, hydraulics and ecological response.

Chapter 9: References

Appendix A: EWR results as RDRM output

The Revised Desktop Reserve Model outputs for every EWR site are provided.

2 SUMMARY OF EWR RESULTS AT EWR SITES (KEY BIOPHYSICAL NODES): SABIE-SAND (X3) CATCHMENT

2.1 SABIE-SAND (X3) CATCHMENT RESERVE DETERMINATION STUDY

In light of the initiation of the Compulsory Licensing Process in the Water Management Area (WMA) and the proposed construction of the Montrose and Mountain View Dams., the CD: RDM commissioned a Comprehensive Reserve study during 2007. Rivers for Africa undertook the study and it was conducted over a three-year period between September 2007 and March 2010.

This study followed comprehensive methods for EcoClassification as well as for Ecological Water Requirement determination and was based on the generic 8-step Reserve process (Louw and Hughes, 2002). The focus of the study was on the Sabie-Sand (X3) catchment and its major rivers and tributaries the Sabie, Sand, Mutlumuvi, Marite and MacMac rivers as well as the Crocodile (X2) catchment which included the Crocodile and Kaap rivers (refer to Section 3). The overall objectives of this study as outlined in DWAF (2007) were as follows:

- *Provide the typing, importance and habitat integrity for wetlands and make recommendations regarding Reserve assessments.*
- *Groundwater: Assess groundwater input to base flows at an intermediate level and make recommendations for Reserve assessments at a higher level of confidence if necessary.*
- *Provide Level 4 EcoStatus assessment for the Resource Units represented by comprehensive EWR sites as part of the EcoClassification process.*
- *Identify a range of ECs for which water requirements must be set.*
- *Determine EWRs for each of these ECs or, where relevant, test existing EWRs for adequacy and purposes of monitoring.*
- *Determine the impact of EWRs on the allocatable yield and, based on the impacts, devise additional scenarios to optimize the allocatable yield.*
- *Determine the ecological and resource-economic consequences of each of these additional scenarios.*
- *Provide the Ecological Specifications (EcoSpecs), as input to the RQOs, associated with the Management Class provided to the PSP, if available.*
- *Provide extrapolated results for each hydrological node in the Sabie and Crocodile catchment.*
- *Provide an implementation strategy for the Reserve*
- *Train selected specialist trainees in specific tasks relating to Reserve determinations.*

2.2 MANAGEMENT RESOURCE UNITS

A summary of the Management Resource Units (MRUs) defined during the 2007 - 2010 study (DWAF, 2008) is provided in Table 2.1.

Table 2.1 Description and rationale of the MRUs in the Sabie-Sand (X3) catchment

MRU	EcoRegion Level 2	Geomorphic zone	Land cover 500m both banks	Delineation	Quat
Sand A	*10.02 (15%) 4.04 (5%) 3.07 (80%)*	*Mountain Headwater Stream (5%) Mountain Stream (5%) Transitional (10%) Lower foothills (40%) Upper foothills (40%)*	*Indigenous forest and degraded bush.*	*Origin of river to confluence with Mutlumuvi. 30.8900; -24.7333 31.2338; -24.7221*	*X32A X32C*
Rationale: *The river is dominated by EcoRegion 3.07, has similar land cover and land use. The upper river will be different, but this will not warrant a separate RAU[1] as too small. The confluence of the Mutlumuvi river forms a logical end of the MRU due to the change in hydrology. The MRU = primary NRU[2] = WQSU[3] 2.*					
Mutlumuvi A.	*10.02 (15%) 4.04 (5%) 3.07 (80%)*	*Mountain Headwater Stream (2.5%) Mountain Stream (2.5%) Transitional (2%) Lower foothills (8%) Upper foothills (85%)*	*Degraded bush.*	*Origin of river to confluence with Sand. 30.9243; -24.7921 31.2338; -24.7221*	*X32D X32F*
Rationale: *The river is dominated by EcoRegion 3.07, Upper Foothills and degraded bush. The upper river will be different, but this will not warrant a separate RAU as to small. The confluence with the Sand River forms a logical end of the MRU due to the change in hydrology. The MRU = primary NRU = WQSU1.*					
Sand B	*3.07 (100%)*	*Lower Foothills (100%)*	*Mostly within the conservation areas with the upper areas of the MRU covered with the degraded bush.*	*Confluence with the Mutlumuvi to the confluence with the Sabie. 31.2338; -24.7221 31.7120; -24.9559*	*X32G X32H X32J*
Rationale: *The river is dominated by EcoRegion 3.07, and conservation areas. Includes both WQSU 3 and 4.*					
RAU Sand B.1	*3.07 (100%)*	*Lower Foothills (100%)*	*Within the conservation areas.*	*Border of Sabie Sand to confluence with the Sabie. 31.3576-24.7539 31.7120; -24.9559*	*X32G X32H X32J*
Rationale: *A RUA was selected due to the change in the landuse. The RAU will be a different (higher) PES than the rest of the MRU due to its protected status. It would be preferable to have a EWR situated in this section as the indicators for EWR assessment will be intact and catering for this RAU will also cater for the rest of the MRU. RAU B.1 = WQSU4.*					

1 Reserve Assessment Unit 2 Natural Resource Unit 3 Water Quality Sub Unit

2.3 EWR SITES

2.3.1 Selection of EWR sites

Eight EWR sites were selected during 2007 (DWAF, 2008) and are listed in Table 2.2 and their location within WMA 5 is provided in Figure 2.2.

Table 2.2 Details of the EWR sites selected during 2007 in the Sabie-Sand (X3) catchment

EWR Site number	EWR Site name	River	Co-ordinates		MRU
			Latitude	Longitude	
EWR 1	*Upper Sabie*	*Sabie River*	*25 04.424*	*30 50.924*	*Sabie A*
EWR 2	*Aan de Vliet*	*Sabie River*	*25 01.675*	*31 03.099*	*Sabie A*
EWR 3	*Kidney*	*Sabie River*	*24 59.256*	*31 17.572*	*Sabie B.1*
EWR 4	*MacMac*	*Mac Mac River*	*25 00.800*	*31 00.243*	*Mac A*
EWR 5	*Marite*	*Marite River*	*25 01.077*	*31 07.997*	*Mar A*
EWR 6	*Mutlumuvi*	*Mutlumuvi River*	*24 45.352*	*31 07.923*	*Mut A*
EWR 7	*Tlulandziteka*	*Tlulandziteka River*	*24 40.829*	*31 05.188*	*Sand A*
EWR 8	*Sand*	*Sand River*	*24 58.045*	*31 37.641*	*Sand B, RAU B.1*

2.3.2 Description of the EWR sites

A description of the EWR sites is provided below (DWAF, 2008).

Table 2.3 Characteristics and view of EWR 1

Site information	Detail	Illustration
EWR site	*EWR 1*	
Name	*Upper Sabie*	
River	*Sabie*	
Co-ordinates	*S 25.0737 E 30.84874*	
MRU	*Sabie A*	
IUA[1]	*IUA X3_2*	
SQ[2] *Reach*	*X31B-00757*	
IEI[3] *rating*	*High (3)*	
WRUI[4] *rating*	*Very high (4)*	
Hotspot rating	*Moderate (2)*	
EWR site advantages and disadvantages: ▪ *This is a bedload system and requires sediment transport modelling to evaluate the geomorphology. As this will not be undertaken at this site, the suitability is low for geomorphology.* ▪ *Overall the site is highly suitable for high flows, but less suitable for low flows due to the complicated hydraulics.*		

1 Integrated Unit of Analysis *2 Sub-quaternary*
3 Integrated Environmental Importance *4 Water Resource Use Importance*

Table 2.4 Characteristics and view of EWR 2

Site information	Detail	Illustration
EWR site	*EWR 2*	
Name	*Aan de Vliet*	
River	*Sabie*	
Co-ordinates	*S 25.0279 E 31.05166*	
MRU	*Sabie A*	
IUA	*IUA X3_2*	
SQ Reach	*X31D-00755*	
IEI rating	*High (3)*	
WRUI rating	*Very high (4)*	
Hotspot rating	*Very high (4)*	
EWR site advantages and disadvantages: ▪ *This is a bedload system and requires sediment transport modelling to evaluate the geomorphology. As this will not be undertaken at this site, the suitability is low for geomorphology.* ▪ *Overall the site is highly suitable for high flows, but less suitable for low flows due to the complicated hydraulics.*		

Table 2.5 Characteristics and view of EWR 3

Site information	Detail	Illustration
EWR site	*EWR 3*	
Name	*Kidney*	
River	*Sabie*	
Co-ordinates	*S 25.0279 E 31.05166*	
MRU	*Sabie B.1*	
IUA	*IUA X3_3*	
SQ Reach	*X31K-00715*	
IEI rating	*High (3)*	
WRUI rating	*High (3)*	
Hotspot rating	*High (3)*	

EWR site advantages and disadvantages:
- *No true morphological cues present.*
- *Moderate suitability for both low and high flows due to complicated hydraulics.*

Table 2.6 Characteristics and view of EWR 4

Site information	Detail	Illustration
EWR site	*EWR 4*	
Name	*Mac Mac*	
River	*Mac Mac*	
Co-ordinates	*S 25.0133 E 31.00405*	
MRU	*Mac A*	
IUA	*IUA X3_2*	
SQ Reach	*X31C-00683*	
IEI rating	*Very high (4)*	
WRUI rating	*Moderate (2)*	
Hotspot rating	*High (3)*	

EWR site advantages and disadvantages:
- *No true morphological cues. This is a bedload system and requires sediment transport modelling to evaluate the geomorphology. As this will not be undertaken at this site, the geomorphology suitability is low.*
- *Highly suitable for low flows, less suitable for high flows due to the complicated hydraulics.*

Table 2.7 Characteristics and view of EWR 5

Site information	Detail	Illustration
EWR site	*EWR 5*	
Name	*Marite*	
River	*Marite*	
Co-ordinates	*S 25.018 E 31.13328*	
MRU	*Mar A*	
IUA	*IUA X3_3*	
SQ Reach	*X31G-00728*	
IEI rating	*High (3)*	
WRUI rating	*High (3)*	
Hotspot rating	*High (3)*	

EWR site advantages and disadvantages:
- *No true morphological cues and sediment transport modelling will have to be undertaken.*
- *Highly suitable for high flows, less suitable for low flows due to the complicated hydraulics.*

Table 2.8 Characteristics and view of EWR 6

Site information	Detail	Illustration
EWR site	*EWR 6*	
Name	*Mutlumuvi*	
River	*Mutlumuvi*	
Co-ordinates	*S 24.7559 E 31.13205*	
MRU	*Mut A*	
IUA	*IUA X3_7*	
SQ Reach	*X32F-00597*	
IEI rating	*Moderate (2)*	
WRUI rating	*Moderate (2)*	
Hotspot rating	*Moderate (2)*	

EWR site advantages and disadvantages:

- *Moderate suitability for both low and high flows.*

Table 2.9 Characteristics and view of EWR 7

Site information	Detail	Illustration
EWR site	*EWR 7*	
Name	*Upper Sand*	
River	*Tlulandziteka (Sand)*	
Co-ordinates	*S 24.6805 E 31.08647*	
MRU	*Sand A*	
IUA	*IUA X3_8*	
SQ Reach	*X32A-00583*	
IEI rating	*High (3)*	
WRUI rating	*Moderate (2)*	
Hotspot rating	*Moderate (2)*	

EWR site advantages and disadvantages:

- *Highly suitable for high flows, less suitable for low flows due to the complicated hydraulics.*

Table 2.10 Characteristics and view of EWR 8

Site information	Detail	Illustration
EWR site	*EWR 8*	
Name	*Lower Sand*	
River	*Sand*	
Co-ordinates	*S 24.9674 E 31.62734*	
MRU	*Sand B, RAU B.1*	
IUA	*IUA X3_9*	
SQ Reach	*X32J-00602*	
IEI rating	*Very high (5)*	
WRUI rating	*Moderate (3)*	
Hotspot rating	*Very high (4)*	

EWR site advantages and disadvantages:

- *Highly suitable for high flows, less suitable for low flows due to the complicated hydraulics.*

2.4 ECOCLASSIFICATION RESULTS

The EcoClassification results for the Sabie-Sand Catchment are summarised in Table 2.11.

Table 2.11 EcoClassification results – Sabie-Sand Catchment

EWR 1: Upper Sabie (Sabie River)

EIS: HIGH
Rare and endangered fish and vegetation species. Fish species present that are intolerant to flow and flow related water quality 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 2: Aan de Vliet (Sabie River)

EIS: HIGH
Rare and endangered fish and vegetation species. Species present intolerant to flow and flow related water quality 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 3 Kidney (Sabie River)

EIS: VERY HIGH
Rare and endangered species, taxon richness and species intolerant to flow and flow related water quality changes. Refuge area for biota and an important migration corridor for birds and fish. Within Kruger National Park (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 4 Mac Mac (Mac Mac River)

EIS: HIGH
Rare and endangered fish and vegetation species. Species present intolerant to flow and flow related water quality changes.

PES: B
Forestry, exotic vegetation and wastewater input. Impacts are flow and non-flow related.

REC: A/B
The EIS at EWR 4 is high and the REC is therefore to improve the PES by improving the fish. Improved water quality 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 5 Marite (Marite River)

EIS: HIGH.
Rare, endangered and unique biota. Species richness high and species intolerant to flow and flow related water quality 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 6 Mutlumuvi (Mutlumuvi River)

EIS: HIGH
Rare, endangered and unique biota. Taxon species richness high and species intolerant to flow and flow related water quality 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 7 Tlulandziteka (Tlulandziteka River)

EIS: MODERATE
Rare and endangered species, high taxon richness, species intolerant to flow and flow related water quality 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 8 Lower Sand (Sand River)

EIS: HIGH
Rare and endangered species, high taxon richness and species intolerant to flow and flow related water quality 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 macro-invertebrate 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

A summary of confidences for all the sites are given in Table 2.12. The confidence score is based on a scale of 0 – 5 and colour coded where:

0 – 1.9: Low *2 – 3.4: Medium* *3.5 – 5: High*

Table 2.12 Confidence in EcoClassification

EWR site	Data Availability							EcoClassification								
	Hydrology	Geomorphology	Physico-chemical	IHI	Fish	Macro-invertebrate	Vegetation	Median	Hydrology	Geomorphology	Physico-chemical	IHI	Fish	Macro-invertebrate	Vegetation	Median
EWR 1	3	3	3	4	3	3	4	3	3	3.5	3	3.2	4	4	3.4	3.4
EWR 2	4	3	3	4	4	4	4	4	4	3.5	3	3.1	4	4	3.2	3.5
EWR 3	3	5	2.5	4	4	4	5	4	3	4	2.5	3.1	4	4	4	4
EWR 4	3	3	3	4	3	3	4	3	3	3	3	3.4	4	3	3.9	3
EWR 5	4	3.5	3	4	4	3	4	4	4	3.5	3	3.2	4	2.5	4	3.5

	Data Availability								EcoClassification							
EWR site	**Hydrology**	**Geomorphology**	**Physico-chemical**	**IHI**	**Fish**	**Macro-invertebrate**	**Vegetation**	**Median**	**Hydrology**	**Geomorphology**	**Physico-chemical**	**IHI**	**Fish**	**Macro-invertebrate**	**Vegetation**	**Median**
EWR 6	*2*	*3*	*2*	*4*	*3*	*3*	*4*	*3*	*2*	*3*	*2*	*2.9*	*4*	*3.5*	*3.8*	*3*
EWR 7	*2.5*	*2*	*2*	*4*	*3*	*2.5*	*2*	*2.5*	*2.5*	*2*	*2*	*2.9*	*3*	*2*	*3.7*	*2.5*
EWR 8	*4*	*3.5*	*3*	*4*	*3*	*3*	*4.5*	*3.5*	*4*	*3*	*2*	*2.9*	*4*	*3.5*	*3.7*	*3.5*

The results indicated MEDIUM to HIGH confidence for data availability at all the sites except for EWR 7. The confidence at EWR 7 was LOW to MEDIUM as this site was only surveyed at a Rapid Level. There was also no hydrological gauge or water quality measuring station nearby. Although good biological response information was available for EWR 1, 4 and 6, information on the ecological drivers was not sufficient and therefore the confidence was MEDIUM. The MEDIUM-HIGH (EWR 8) and HIGH (EWR 2, 3 and 5) confidence was due to data collated during national and provincial RHP surveys, research that was conducted in the KNP as well as the 1996 and 1997 Reserve studies (previously referred to as 'IFR studies'). An updated hydrology study was also undertaken for the Sabie and Sand Rivers. However, confidence in the hydrology data for the Sand River will always be low due to the fact that there is only one gauge that represents the whole catchment.

MEDIUM to LOW levels of confidence in the EcoClassification results in the Sabie-Sand River catchments were attributed to the following:

- *EWR 1: Apart from the instream biological surveys and one geomorphology survey, no other work has been undertaken at this site.*
- *EWR 2: This site is a complex site from a vegetation point of view which resulted in the site not having a HIGH EcoClassification confidence.*
- *EWR 4 and 7: EWR 7 was an additional site, and as such the EcoClassification assessment was only conducted at a Rapid level III. There was also no nearby hydrological or water quality measuring gauge for both EWR sites.*
- *EWR 5: There was a lack of macro-invertebrate information (probably due to the bedrock nature of the system), as well as lack of hydrological and water quality measuring data.*
- *EWR 8: The lack of confidence was a result of a lack of physico-chemical information, especially as this site dries up which means that temperature and oxygen information becomes crucial.*

2.5 EWR RESULTS

The EWR results are summarised in Table 2.13 to Table 2.20 and the high flow requirements are provided in Table 2.21.

Table 2.13 EWR 1 Upper Sabie: Low flow EWR results for PES B/C and REC B

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*0.97*	*0.4*	*1.25*	*0.4*
NOVEMBER	*1.14*	*0.451*	*1.5*	*0.451*
DECEMBER	*1.32*	*0.494*	*1.8*	*0.494*
JANUARY	*1.6*	*0.569*	*2.1*	*0.569*
FEBRUARY	*2.1*	*0.722*	*2.8*	*0.722*
MARCH	*2*	*0.677*	*2.75*	*0.677*
APRIL	*1.93*	*0.661*	*2.6*	*0.661*
MAY	*1.7*	*0.598*	*2.25*	*0.598*
JUNE	*1.58*	*0.567*	*2.1*	*0.567*
JULY	*1.31*	*0.492*	*1.7*	*0.492*
AUGUST	*1.12*	*0.439*	*1.44*	*0.439*
SEPTEMBER	*1.02*	*0.417*	*1.3*	*0.417*

Table 2.14 EWR 2 Aan de Vliet: Low flow EWR results for PES B/C and REC B

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*1.252*	*0.747*	*1.598*	*0.747*
NOVEMBER	*1.392*	*0.815*	*1.904*	*0.815*
DECEMBER	*1.513*	*0.861*	*2.265*	*0.861*
JANUARY	*1.721*	*0.952*	*2.797*	*0.952*
FEBRUARY	*2.170*	*1.170*	*3.772*	*1.170*
MARCH	*2.043*	*1.093*	*3.619*	*1.093*
APRIL	*2.002*	*1.082*	*3.461*	*1.082*
MAY	*1.812*	*0.992*	*3.028*	*0.992*
JUNE	*1.733*	*0.964*	*2.774*	*0.964*
JULY	*1.516*	*0.863*	*2.274*	*0.863*
AUGUST	*1.369*	*0.798*	*1.897*	*0.798*
SEPTEMBER	*1.309*	*0.779*	*1.692*	*0.779*

Table 2.15 EWR 3 Kidney: Low flow EWR results for PES and REC A/B

Months	PES and REC		AEC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*2.703*	*1.090*	*1.492*	*1.090*
NOVEMBER	*3.362*	*1.234*	*1.982*	*1.234*
DECEMBER	*4.274*	*1.386*	*2.706*	*1.386*
JANUARY	*5.546*	*1.626*	*3.689*	*1.626*
FEBRUARY	*7.843*	*2.121*	*5.401*	*2.121*
MARCH	*7.508*	*1.995*	*5.205*	*1.995*
APRIL	*6.941*	*1.908*	*4.747*	*1.908*
MAY	*5.794*	*1.673*	*3.881*	*1.673*
JUNE	*5.120*	*1.565*	*3.340*	*1.565*
JULY	*4.086*	*1.351*	*2.561*	*1.351*
AUGUST	*3.326*	*1.208*	*1.974*	*1.208*
SEPTEMBER	*2.881*	*1.143*	*1.610*	*1.143*

Table 2.16 EWR 4 Mac Mac: Low flow EWR results for PES and REC B

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*0.047*	*0.160*
NOVEMBER	*0.561*	*0.200*
DECEMBER	*0.675*	*0.254*
JANUARY	*0.836*	*0.329*
FEBRUARY	*1.133*	*0.459*
MARCH	*1.098*	*0.449*
APRIL	*1.053*	*0.427*
MAY	*0.915*	*0.365*
JUNE	*0.840*	*0.329*
JULY	*0.682*	*0.258*
AUGUST	*0.565*	*0.204*
SEPTEMBER	*0.500*	*0.172*

Table 2.17 EWR 5 Marite: Low flow EWR results for PES B/C and REC B

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*0.491*	*0.277*	*0.826*	*0.277*
NOVEMBER	*0.650*	*0.317*	*1.030*	*0.317*
DECEMBER	*0.904*	*0.366*	*1.336*	*0.366*
JANUARY	*1.247*	*0.440*	*1.759*	*0.440*
FEBRUARY	*1.849*	*0.587*	*2.525*	*0.587*
MARCH	*1.783*	*0.555*	*2.421*	*0.555*
APRIL	*1.553*	*0.511*	*2.143*	*0.511*
MAY	*1.163*	*0.422*	*1.655*	*0.422*
JUNE	*0.970*	*0.386*	*1.424*	*0.386*
JULY	*0.752*	*0.333*	*1.149*	*0.333*
AUGUST	*0.608*	*0.302*	*0.970*	*0.302*
SEPTEMBER	*0.521*	*0.290*	*0.871*	*0.290*

Table 2.18 EWR 6 Mutlumuvi: Low flow EWR results for PES C and REC B

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*0.140*	*0.040*	*0.270*	*0.150*
NOVEMBER	*0.180*	*0.070*	*0.300*	*0.160*
DECEMBER	*0.260*	*0.110*	*0.280*	*0.170*
JANUARY	*0.370*	*0.160*	*0.510*	*0.190*
FEBRUARY	*0.520*	*0.260*	*0.740*	*0.272*
MARCH	*0.500*	*0.270*	*0.733*	*0.271*
APRIL	*0.450*	*0.240*	*0.660*	*0.243*
MAY	*0.370*	*0.180*	*0.520*	*0.185*
JUNE	*0.330*	*0.160*	*0.460*	*0.175*
JULY	*0.280*	*0.120*	*0.420*	*0.170*
AUGUST	*0.240*	*0.100*	*0.350*	*0.160*
SEPTEMBER	*0.180*	*0.070*	*0.300*	*0.150*

Table 2.19 EWR 7 Thulandziteka: Low flow EWR results for PES and REC C

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	0.07	0
NOVEMBER	0.07	0
DECEMBER	0.12	0.05
JANUARY	0.2	0.1
FEBRUARY	0.26	0.14
MARCH	0.27	0.16
APRIL	0.25	0.12
MAY	0.2	0.09
JUNE	0.18	0.06
JULY	0.15	0.04
AUGUST	0.1	0.02
SEPTEMBER	0.08	0

Table 2.20 EWR 8 Lower Sand: Low flow EWR results for PES and REC B

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	0.26	0
NOVEMBER	0.34	0.05
DECEMBER	0.56	0.1
JANUARY	0.9	0.2
FEBRUARY	1.63	0.3
MARCH	1.52	0.3
APRIL	1.17	0.25
MAY	0.72	0.2
JUNE	0.62	0.15
JULY	0.5	0.1
AUGUST	0.39	0.05
SEPTEMBER	0.3	0.02

Table 2.21 High flow EWR results the EWR sites

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
EWR 1 UPPER SABIE: PES: B/C ECOSTATUS								
CLASS I (5 - 7 m^3/s)	4		4	4	4	Oct, Dec, Feb, Mar	6	4
CLASS II (10 - 20 m^3/s)	1		1	1	1	Jan	15	5
CLASS III (35 - 55 m^3/s)			1:2	1:3	1:2**		N/S[2]	N/S
CLASS IV (<70 m^3/s)			1:3 to 1:5		1:3		N/S	N/S
EWR 1 UPPER SABIE: REC: B ECOSTATUS								
CLASS I (5 - 7 m^3/s)	4		4	5	5	Oct, Nov, Dec, Feb, Apr	6	4
CLASS II (10 - 20 m^3/s)	1		1	1	1	Jan	15	5

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
CLASS III (35 - 55 m^3/s)			1:2	1:2	1:2		N/S	N/S
CLASS IV (<70 m^3/s)			1:3 to 1:5		1:3		N/S	N/S
EWR 2 AAN DE VLIET: PES: C ECOSTATUS								
CLASS I (9 - 12 m^3/s)	4		4	4	4	Nov, Dec, Jan, Mar	10	4
CLASS II (15 - 25 m^3/s)	1		1	1	1	Feb	20	5
CLASS III (35 - 55 m^3/s)	1:2		1:2	1:2	1:2		N/S	N/S
CLASS IV (<70 m^3/s)	1:3		1:3+	1:5	1:3		N/S	N/S
EWR 2 AAN DE VLIET: REC: B ECOSTATUS								
CLASS I (9 - 12 m^3/s)	5		4*	5[#]	5	Nov, Dec, Jan, Feb, Mar	10	4
CLASS II (15 - 25 m^3/s)	1		1	1	1	Feb	20	5
CLASS III (35 - 55 m^3/s)	1:2		1:2	1:2	1:2		N/S	N/S
CLASS IV (<70 m^3/s)	1:3		1:3+	1:5	1:3		N/S	N/S
EWR 3 KIDNEY: PES AND REC: A/B ECOSTATUS								
CLASS I (10 - 15 m^3/s)	4				4	Nov, Dec, Jan, Feb	8	3
CLASS II (15 - 30 m^3/s)			4	4	4	Nov, Dec, Jan, Mar	20	4
CLASS III (45 - 55 m^3/s)			1		1	Mar	40	5
CLASS IV (70 - 100 m^3/s)			1:2	1:2	1:2		N/S	N/S
CLASS V (<150 m^3/s)			1:3+		1:3		N/S	N/S
CLASS V (250 m^3/s)				1:5	1:5		N/S	N/S
EWR 4 MAC MAC: PES AND REC: B ECOSTATUS								
CLASS I (3 - 5 m^3/s)	4		4		4	Nov, Dec, Jan, Mar	4	3
CLASS II (6 - 12 m^3/s)	1		1		1	Feb	15	4
CLASS III (25 - 35 m^3/s)			1:2		1:2		N/S	N/S
CLASS IV (<70 m^3/s)			1:3+	1:10	1:3		N/S	N/S
EWR 5 MARITE: PES: B/C ECOSTATUS								
CLASS I (4 - 6 m^3/s)			4	4	4	Nov, Dec, Feb, Mar	4	3
CLASS II (8 - 18 m^3/s)			1	2	2	Dec, Jan	8	4
CLASS III (28 - 42 m^3/s)			1:2	1:2	1:2	Feb	25	5
CLASS IV (<80 m^3/s)			1:3	1:5	1:3		N/S	N/S
CLASS I (<250 m^3/s)			1:5+		1:5		N/S	N/S
EWR 5 MARITE: REC: B ECOSTATUS								
CLASS I (4 - 6 m^3/s)			4	5	5	Nov, Dec, Jan, Feb, Mar	4	3
CLASS II (8 - 18 m^3/s)			1	2	2	Dec, Jan	8	4
CLASS III (28 - 42 m^3/s)			1:2	1:2	1:2	Feb	25	5
CLASS IV (<80 m^3/s)			1:3	1:5	1:3		N/S	N/S
CLASS I (<250 m^3/s)			1:5+		1:5		N/S	N/S
EWR 6 MUTLUMUVI: PES: C ECOSTATUS								

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
CLASS I (1.6 – 2.5 m^3/s)			*4*	*3*	*4*	*Nov, Dec, Jan, Mar*	*1.6*	*3*
CLASS II (10 - 12 m^3/s)			*1*	*1*	*1*	*Feb*	*10*	*4*
CLASS III (16 - 30 m^3/s)			*1:2*		*1:2*		*N/S*	*N/S*
CLASS IV (<50 m^3/s)			*1:3*	*1:3*	*1:3*		*N/S*	*N/S*
CLASS V (<190 m^3/s)			*1:5+*		*1:5*		*N/S*	*N/S*
EWR 6 MUTLUMUVI: REC: B ECOSTATUS								
CLASS I (1.6 – 2.5 m^3/s)			*4*	*4*	*4*	*Nov, Dec, Jan, Mar*	*1.6*	*3*
CLASS II (10 - 12 m^3/s)			*1*	*1*	*1*		*10*	*4*
CLASS III (16 - 30 m^3/s)			*1:2*		*1:2*		*N/S*	*N/S*
CLASS IV (<50 m^3/s)			*1:3*	*1:3*	*1:3*		*N/S*	*N/S*
CLASS V (<190 m^3/s)			*1:5+*		*1:5*		*N/S*	*N/S*
EWR 7 THULANDZITEKA: PES AND REC: C ECOSTATUS								
CLASS I (1.6 – 2.5 m^3/s)			*4*		*4*	*Nov, Dec, Jan, Mar*	*1.5*	*3*
CLASS II (4 - 9 m^3/s)			*1*	*3*	*1*	*Jan*	*4*	*3*
CLASS III (15 m^3/s ave)				*1*	*1*	*Feb*	*9*	*4*
CLASS IV (28 m^3/s ave)				*1:2*	*1:2*		*N/S*	*N/S*
CLASS V (<68 m^3/s)			*1:3+*	*1:10*	*1:3*	*Wet*	*N/S*	*N/S*
EWR 8 LOWER SAND: PES AND REC: B ECOSTATUS								
CLASS I (1.6 – 2.5 m^3/s)			*4*		*4*	*Nov, Dec, Jan, Mar*	*5*	*4*
CLASS II (4 - 9 m^3/s)			*1*		*1*	*Feb*	*30*	*5*
CLASS III (15 m^3/s ave)							*N/S*	*N/S*
CLASS IV (28 m^3/s ave)							*N/S*	*N/S*
CLASS V (<68 m^3/s)			*1:3*	*1:2*	*1:2*		*N/S*	*N/S*

1 Final refers to the agreed on number of events considering the individual requirements for each component.
2 Not Specified

Table 2.22 Summary of PES results as a percentage of the natural MAR (nMAR)

EWR site	PES	nMAR (MCM)	pMAR (MCM)	Low flows (MCM)	Low flows (%nMAR)	High flows (MCM)	High flows (%nMAR)	Long term mean	
								Total flows (MCM)	Total (%nMAR)
EWR 1	*B/C*	*140.2*	*109.6*	*46.5*	*33.2*	*7.4*	*5.3*	*53*	*37.8*
EWR 2	*B/C*	*262.1*	*199.5*	*51.9*	*19.8*	*11.5*	*4.4*	*73.4*	*28*
EWR 3	*A/B*	*495.9*	*322.1*	*155.2*	*31.3*	*31.7*	*6.4*	*183.5*	*37*
EWR 4	*A/B*	*65.8*	*51.8*	*20.6*	*31.3*	*4.21*	*6.4*	*24.3*	*37*
EWR 5	*B/C*	*157.1*	*89.7*	*32.7*	*20.8*	*10.2*	*6.5*	*44.3*	*28.2*
EWR 6	*C*	*45*	*29.9*	*10*	*22.2*	*2.8*	*6.3*	*14.6*	*32.4*
EWR 7	*C*	*28.9*	*17.3*	*5.1*	*17.7*	*3.2*	*11*	*9.2*	*31.7*
EWR 8	*B*	*133.6*	*88.5*	*22.9*	*17.1*	*9.8*	*7.3*	*33.8*	*25.3*

Table 2.23 Summary of REC results as a percentage of the natural MAR (nMAR)

EWR site	REC	nMAR (MCM)	pMAR (MCM)	Low flows (MCM)	Low flows (%nMAR)	High flows (MCM)	High flows (%nMAR)	Long term mean	
								Total flows (MCM)	Total (%nMAR)
EWR 1	*B*	*140.2*	*109.6*	*61.8*	*44.1*	*8.6*	*6.1*	*64.9*	*46.3*
EWR 2	*B*	*262.1*	*199.5*	*81.5*	*31.1*	*13.1*	*5*	*93.6*	*35.7*
EWR 5	*B*	*157.1*	*89.7*	*47.4*	*30.2*	*11.2*	*7.1*	*57.0*	*36.3*
EWR 6	*B*	*45*	*29.9*	*14.5*	*32.2*	*2.8*	*6.3*	*17.4*	*38.6*

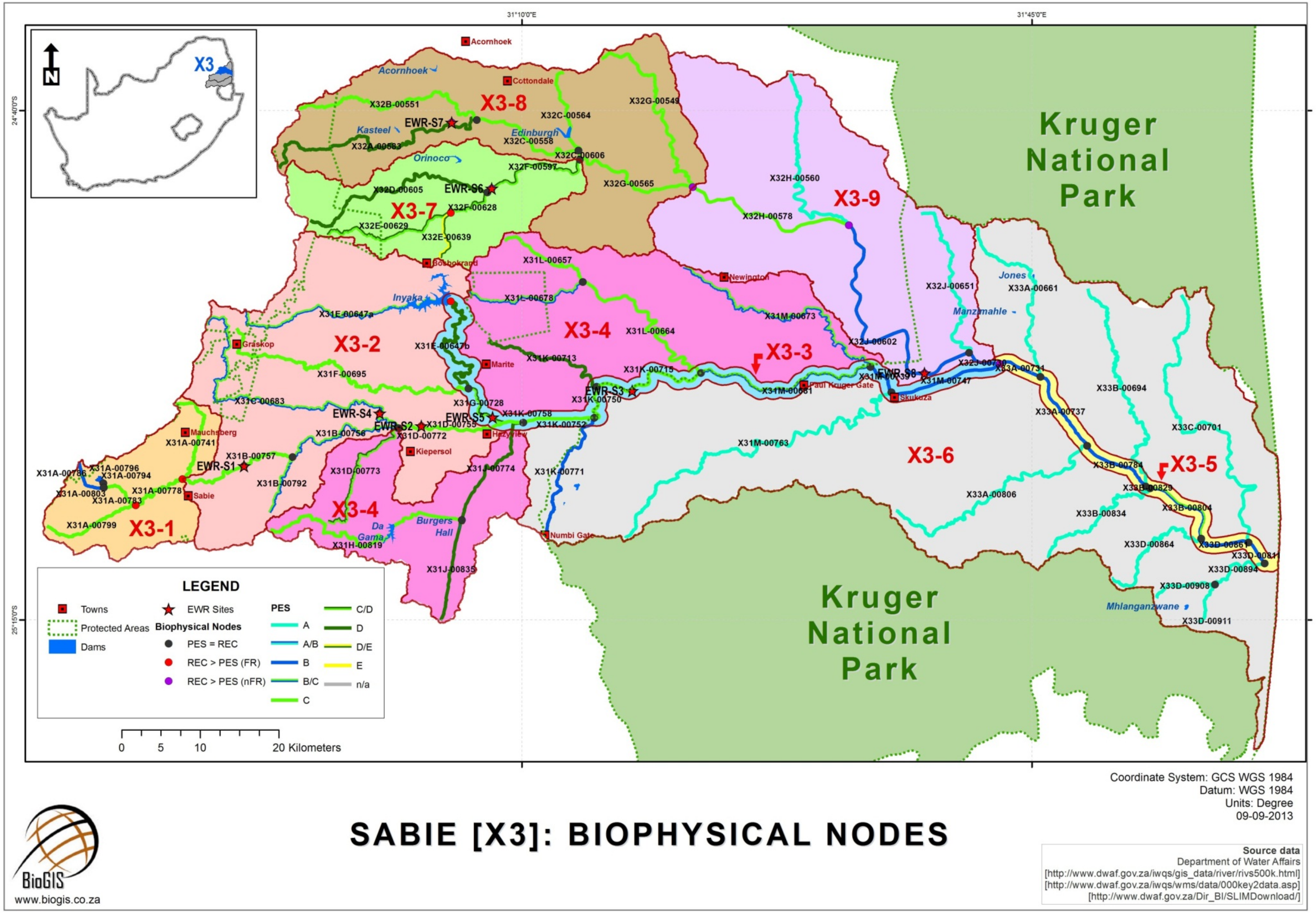


Figure 2.1 Locality of the selected EWR sites in the Sabie-Sand (X3) catchment

3 SUMMARY OF EWR RESULTS AT EWR SITES (KEY BIOPHYSICAL NODES): CROCODILE (X2) CATCHMENT

3.1 CROCODILE (X2) CATCHMENT RESERVE DETERMINATION STUDY

In light of the initiation of the Compulsory Licensing Process in the Water Management Area (WMA) and the proposed construction of the Montrose and Mountain View Dams., the CD: RDM commissioned a Comprehensive Reserve study during 2007. Rivers for Africa undertook the study and it was conducted over a three-year period between September 2007 and March 2010.

The focus of the study was on the Crocodile (X2) catchment and its major rivers and tributaries the Crocodile and Kaap rivers as well as the Sabie-Sand (X3) catchment including the Sabie, Sand, Mutlumuvi, Marite and MacMac rivers. The background and overall objectives of the study are provided in Section 2.1 of this report.

3.2 MANAGEMENT RESOURCE UNITS

A summary of the MRUs defined during the 2007 - 2010 study (DWAF, 2008) is provided in Table 3.1.

Table 3.1 Description and rationale of the MRUs in the Crocodile (X2) catchment

MRU	EcoRegion Level 2	Geomorphic zone	Land cover 500 m both banks	Delineation	Quat
Croc A	*9.02 (70%) 9.04 (30%)*	*Mountain Stream (1%) Transitional (6%) Upper Foothills (90%) Lower Foothills (3%)*	*Dominated by grassland.*	*Origin of river to upper reaches of Kwena Dam. 30.1074;-25.3380 30.3443;-25.3821*	*X21A X21B*
Rationale: *The river is dominated by EcoRegion 9.02 and Upper Foothills, has similar land cover and land use and includes to WQSU (1 and 2). The Kwena Dam is the operational break in the MRU. The MRU = primary NRU A, B and C.*					
Croc B	*10.02 (15%) 4.04 (5%) 3.07 (80%)*	*Lower foothills (20%) Upper foothills (80%)*	*Riparian zone dominated by bush clumps. Operation to Elands River dominated by releases (unseasonal) from Kwena.*	*Kwena Dam Wall to the Elands River confluence. 30.3862; -25.3590. 30.7156; -25.4527*	*X21D X21E*
Rationale: *The river is dominated by EcoRegion 3.07, and Upper Foothills. The releases from Kwena Dam forms a change from the natural hydrology and 1 EWR site in this reach will represent the reach. Water quality is homogenous. The Elands River (largest tributary) forms a hydrological break as it introduces a more natural diversity of flow at times. The MRU = primary NRU C and E = WQSU3.*					
Croc C	*4.04 (100%)*	*Upper Foothills (2%) Lower Foothills (98%)*	*Riparian indigenous bush with exotics and irrigation.*	*Elands River confluence to Blinkwater confluence. 30.7156;-25.4527 31.18018; -25.4996*	*X22B X22C X22J X22K*
Rationale: *Consists of EcoRegion 4.04 and Lower Foothills. Land cover and use similar with Nelspruit and adjacent KaNyamazane a logical break due to water quality impacts (forms 1 WQSU 4). The MRU = primary NRU F = WQSU 4.*					
Croc D	*3.07 (100%)*	*Upper Foothills (47%) Lower Foothills (47%) Transitional (6%)*	*Riparian indigenous bush with exotics.*	*Blinkwater confluence to border of KNP. 31.18018; -25.4996 31.3714; -5.5278*	*X22K X24C*
Rationale: *Breaks are indicated by change in land use and a distinctive gorge. The lower border indicates the change of sugarcane on the right bank (RB) and KNP on the left bank (LB).*					
RAU Croc D.1	*3.06 (100%)*	*Upper Foothills (90%) Lower Foothills (9%) Transitional (1%)*	*Gorge with a railway and tar roads flanking it with indigenous riparian bush with exotics.*	*Gorge 31.2026; -25.5090 31.3164; -25.5328*	*X22K X24C*

MRU	EcoRegion Level 2	Geomorphic zone	Land cover 500 m both banks	Delineation	Quat
Rationale: *This section of river is protected by being flanked by mountains. Ecological indicators more intact. The steeper gradient makes this section more sensitive to decreased flows and an EWR site within this section will be recommended.*					
Croc E	*3.06 (15%) 3.07 (70%) 12.01 (15%)*	*Lower Foothills (100%)*	*Natural bush (KNP) on LB and irrigation/lodges on RB*	*KNP border to Komati confluence 31.3714; -25.5278 31.9359; -25.3390*	*X24D X24E X24F X24H*
Rationale: *RU consists of Lower Foothills and the same land cover and use and water quality. The logical breaks are therefore from the point where the KNP borders the Crocodile River to the Komati River confluence.*					

3.3 EWR SITES

3.3.1 Selection of EWR sites

Seven EWR sites were selected during 2007 (DWAF, 2008) and are listed in Table 3.2 and their location within WMA 5 is provided in Figure 3.2.

Table 3.2 Details of the EWR sites selected during 2007 in the Crocodile (X2) catchment

EWR Site number	EWR Site name	River	Co-ordinates		MRU
			Latitude	Longitude	
EWR 1	*Valeyspruit*	*Crocodile*	*25 29.647*	*30 08.656*	*Croc A*
EWR 2	*Goedenhoop*	*Crocodile*	*25 24.555*	*30 18.955*	*Croc A*
EWR 3	*Poplar Creek*	*Crocodile*	*25 27.127*	*30 40.865*	*Croc B*
EWR 4	*KaNyamazane*	*Crocodile*	*25 30.146*	*31 10.919*	*Croc D (RUA Croc D.1)*
EWR 5	*Malelane*	*Crocodile*	*25 28.972*	*31 30.464*	*Croc E*
EWR 6	*Nkongoma*	*Crocodile*	*25 23.430*	*31 58.467*	*Croc E*
EWR 7	*Honeybird*	*Kaap*	*25 38.968*	*31 14.572*	*Kaap A*

3.3.2 Description of the EWR sites

A description of the EWR sites is provided below (DWAF, 2008).

Table 3.3 Characteristics and view of EWR 1

Site information	Detail	Illustration
EWR site	*EWR 1*	
Name	*Valyspruit*	
River	*Crocodile River*	
Co-ordinates	*S 25.49412 E 30.14427*	
MRU	*Croc A*	
IUA	*IUA X2_1*	
SQ Reach	*X21A-00930*	
IEI rating	*Very High (4)*	
WRUI rating	*Low (1)*	
Hotspot rating	*Moderate (2)*	
EWR site advantages and disadvantages: ▪ *Fish is lower suitability as only semi rheophilics are naturally present. This provides difficulties for setting flow requirements for fish during the dry season. This does not mean that there are better sites available.* ▪ *Highly suitable from both low and high flow perspective and both biophysical and hydraulic perspective.*		

Table 3.4 Characteristics and view of EWR 2

Site information	Detail	Illustration
EWR site	*EWR 2*	
Name	*Goedenhoop*	
River	*Crocodile*	
Co-ordinates	*S 25.40925 E 30.31592*	
MRU	*Croc A*	
IUA	*IUA X2_1*	
SQ Reach	*X21B-00962*	
IEI rating	*High (3)*	
WRUI rating	*Low (1)*	
Hotspot rating	*Moderate (2)*	

EWR site advantages and disadvantages:
- *Not easy to relate geomorphological cues to cross-section.*
- *Highly suitable from both low and high flow perspective and both biophysical and hydraulic perspective.*

Table 3.5 Characteristics and view of EWR 3

Site information	Detail	Illustration
EWR site	*EWR 3*	
Name	*Poplar Creek*	
River	*Crocodile*	
Co-ordinates	*S 25.45211 E 30.68108*	
MRU	*Croc B*	
IUA	*IUA X2_2*	
SQ Reach	*X21E-00943*	
IEI rating	*High (3)*	
WRUI rating	*High (3)*	
Hotspot rating	*High (3)*	

EWR site advantages and disadvantages:
- *Lack of diverse hydraulic habitat for macro-invertebrates.*
- *Highly suitable from both low and high flow perspective and both biophysical and hydraulic perspective.*

Table 3.6 Characteristics and view of EWR 4

Site information	Detail	Illustration
EWR site	*EWR 4*	
Name	*KaNyamazane*	
River	*Crocodile*	
Co-ordinates	*S 25.50243 E 31.18198*	
MRU	*Croc D*	
IUA	*IUA X2_9*	
SQ Reach	*X22K-01018*	
IEI rating	*High (3)*	
WRUI rating	*Very high (4)*	
Hotspot rating	*Very high (4)*	

EWR site advantages and disadvantages:
- *Disturbed banks problematic for geomorphological assessment.*
- *Highly suitable for high flows, slightly less suitable for low flows due to the complicated hydraulics. A low flow cross-section might have to be added to address the complications associated with the very steep rapid selected during the previous studies.*

Table 3.7 Characteristics and view of EWR 5

Site information	Detail	Illustration
EWR site	*EWR 5*	
Name	*Malelane*	
River	*Crocodile*	
Co-ordinates	*S 25.48287 E 31.50773*	
MRU	*Croc E*	
IUA	*IUA X2_11*	
SQ Reach	*X24D-00994*	
IEI rating	*High (3)*	
WRUI rating	*Very high (4)*	
Hotspot rating	*Very high (4)*	

EWR site advantages and disadvantages:
- *No clear terraces present - problematic for geomorphology assessment.*
- *Highly suitable from both low and high flow perspective and both biophysical and hydraulic perspective*

Table 3.8 Characteristics and view of EWR 6

Site information	Detail	Illustration
EWR site	*EWR 6*	
Name	*Nkongoma*	
River	*Crocodile*	
Co-ordinates	*S 25.39050 E 31.97444*	
MRU	*Croc E*	
IUA	*IUA X2_11*	
SQ Reach	*X24H-00934*	
IEI rating	*High (3)*	
WRUI rating	*Very high (4)*	
Hotspot rating	*Very high (4)*	

EWR site advantages and disadvantages:
- *No clear terraces present - problematic for geomorphology assessment.*
- *Highly suitable for high flows, slightly less suitable for low flows due to the complicated hydraulics.*

Table 3.9 Characteristics and view of EWR 7

Site information	Detail	Illustration
EWR site	*EWR 7*	
Name	*Honeybird*	
River	*Kaap*	
Co-ordinates	*S 25.64947 E 31.24286*	
MRU	*Kaap A*	
IUA	*IUA X2_10*	
SQ Reach	*X23G-01057*	
IEI rating	*High (3)*	
WRUI rating	*Very high (4)*	
Hotspot rating	*Very high (4)*	

EWR site advantages and disadvantages:
- *Impacts worse at site than rest of RU, bridge has impact, presence of bedrock - problematic for geomorphology assessment.*
- *Moderate suitability for both low and high flows. Low suitability for hydraulics due to rapidly varied flow conditions and large scale roughness due to bedrock influence in this gorge.*

3.4 ECOCLASSIFICATION RESULTS

The EcoClassification results for the Sabie-Sand Catchment are summarised in Table 3.10.

Table 3.10 EcoClassification results – Crocodile Catchment

EWR 1 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: 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 2 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 3 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 4 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, water quality 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

EWR 5 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 6 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 7 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

A summary of confidences for all the sites are given in Table 3.11. The confidence score is based on a scale of 0 – 5 and colour coded where:

0 – 1.9: Low *2 – 3.4: Medium* *3.5 – 5: High*

Table 3.11 Confidence in EcoClassification

	Data Availability								EcoClassification							
EWR site	**Hydrology**	**Geomorphology**	**Physico-chemical**	**IHI**	**Fish**	**Macro-invertebrate**	**Vegetation**	**Median**	**Hydrology**	**Geomorphology**	**Physico-chemical**	**IHI**	**Fish**	**Macro-invertebrate**	**Vegetation**	**Median**
EWR 1	*4*	*3*	*2*	*4*	*4*	*4*	*4*	*4*	*4*	*3*	*2*	*3.75*	*5*	*4*	*4.1*	*4*
EWR 2	*4*	*3*	*2*	*4*	*4*	*4*	*3.5*	*4*	*4*	*2.5*	*2*	*3.75*	*4*	*4*	*3.7*	*3.75*
EWR 3	*4*	*3*	*3*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*3*	*3.75*	*4*	*4*	*3.7*	*4*
EWR 4	*4*	*3*	*3*	*4*	*4*	*4*	*4*	*4*	*4*	*3*	*3*	*3.3*	*4*	*3*	*3.6*	*3.3*
EWR 5	*4*	*3*	*3*	*4*	*4*	*4*	*3*	*4*	*4*	*3.5*	*3*	*3.25*	*4*	*4*	*3.4*	*3.5*
EWR 6	*4*	*3*	*3*	*4*	*4*	*4*	*4.5*	*4*	*4*	*3*	*3*	*3.3*	*4*	*3*	*3.6*	*3.3*
EWR 7	*4*	*3*	*3*	*4*	*4*	*4*	*3.5*	*4*	*4*	*2.5*	*3*	*2.9*	*3.5*	*3*	*3.1*	*3*

The results indicated that there was a lot of data available and therefore the confidence in data availability was rated as HIGH. This was due to the recent and historical information collected during national and provincial River Health Programme (RHP) surveys, research in the Kruger national Park (KNP), previous EWR studies and the detailed updated hydrological study recently undertaken. Historical information from surveys undertaken by the Transvaal Provincial Administration's Nature Conservation Department (Mpumalanga Department of Nature Conservation) also contributed to the data that used to undertake the EcoClassification assessments at each site.

Whereas a HIGH level of confidence in the EcoClassification results was obtained for EWR 1 and 3, a MEDIUM to HIGH level of confidence was obtained for EWR 2, 4, 5 and 6 and a MEDIUM level of confidence was obtained for EWR 7.

Medium levels of confidence in the EcoClassification results were attributed to the following:

- *EWR 2: Lack of measured water quality data.*
- *EWR 4: Unsuitability of previously selected cross-section which makes interpretation difficult.*
- *EWR 5: Interpretation of vegetation is problematic and not necessarily representative of the rest of the reach.*
- *EWR 6: Problems with biological surveys (difficult habitats) and lack of critical habitats (e.g. riffles).*
- *EWR 7: Same problem as at EWR 6 as well as the presence of extensive alien vegetation which is increasing continuously, thus resulting in the lack of indigenous vegetation that can be used as indicators for flow requirements along the cross sections.*

3.5 EWR RESULTS

The EWR results are summarised in Table 3.12 to Table 3.18 and the high flow requirements are provided in Table 3.19.

Table 3.12 EWR 1 Valeyspruit: Low flow EWR results for PES and REC A/B

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	0.065	0.020
NOVEMBER	0.093	0.035
DECEMBER	0.111	0.045
JANUARY	0.157	0.069
FEBRUARY	0.200	0.090
MARCH	0.173	0.077
APRIL	0.166	0.073
MAY	0.138	0.059
JUNE	0.114	0.046
JULY	0.091	0.034
AUGUST	0.071	0.023
SEPTEMBER	0.060	0.018

Table 3.13 EWR 2 Goedehoop: Low flow EWR results for PES and REC B

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	0.384	0.187
NOVEMBER	0.568	0.242
DECEMBER	0.692	0.275
JANUARY	0.987	0.360
FEBRUARY	1.270	0.450
MARCH	1.104	0.394
APRIL	1.057	0.383
MAY	0.874	0.328
JUNE	0.716	0.285
JULY	0.567	0.240
AUGUST	0.425	0.199
SEPTEMBER	0.350	0.180

Table 3.14 EWR 3 Poplar Creek: Low flow EWR results for PES B/C[1]

Months	PES	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*2.249*	*0.784*
NOVEMBER	*2.285*	*0.733*
DECEMBER	*2.158*	*0.878*
JANUARY	*2.284*	*0.968*
FEBRUARY	*2.704*	*1.195*
MARCH	*2.410*	*1.058*
APRIL	*2.424*	*1.046*
MAY	*2.320*	*0.993*
JUNE	*2.448*	*1.062*
JULY	*2.394*	*1.046*
AUGUST	*2.435*	*1.075*
SEPTEMBER	*2.249*	*0.784*

Table 3.15 EWR 4 KaNyamazane: Low flow EWR results for PES and REC B

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*4.185*	*1.252*
NOVEMBER	*5.248*	*1.684*
DECEMBER	*6.347*	*2.165*
JANUARY	*8.068*	*2.892*
FEBRUARY	*10.975*	*4.064*
MARCH	*10.141*	*3.767*
APRIL	*9.351*	*3.416*
MAY	*7.763*	*2.763*
JUNE	*6.653*	*2.277*
JULY	*5.361*	*1.749*
AUGUST	*4.470*	*1.373*
SEPTEMBER	*4.105*	*1.201*

Table 2.16 EWR 5 Malelane: Low flow EWR results for PES C and REC B

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*4.706*	*3.422*	*7.898*	*3.422*
NOVEMBER	*5.571*	*3.672*	*9.231*	*3.672*
DECEMBER	*6.365*	*3.739*	*10.405*	*3.739*
JANUARY	*7.597*	*3.974*	*12.266*	*3.974*
FEBRUARY	*10.008*	*4.706*	*15.994*	*4.706*
MARCH	*9.214*	*4.283*	*14.709*	*4.283*
APRIL	*8.708*	*4.271*	*13.972*	*4.271*
MAY	*7.497*	*3.955*	*12.115*	*3.955*
JUNE	*6.776*	*3.902*	*11.052*	*3.902*
JULY	*5.739*	*3.620*	*9.459*	*3.620*

1 A time series of requirements could not be generated for the REC of a B as improvement of the PES required flows higher than the reference time series (present day), during the wet season.

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
AUGUST	*4.996*	*3.478*	*8.336*	*3.478*
SEPTEMBER	*4.707*	*3.507*	*7.925*	*3.507*

Table 3.17 EWR 6 Nkongoma: Low flow EWR results for PES C and REC B

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*3.136*	*1.863*	*7.218*	*1.863*
NOVEMBER	*3.896*	*2.496*	*8.446*	*2.496*
DECEMBER	*4.694*	*3.220*	*9.567*	*3.220*
JANUARY	*5.903*	*4.274*	*11.391*	*4.274*
FEBRUARY	*8.213*	*6.195*	*15.142*	*6.195*
MARCH	*7.555*	*5.715*	*13.884*	*5.715*
APRIL	*6.915*	*5.128*	*13.002*	*5.128*
MAY	*5.709*	*4.105*	*11.099*	*4.105*
JUNE	*4.988*	*3.447*	*10.093*	*3.447*
JULY	*4.077*	*2.682*	*8.637*	*2.682*
AUGUST	*3.402*	*2.094*	*7.619*	*2.094*
SEPTEMBER	*3.100*	*1.802*	*7.249*	*1.802*

Table 3.18 EWR 7 Kaap: Low flow EWR results for PES C and REC B

Months	PES		REC	
	Maintenance (m^3/s)	Drought (m^3/s)	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*0.374*	*0.090*	*0.918*	*0.090*
NOVEMBER	*0.551*	*0.200*	*1.204*	*0.200*
DECEMBER	*0.735*	*0.320*	*1.477*	*0.320*
JANUARY	*0.924*	*0.430*	*1.769*	*0.430*
FEBRUARY	*1.245*	*0.620*	*2.302*	*0.620*
MARCH	*1.204*	*0.610*	*2.202*	*0.610*
APRIL	*1.141*	*0.560*	*2.116*	*0.560*
MAY	*0.991*	*0.470*	*1.873*	*0.470*
JUNE	*0.903*	*0.410*	*1.748*	*0.410*
JULY	*0.711*	*0.300*	*1.439*	*0.300*
AUGUST	*0.506*	*0.160*	*1.123*	*0.160*
SEPTEMBER	*0.366*	*0.070*	*0.917*	*0.070*

Table 3.19 High flow EWR results the EWR sites

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
EWR 1 VALEYSPRUIT: PES AND REC : A/B ECOSTATUS								
CLASS I (0.6 - 2 m^3/s)	*3*	*3*	*2 per annum*		*3*	*Nov, Dec, Mar*	*1*	*3*
CLASS II (3 - 5 m^3/s)	*1*		*1*	*1:2[2]*	*1*	*Jan*	*3*	*3*

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
CLASS III (>10 m^3/s)		1:3	1:3	1:3	1:3			
EWR 2 GOEDEHOOP: PES AND REC : A/B ECOSTATUS								
CLASS I (2 - 5 m^3/s)	4	4	4		4	Nov, Dec, Jan, Mar, Apr	3	3
CLASS II (6 - 9 m^3/s)	1		1	1	1	Feb	9	4
CLASS III (13 - 25 m^3/s)			1:2			Late summer	N/S	N/S
CLASS IV (30 0 35 m^3/s)			1:4	1:2		Dec - Feb	N/S	N/S
EWR 3 POPLAR CREEK: PES: B/C ECOSTATUS								
CLASS I (8 m^3/s)	4	4	4	4	4	Nov, Dec, Jan, Apr	8	3
CLASS II (15 m^3/s)	2	2	2	2	2	Nov, Mar	15	4
CLASS III (30 m^3/s)		1	1	1	1	Feb	30	5
CLASS IV (<90 m^3/s)			1:2 to 1:3			Late summer	N/S	N/S
EWR 4 KANYAMAZANE: PES: C ECOSTATUS								
CLASS I (25 - 40 m^3/s)	3		4	4	4	Nov, Dec, Jan, Apr	25	4
CLASS II (40 m^3/s)	1			2	2	Feb, Mar	40	4
CLASS III (60 - 110 m^3/s)	1		1	1	1	Feb	70	5
CLASS IV (170 - 220 m^3/s)			1:2 - 1:3	1:3	1:2	Late summer	N/S	N/S
CLASS V (<330 m^3/s)			1:3 - 1:5	>1:5	>1:5	Wet season	N/S	N/S
EWR 4 KANYAMAZANE: REC: B ECOSTATUS								
CLASS I (25 - 40 m^3/s)	4		4	4	4	Nov, Dec, Jan, Apr	25	4
CLASS II (40 m^3/s)	2			2	2	Feb, Mar	40	7
CLASS III (60 - 110 m^3/s)	1		1	1	1	Jan	70	5
CLASS IV (170 - 220 m^3/s)			1:2 - 1:3	1:2	1:2	Late summer	N/S	N/S
CLASS V (<330 m^3/s)			1:3 - 1:5	1:3 - 1:5	1:3 - 1:5	Wet season	N/S	N/S
EWR 5 MALELANE: PES: C ECOSTATUS								
CLASS I (15 - 20 m^3/s)	4	4	4		4	Nov, Dec, Jan, Mar	8	4
CLASS II (22 - 50 m^3/s)	2	2	2	2	2	Dec, Mar	30	4
CLASS III (60 m^3/s)				2	2	Feb, Mar	50	4
CLASS IV (70 - 100 m^3/s)			1	1	1	Feb	90	5
CLASS V (<370 m^3/s)			1:3+	1:3	1:3	Summer to late summer	N/S	N/S
EWR 5 MALELANE: REC: B ECOSTATUS								
CLASS I (15 - 20 m^3/s)	6	6	6		6	Nov, Dec, Jan, Feb, Mar	8	4
CLASS II (22 - 50 m^3/s)	3	3	3	3	3	Dec, Jan, Mar	30	4
CLASS III (60 m^3/s)				3	3	Jan, Feb, Mar	50	4
CLASS IV (70 - 100 m^3/s)			1	1	1	Feb	90	5
CLASS V (<370 m^3/s)			1:3+	1:2 - 1:3	1:3	Summer to late summer	N/S	N/S
EWR 6 NKONGOMA: PES C ECOSTATUS								
CLASS I (20 - 30 m^3/s)			4		4	Nov, Dec, Jan, Mar	12	4

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
CLASS II (60 - 100 m^3/s)			*2*	*2*	*2*	*Dec, Mar*	*60*	*4*
CLASS III (130 - 160 m^3/s)			*1*	*1*	*1*	*Feb*	*120*	*6*
CLASS IV (200 – 350 m^3/s)			*1:2 - 3*	*1:3*			*N/S*	*N/S*
EWR 6 NKONGOMA: REC B ECOSTATUS								
CLASS I (20 - 30 m^3/s)			*6*		*6*	*Nov, Dec, Jan (2), Feb, Mar*	*10*	*4*
CLASS II (60 - 100 m^3/s)			*3*		*3*	*Dec, Jan, Mar*	*50*	*4*
CLASS III (130 - 160 m^3/s)			*2*	*3*	*2*	*Jan, Feb, Mar*	*100*	*5*
CLASS IV (200 – 350 m^3/s)			*1:2 - 3*	*1*		*Feb*	*180*	*6*
EWR 7 HONEYBIRD: PES: C ECOSTATUS								
CLASS I (5 - 8 m^3/s)	*4*		*4*		*4*	*Nov, Dec, Jan, Mar*	*5*	*3*
CLASS II (8 - 12 m^3/s)	*2*		*1*	*2*	*2*	*Jan, Feb*	*8*	*3*
CLASS III (17 m^3/s)				*1*	*1*	*Feb*	*20*	*4*
CLASS IV (25 - 80 m^3/s)			*1:2*	*1:3*	*1:2*		*N/S*	*N/S*
CLASS V (<130 m^3/s)			*1:3 +*		*1:3*		*N/S*	*N/S*
EWR 7 HONEYBIRD: PES: C ECOSTATUS								
CLASS I (5 - 8 m^3/s)	*4*		*4*		*4*	*Nov, Dec, Jan, Mar*	*5*	*3*
CLASS II (8 - 12 m^3/s)	*2*		*2*	*3*	*3*	*Dec, Jan, Feb*	*8*	*3*
CLASS III (17 m^3/s)				*1*	*1*	*Jan*	*15*	*4*
CLASS IV (25 - 80 m^3/s)			*1*	*1:3*	*1*	*Feb*	*25*	*4*
CLASS V (<130 m^3/s)			*1:3*		*1:3*		*N/S*	*N/S*

*1 * Final refers to the agreed on number of events considering the individual requirements for each component.*
2 Not Specified

Table 3.20 Summary of PES results as a percentage of the natural MAR (nMAR)

EWR site	PES	nMAR (MCM)	pMAR (MCM)	Low flows (MCM)	Low flows (%nMAR)	High flows (MCM)	High flows (%nMAR)	Long term mean	
								Total flows (MCM)	Total (%nMAR)
EWR 1	*A/B*	*15.191*	*14.90*	*3.8*	*24.8*	*0.93*	*6.14*	*4.7*	*30.9*
EWR 2	*B*	*47.11*	*44.80*	*23.5*	*49.9*	*3.5*	*7.4*	*27*	*57*
EWR 3	*B/C*	*169.9*	*1515.2*	*74.8*	*44.0*	*16.6*	*9.8*	*93.78*	*55.2*
EWR 4	*B*	*754.1*	*528.3*	*216.4*	*28.7*	*46.8*	*6.23*	*260.2*	*34.5*
EWR 5	*C*	*1006.2*	*637.9*	*214.5*	*21.3*	*53.3*	*5.3*	*301.9*	*30*
EWR 6	*C*	*1063.1*	*525.2*	*147.8*	*13.9*	*78.7*	*7.4*	*264.7*	*24.9*
EWR 7	*C*	*169*	*86.6*	*25.2*	*14.9*	*10.8*	*6.4*	*38.9*	*23*

Table 3.21 Summary of REC results as a percentage of the natural MAR (nMAR)

EWR site	REC	nMAR (MCM)	pMAR (MCM)	Low flows (MCM)	Low flows (%nMAR)	High flows (MCM)	High flows (%nMAR)	Long term mean	
								Total flows (MCM)	Total (%nMAR)
EWR 3	*B*	*169.9*	*1515.2*	*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.*					
EWR 5	*C*	*1006.2*	*637.9*	*349.4*	*34.7*	*74.5*	*7.4*	*404.5*	*40.2*
EWR 6	*B*	*1063.1*		*323.2*	*30.4*	*140.7*	*13.2*	*466.7*	*43.9*
EWR 7	*B*	*169*	*86.6*	*50*	*29.6*	*12.5*	*7.4*	*62.2*	*36.8*

3.6 ELANDS RIVER CATCHMENT RESERVE DETERMINATION STUDY

A team of specialists were tasked to review the Instream Flow Requirements (IFRs) determined at sites ER 1 and ER 2 which were determined during the Elands River Intermediate Reserve determination study (DWAF, 2000). The CSIR, Environmentek undertook this study between 2003 – 2005 with the primary objective to provide DWA with a high-confidence (comprehensive) Reserve determination that included appropriate scenarios for water quality and quantity of surface water for various levels of protection (Hill, 2005).

3.7 MANAGEMENT RESOURCE UNITS

A summary of the surface water MRUs defined during the 2003 - 2005 study (Hill, 2003) is provided in Table 3.22.

Table 3.22 Description and rationale of the MRUs in the Elands River catchment

MRU	Veld type	EcoRegion	Geomophic Zone	Delineation	Quat
RU 1	*North-Eastern Sandy Highveld*	*10.03 10.02*	*Upper Foothills.*	*Elands River from its origin to the waterfall at Waterval Boven.*	*X21F X21G*
RU 2	*Lowveld Sour Bushveld*	*10.02*	*Upper Foothills.*	*Elands River from the waterfall to its confluence with the Crocodile River at Lindenau.*	*X21G X21J X21K*

3.8 EWR SITES

3.8.1 Selection of EWR sites

Two EWR sites were selected and are listed in Table 3.23 and their location within WMA 5 is provided in Figure 3.1.

Table 3.23 Details of the EWR sites selected in the Elands River catchment

EWR Site number	River	Co-ordinates		MRU
		Latitude	Longitude	
ER 1	*Elands*	*25.631000*	*30.326250*	*RU 1*
ER 2	*Elands*	*25.567972*	*30.666694*	*RU 2*

3.8.2 Description of the EWR sites

A description of the EWR sites is provided below (Hill, 2005; DWAF, 2000).

Table 3.24 Characteristics and view of EWR 1

Site information	Detail
EWR site	*ER 1*
River	*Elands River*
Co-ordinates	*S 25.631000 E 30.326250*
MRU	*RU 1*
IUA	*IUA X2_4*
SQ Reach	*X21G-01037*
IEI rating	*Moderate (2)*
WRUI rating	*Low (1)*
Hotspot rating	*Low (1)*
EWR site advantages: ▪ *Flow regime largely unregulated.* ▪ *Representative of macro-reach 1. Good morphological features.* ▪ *Salix mucronata and Cliffortia sp. on both banks will provide good clues for summer flows and annual floods. Diospyros lycioides on the left bank will provide clues for annual flood levels. Schoenoplectus corymbosus can provide clues about summer baseflow requirements. Terraces on both banks for indicating levels of annual floods. Tertiary channels next to the active channel maintain a stand of riparian vegetation for summer base-flow requirements.* ▪ *Rocks provide good cover for fish. Fast-deep (rapids), fast-shallow and slow deep habitats available. Marginal vegetation present. Potentially good ecological flow interpretation with flow variation.* ▪ *Moderate diversity of macro-invertebrate biotopes, including cobbles in and out of current, marginal vegetation and some sand. Rapids always present irrespective of flow. Biotope availability sensitive to small changes in flow, therefore a good indicator site. High diversity of hydraulic conditions present.*	**EWR site disadvantages:** ▪ *The occurrence of Acacia karroo and Ziziphus mucronata indicates terrestrialization, possibly due to reduced flows. The rock face on the left bank can have an influence on the exaggeration of the marginal zone, which makes the interpretation of marginal areas difficult. This site appears to be dynamic because of the number of high flow and seasonal channels and introduces complexity, for particularly high flows.* ▪ *Slow-shallow habitats limited for fish. Cobbles and pebbles/gravel limited. Only one completely flow dependant species (natural situation). Predation by rainbow trout.* ▪ *Predation by rainbow trout on macro-invertebrates. Influence of trout dams (water quality). Gravel bars scarce.*

Table 3.25 Characteristics and view of EWR 2

Site information	Detail
EWR site	*ER 2*
River	*Elands*
Co-ordinates	*S 25.567972 E 30.666694*
MRU	*RU 2*
IUA	*IUA X2_5*
SQ Reach	*X21K-01035*
IEI rating	*Moderate (2)*
WRUI rating	*High (3)*
Hotspot rating	*High (3)*

Site information	Detail
EWR site advantages: ▪ *Flow regime largely unregulated.* ▪ *Reasonably uniform flow conditions along length of extensive rapid feature.* ▪ *Representative of macro-reach 2. Reasonably undisturbed site.* ▪ *Combretum erythrophylum and D. lycioides can be good indicators of elevated flow requirements. Salix mucronata and Cliffortia sp. on both banks will provide good clues for base flow requirements. Phragmites and Cyperus latifolius can provide clues about summer baseflow requirements. Tertiary channels next to the active channel maintain a stand of riparian vegetation for setting summer base-flow requirements.* ▪ *Variety of substrate cover (rocks, cobbles, gravel) for fish. Slow-deep and fast-deep excellent and abundant. Fast-shallow habitats less abundant. Good marginal vegetation, side channels present. Diversity of flow dependant species. Potentially very good ecological flow interpretation with flow variation.* ▪ *High diversity of substrates, biotopes and hydraulic conditions present for macro-invertebrates. Biotope availability sensitive to small changes in flow, therefore a good indicator site. Riffles always present irrespective of flow. Cobbles provide refuge areas for invertebrates during high flow.*	**EWR site disadvantages:** ▪ *Seepage from right bank. Influence of regulation of Ngodwana River (provides about 20% of MAR).* ▪ *Extremely rough bed.* ▪ *No morphological clues.* ▪ *Species on the right bank can be dependent on water from a fringe wetland and not from flow rates per se. This can confuse the interpretation of the importance of water from the river. Afforestation close to the riparian zone can lead to a reduced baseflow. Recreation and forestry activities could have caused the low species diversity and quantity of individual plants.* ▪ *Slow-shallow habitat backwaters and limited for fish. Modifications: Possible influence of water quality modification from paper mill. Influence of introduced species.* ▪ *Close proximity to Sappi Ngodwana, therefore macro-invertebrates are subject to water quality problems.*

3.9 ECOCLASSIFICATION RESULTS

The EcoClassification results for the Sabie-Sand Catchment are summarised in Table 3.26.

Table 3.26 EcoClassification results – Elands River Catchment

EWR ER 1 (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 water quality 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 areas 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

A summary of confidences for all the sites are given in Table 3.27. The confidence score is based on a scale of 0 – 5 and colour coded where:

0 – 1.9: Low *2 – 3.4: Moderate* *3.5 – 5: High*

Table 3.27 Confidence in EcoClassification

EWR site	Data Availability						EcoClassification					
	Hydrology	Geomorphology	Physico-chemical	Fish	Macro-invertebrate	Vegetation	Hydrology	Geomorphology	Physico-chemical	Fish	Macro-invertebrate	Vegetation
ER 1	*3.5*	*3*	*4*	*4*	*3*	*4*	*3*	*3.5*	*4*	*4*	*4*	*4*
ER 2	*3.5*	*2.5*	*3*	*5*	*4*	*4*	*3*	*3*	*3*	*5*	*4*	*3*

The results indicated that there was a lot of data available and therefore the confidence in data availability and EcoClassification was rated as HIGH.

3.10 EWR RESULTS

The EWR results are summarised in Table 3.28 and Table 3.29 and the high flow requirements are provided in Table 3.30.

Table 3.28 ER 1: Low flow EWR results for PES and REC B

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*0.45*	*0.118*
NOVEMBER	*0.65*	*0.144*
DECEMBER	*0.7*	*0.163*
JANUARY	*0.8*	*0.182*
FEBRUARY	*0.9*	*0.214*
MARCH	*0.8*	*0.188*
APRIL	*0.65*	*0.186*
MAY	*0.527*	*0.164*
JUNE	*0.469*	*0.149*
JULY	*0.396*	*0.129*
AUGUST	*0.355*	*0.118*
SEPTEMBER	*0.345*	*0.116*

Table 3.29 ER 2: Low flow EWR results for PES and REC B

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
OCTOBER	*1.549*	*0.52*
NOVEMBER	*1.851*	*0.605*
DECEMBER	*2.113*	*0.673*
JANUARY	*2.408*	*0.752*
FEBRUARY	*2.918*	*0.901*
MARCH	*2.634*	*0.813*

Months	PES and REC	
	Maintenance (m^3/s)	Drought (m^3/s)
APRIL	2.622	0.814
MAY	2.429	0.758
JUNE	2.307	0.728
JULY	1.975	0.635
AUGUST	1.714	0.565
SEPTEMBER	1.594	0.536

Table 3.30 High flow EWR results the EWR sites

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
ER 1: PES AND REC : B ECOSTATUS								
CLASS I (2 - 3.5 m^3/s)	2 - 4	2-3			2	Mar, Nov	2.5	2
CLASS II (3.5 - 8 m^3/s)	4 - 7	3 - 5	3.5 - 8		2	Dec, Mar	5	2
CLASS III (5 - 13 m^3/s)				5 - 13	2	Feb	9	2
CLASS IV (13 - 34 m^3/s)			17 - 28	13 - 34	1	Jan	22	3
ER 2: PES AND REC : B ECOSTATUS								
CLASS I (5 - 10 m^3/s)	5 - 7	10			2	Nov, Apr	6	2
CLASS II (7 - 13 m^3/s)	7 - 10	10 - 13	3.5 - 8		1	Mar	10	2
CLASS III (15 - 42 m^3/s)			15-20	20 - 42	2	Dec, Feb	25	3
CLASS IV (42 - 107 m^3/s)			65-70	42 - 107	1:2; 1:5 (v)	Jan	65	4
CLASS V (107 - 172 m^3/s)			107 - 172	107 - 172	1:10		135	4

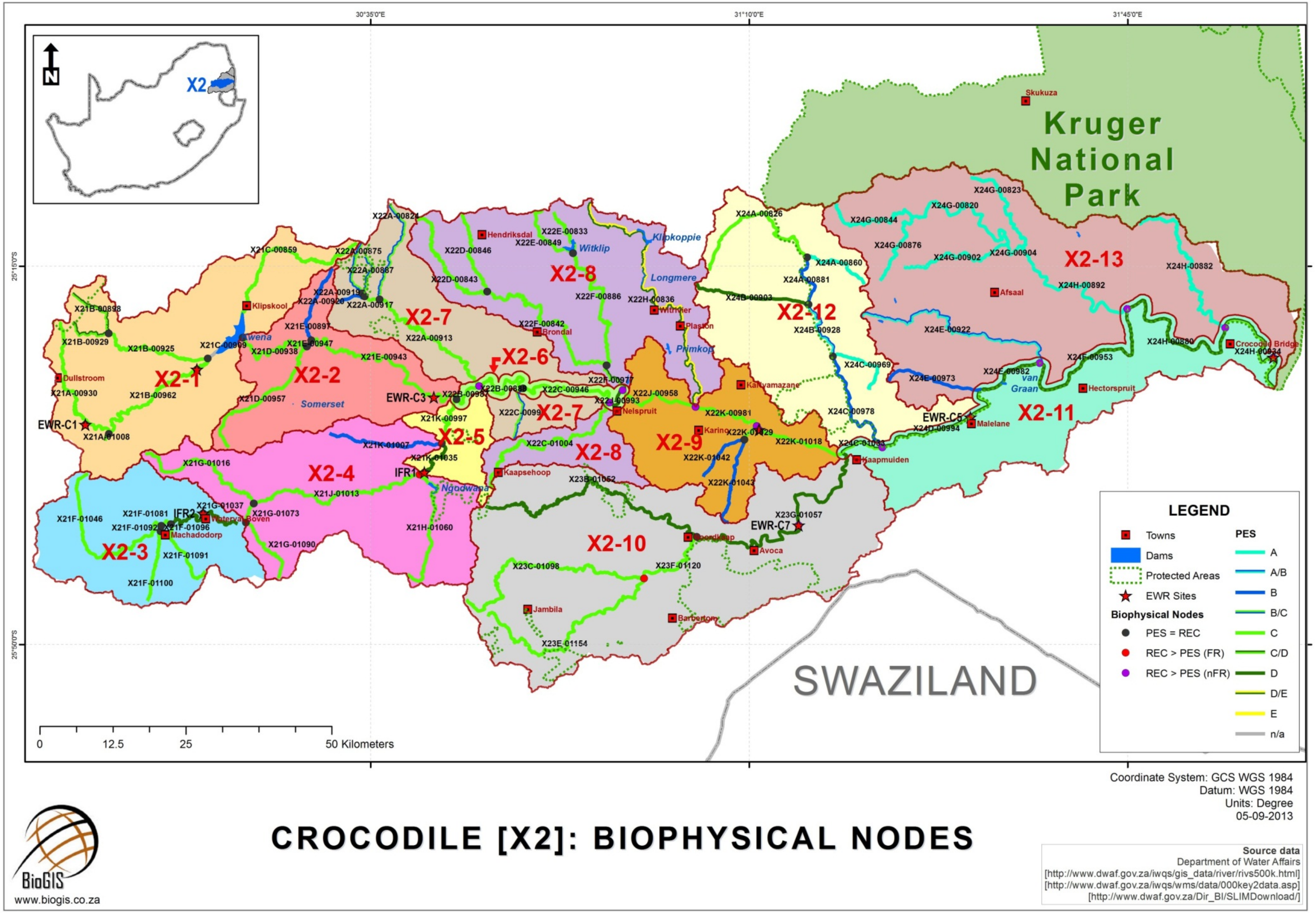


Figure 3.1 Locality of the selected EWR sites in the Crocodile (X2) catchment

4 SUMMARY OF EWR RESULTS AT EWR SITES (KEY BIOPHYSICAL NODES): KOMATI (X1) CATCHMENT

4.1 THE KOMATI CATCHMENT RESERVE DETERMINATION STUDY

The Komati River Catchment was identified by the Department of Water Affairs and Forestry (DWAF) as a priority catchment for a comprehensive Reserve determination due to high water demands. The CD: RDM commissioned The Komati Catchment Reserve Determination study during 2003 which was undertaken by AfriDev consultants over a three-year period between April 2003 and March 2006 (AfriDev, 2006).

This study followed comprehensive methods for EcoClassification as well as for Ecological Water Requirement determination and was based on the generic 8-step process (DWAF, 1999). The focus of the study was on the Komati River and main tributaries, namely: Lomati, Teespruit, Gladdespuit and Seekoeispruit. The overall objectives of this study as outlined in AfriDev (2006) were as follows:

- *To recommend a comprehensive EWR, for water quality and quantity, for various reaches of the Komati River system.*
- *To assess the need for groundwater and wetland EWR assessments based on a desktop, scoping level studies.*
- *To train persons from persons from previously disadvantaged communities in specific aspects of assessing EWRs.*

4.2 MANAGEMENT RESOURCE UNITS

A summary of the Resource Units (RUs) defined during the 2003 - 2006 study (AfriDev, 2005b) is provided in Table 4.1.

Table 4.1 Description and rationale of the Resource Units

RU	EcoRegion Level 2	Geomorphic zone	Land cover	Delineation	Quat[1]
KOMATI RIVER					
A	*11.02 (80%)* *11.04 (20%)*	*Source zone (100%)*	*Dominated by livestock grazing on unimproved grasslands and dryland commercial maize.*	*Komati River from the source upstream of Nooitgedacht Dam.*	*X11A*
Rationale: *The dam is located at the boundary between two EcoRegions and the area upstream of the dam is located in the Highveld EcoRegion. Furthermore, the dam is located where the stream geomorphology changes naturally from "source zone" to "foothill zone".*					
B	*10.03 (100%)*	*Rejuvenated Lower Foothills (40%)* *Rejuvenated Upper Foothills (60%)*	*Limited and dominated by commercial livestock grazing.*	*Komati River between Nooitgedacht Dam and Vygeboom Dam.*	*X11D* *X11E* *X11F* *X11G* *X11H*
Rationale: *This RU has three ecologically distinct sections. The upper section is located between Nooitgedacht Dam and the top end of the Komati Gorge (Segments 9-17), and is characterised by a meandering stream with oxbow lakes and low to moderate gradient. The river then enters the Komati Gorge (Segments 18-22), a rejuvenated Upper Foothill stream with almost continuous cobble riffles. Gemsbokhoek Weir is situated at the lower end of this gorge. Water is abstracted from the weir and pumped up to Nooitgedacht Dam. The weir represents a major discontinuity in river conditions, particularly during low flows, when compensation flows are often zero. Downstream of Gemsbokhoek Weir (Segments 22 to 28) the river flattens out before entering Vygeboom Dam. What these sections have in common is that they are all situated in the Northern Escarpment Mountain EcoRegion, the vegetation consists of Piet Retief sourveld, riparian vegetation is generally in a good condition (Category B to C), water quality is good, and landuse is similar. It was therefore decided to treat the area as a single RU.*					

RU	EcoRegion Level 2	Geomorphic zone	Land cover	Delineation	Quat[1]
C	*10.03 (100%)*	*Upper Foothills (40%) Lower Foothills (60%)*	*Limited and dominated by communal livestock grazing and conservation areas (Nkomazi Wilderness Area and Songimvelo Nature Reserve).*	*Komati river downstream of Vygeboom Dam to Swaziland border.*	*X11K X12G X12H X12K X13H*
Rationale: *Three significant tributaries enter the river: the Gladdespruit, Seekoeispruit and Teespruit. This stretch of the Komati River could therefore be sub-divided into four distinct sections based on tributary junctions, but it was decided to treat these as a single RU on account of the similar channel characteristics, as well as instream and riparian habitats. The entire area falls within the same EcoRegion.*					
D	*3.06 (10%) 3.07 (90%)*	*Lower Foothills (20%) Lowland River (50%) Rejuvenated Lower Foothills (30%)*	*Subsistence agriculture and communal sugar production.*	*The lower Komati River from the Swaziland border at Mananga to the confluence of the Lomati River.*	*X13J*
Rationale: *There are a number of discontinuities in this stretch of river, in particular the disjunction between a low-gradient, inundated lowland river in the vicinity of Mananga, and the high gradient, rejuvenated lower foothills comprising bedrock outcrops and multiple channels that characterise a 5 km section of river between Ntunda and just downstream of Tonga Weir. The Tonga Weir also represents a significant discontinuity in terms of low flows and associated water quality deterioration. The choice of the Lomati confluence as the lower boundary of this RU was based mainly on practical considerations concerning releases from Driekoppies Dam and the much larger size of the Komati River downstream of this tributary junction.*					
E	*3.06 (30%) 3.07 (30%) 12.01 (40%)*	*Rejuvenated Lower Foothills (55%) Lowland River (45%)*	*Commercial irrigated agriculture, mainly sugarcane.*	*Lower Komati River from the Lomati River confluence to Komatipoort.*	*X14K*
Rationale *The river here is characterised by a wide, low gradient river almost completely inundated by weirs, leaving almost no flowing water habitats. Flows are regulated by Maguga and Driekoppies Dams, and the system is managed to meet the minimum requirements of the international obligations to Mozambique.*:					
LOMATI RIVER					
L	*10.03 (20%) 10.02 (30%) 4.05 (50%)*	*Mountain Stream (40%) Transitional (60%)*	*Dominated by pine plantations in source zone.*	*Lomati River upstream of Swaziland.*	*X14B X14D*
Rationale: *The RU has two distinct ecological sections. The source zone upstream of Barberton Dam which has a gentle gradient. Downstream of the Barberton Dam the river passes through a highly inaccessible and unexploited section of the Barberton Mountains, where the gradient is very steep – a typical Mountain Stream. It was decided to treat these two sections as a single RU for the purposes of this study, mainly because the source zone is so short in length that it did not justify to separate them. Both sections fall within the same EcoRegion.*					
M	*3.07 (100%)*	*Lower Foothills (100%)*	*Commercial sugarcane plantations (left bank) and subsistence agriculture (right bank).*	*Lomati River downstream of Driekoppies Dam.*	*X14G X14H*
Rationale: *The reach is characterised by uniform geomorphology, vegetation and system operation. Reach also falls within on EcoRegion.*					
TEESPRUIT					
T	*10.03 (80%) 11.04 (20%)*	*Upper Foothills (100%)*	*Communal livestock grazing.*	*Teespruit from source to confluence with Komati River.*	*X12E X12F*
Rationale: *The Teespruit was delineated into a single RU based on uniform geomorphology, Habitat Integrity and landuse. A characteristic feature of this RU is the large numbers of lateral seepage wetlands, usually situated upstream of doleritic intrusions. These geology of this area is dominated by gneisses and migmatites. It is likely that these wetlands contribute a significant proportion of the baseflows in this river.*					
SEEKOEISPRUIT					
S	*10.03 (80%) 11.04 (20%)*	*Mountain Stream (10%) Transitional (15%) Rejuvenated Bedrock Cascades (5%) Upper Foothills (70%)*	*Mostly as unimproved grasslands.*	*The Seekoeispruit from source to confluence with Komati River.*	*X12A X12C X12D*

RU	EcoRegion Level 2	Geomorphic zone	Land cover	Delineation	Quat[1]
Rationale: *The Seekoeispruit falls naturally into a single RU on account of generally uniform habitats. Bank erosion is common, particularly in the upper reaches. The river is largely unregulated, although a considerable volume of water is diverted through the Aventura Holiday Resort. The river is used fairly intensively for sand mining, brick making and washing of clothes. The extent to of current water demand is unknown as there are no operational gauging stations on the river.*					
GLADDESPRUIT					
G	*10.02 (40%) 10.03 (60%)*	*Mountain Headwater Stream (5%) Mountain Stream (5%) Transitional (40%) Upper Foothills (50%)*	*Mountainous zone: Mining activities, forestry operations, trout hatcheries and severe encroachment of wattles, fire and severe erosion. Upper Foothill zone: Cattle.*	*The Gladdespruit from source to confluence with Komati River.*	*X11J X11K*
Rationale: *Delineation of the Gladdespruit presents a dilemma as the river falls naturally into two ecological zones: a fast-flowing mountainous zone that is highly impacted by anthropogenic activities, exotics and erosion, and an Upper Foothill zone where the gradient is flatter and the vegetation is grassland. The diversion of most of the medium to low-flow component into the Vygeboom Dam further divides the Upper Foothill zone into an unregulated section upstream of the Vriesland diversion weir, and a highly regulated section downstream of the weir. Despite these differences, it was decided to treat the Gladdespruit as a single RU because of its short length (40 km), on the assumption that the flow requirements defined at the selected sampling site, situated about half way along the river course, will cater for the requirements further upstream and downstream.*					

1 Quaternary catchment

4.3 EWR SITES

4.3.1 Selection of EWR sites

Seven EWR sites were selected during 2003 - 2006 (AfriDev, 2005a) and are listed in Table 4.2 and their location within WMA 2 is provided in Figure 2.2.

Table 4.2 Details of the EWR sites selected during 2003 in WMA 2

EWR Site number	EWR Site name	River	Co-ordinates		RU
			Latitude	Longitude	
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*

Reasoning for excluding EWR sites from certain river reaches were mainly based on prioritisation of RUs and are provided below:

- **Upstream of Nooitgedacht Dam (RU A):** *The area upstream of Nooitgedacht Dam was considered a low priority because the streams are small, unregulated and water demands are few. The contribution that the EWR in this part of the catchment would make to the total MAR of the catchment would be minor.*
- **Seekoeispruit (RU S):** *The Seekoeispruit was considered a low priority area partly because the characteristic bedrock and highly mobile sands provide unsuitable conditions for EWR assessment, partly because of highly complex hydraulics and partly because of generally degraded conditions, particularly slumping banks. Furthermore, the lower reaches (10 km) were generally inaccessible, and the river was at that stage ungauged.*
- **Upper Lomati River (RU L):** *The Lomati River upstream of the Swaziland Border was rejected as a suitable area for an EWR site because the area was totally inaccessible, (apart from the*

very upper reaches which were highly degraded and flow volumes insignificant). The river was also not gauged at that stage.

EWR M1 is located in Swaziland and falls outside of the current study. Therefore further detail regarding this site is not provided.

4.3.2 Description of the EWR sites

A description of the EWR sites are provided below based on information from AfriDev (2005b).

Table 4.3 Characteristics and view of EWR K1

Site information	Detail	Illustration
EWR site	*K1*	
Name	*Gevonden*	
River	*Upper Komati*	
Co-ordinates	*S 25.854333 E 30.376639*	
MRU	*B*	
IUA	*IUA X1_3*	
SQ Reach	*X11G-01142*	
IEI rating	*Very high (4)*	
WRUI rating	*High (3)*	
Hotspot rating	*Very high (4)*	
EWR site advantages: ▪ *Waterval gauging station (X1H017) situated 16 km upstream.* ▪ *Suitable location at site (upstream) for discharge measurement using velocity area method.* ▪ *The site is a good representation of the geomorphological zone and diverse geomorphological features that provide a wide variety of habitats. No intensive landuse in the catchment slopes.* ▪ *Clearly defined vegetation zones and good representation of riparian plant indicators.* ▪ *Suitable macro-invertebrate biotopes with moderate diversity.* ▪ *Diversity of flow dependant species and flow related habitat types present.*		**EWR site disadvantages:** ▪ *Riffle characterised by non-uniform conditions at low to medium flows. Rough bed conditions, with flow resistance consequently a function of stage. LB high-flow channels upstream of positioned cross-section, as well as minor drainage channel.* ▪ *Alien invader species (Bugweed and Wattle) beginning to encroach and rock outcrop on RB limiting to riparian vegetation formation.* ▪ *Bedrock biotope absent and limited aquatic vegetation at low flows. Poor marginal vegetation, gravel and sand habitat.* ▪ *Rocks with senescent algae and diatoms limiting habitat suitability.* ▪ *Fast deep and slow deep habitats limited.* ▪ *Deep habitat biotopes limited and marginal vegetation and undercut banks relatively poorly represented.*

Table 4.4 Characteristics and view of EWR K2

Site information	Detail	Illustration
EWR site	*K2*	
Name	*Kromdraai*	
River	*Upper Komati*	
Co-ordinates	*S 26.038806 E 31.003139*	
MRU	*C*	
IUA	*IUA X1_5*	
SQ Reach	*X12H-01258*	
IEI rating	*Very high (4)*	
WRUI rating	*High (3)*	
Hotspot rating	*Very high (4)*	

EWR site advantages:

- *Hoogenoeg gauging station (X1H001) situated about 500 m upstream, providing flow records since 1909.*
- *Reasonably uniform flow conditions at medium to high flows.*
- *The site is diverse geomorphological features. Located near the break between two different geomorphological zones that do not have sites, therefore, act as a representation of both. It is inside a reserve, therefore, no significant catchment landuse.*
- *Clearly defined vegetation zones and good representation of riparian plant indicators.*
- *High diversity of macro-invertebrate biotopes.*
- *Several flow dependant species present and diversity of flow related habitat types available.*

EWR site disadvantages:

- *Large bed roughness (including boulders), with flow resistance consequently a function of stage. Complex, non-uniform flow characteristics at low flows.*
- *Fine sediments are absent (impact of the upstream gauging station).*
- *Longitudinal heterogeneity (diverse habitats upstream and downstream of profile). Trampling of vegetation by cattle and elephant*
- *Absent macro-invertebrate biotopes include bedrock and mud.*
- *Fast deep and slow deep habitats limited.*
- *Large increments in flow may be necessary to effect habitat changes in cross section.*
- *Marginal vegetation and undercut banks relatively poorly represented.*

Table 4.5 Characteristics and view of EWR K3

Site information	Detail	Illustration
EWR site	*K3*	
Name	*Tonga*	
River	*Lower Komati*	
Co-ordinates	*S 25.666972 E 31.801333*	
MRU	*C*	
IUA	*IUA X1_9*	
SQ Reach	*X13J-011130*	
IEI rating	*Moderate (2)*	
WRUI rating	*Very high (4)*	
Hotspot rating	*High (3)*	

Site information	Detail	Illustration
EWR site advantages: ▪ *Upstream gauging station at Tonga (X1H003).* ▪ *Reasonably uniform conditions over a range of flows.* ▪ *Suitable nearby locations for accurate discharge measurement at low flows using velocity-area method (account for return flows, however).* ▪ *A number of significant geomorphological features present and representative of the geomorphological zone. The only viable option in the whole area.* ▪ *Clearly defined vegetation zones and fairly good representation of riparian plant indicators.* ▪ *Moderate diversity of macro-invertebrate biotopes.* ▪ *At least three flow dependant species should be present (none collected).* ▪ *Diversity of flow related habitat types available with increased flow.* ▪ *• Marginal vegetation and undercut banks relatively well represented.*		**EWR site disadvantages:** ▪ *The site was previously inundated by backup from Ronel Weir, but the weir was damaged during the floods in 2000, and has been rebuilt at a lower level that does not inundate the site, at least at low to medium flows.* ▪ *High flow/flood channels on extensive macro-channel infill (left bank of active channel).* ▪ *Agricultural return flows between the site and the upstream gauging weir (Tonga) are significant during low flows.* ▪ *River is largely modified rendering some geomorphological features insignificant (seasonal channels may no longer be active even during significant annual flood events).* ▪ *Footpaths and animal trampling are common in the flood plain and along the banks.* ▪ *Previous inundation by Ronel Weir has drowned large riparian trees at the site.* ▪ *Considerable ongoing deforestation of river banks.* ▪ *Moderate encroachment of alien invader species (Lantana, Chromalaena).* ▪ *Cattle trampling and erosion.* ▪ *Absent macro-invertebrate biotopes include bedrock and mud.* ▪ *Abundance of benthic algae limits habitat availability.* ▪ *Fast deep habitats limited and low abundance and diversity of species present during sampling (much lower than expected).*

Table 4.6 Characteristics and view of EWR G1

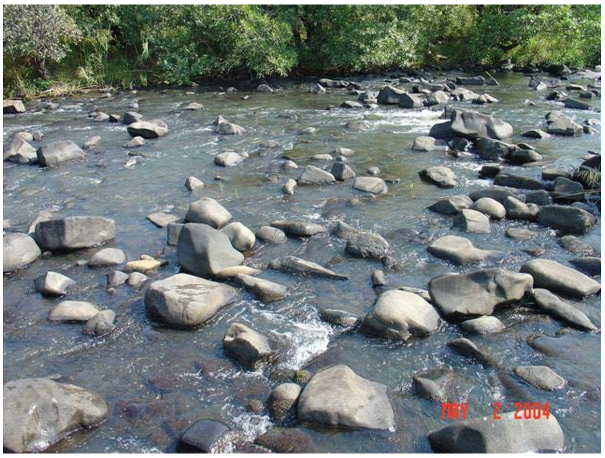
Site information	Detail	Illustration
EWR site	*G1*	
Name	*Vaalkop*	
River	*Gladdespruit*	
Co-ordinates	*S 25.771722 E 30.627167*	
MRU	*G*	
IUA	*IUA X1_5*	
SQ Reach	*X11J-01106*	
IEI rating	*Moderate (2)*	
WRUI rating	*High (3)*	
Hotspot rating	*High (3)*	

Site information	Detail	Illustration
EWR site advantages: ▪ *Gauging station at Vriesland.* ▪ *Suitable nearby locations for accurate discharge measurement using velocity-area method.* ▪ *Short rapid/riffle features will be drowned-out at medium to high flows resulting in more uniform flow conditions.* ▪ *Representative of the geomorphological zone. Good contrasting banks (steep LB and gentle RB).* ▪ *Pool-riffle morphology.* ▪ *Not severely impacted by catchment landuse compared to the most part of the river.* ▪ *Site has geomorphologically significant features.* ▪ *Clearly (substrate) defined vegetation zones.* ▪ *High diversity of macro-invertebrate biotopes.* ▪ *One flow dependant species present.* ▪ *Diversity of flow related habitat types available.* ▪ *Marginal vegetation and undercut banks relatively well represented.*		**EWR site disadvantages:** ▪ *Non-uniform flows at low-flow conditions.* ▪ *Upstream crossing (drift). Dirt road along the macro channel.* ▪ *Poor representation of riparian plant indicators.* ▪ *Vegetation on RB is secondary.* ▪ *Cattle trampling and erosion.* ▪ *Encroachment of alien invader species (Bugweed, Bramble).* ▪ *Absent macro-invertebrate biotopes include vegetation and sand.* ▪ *Only one fish species present.*

Table 4.7 Characteristics and view of EWR T1

Site information	Detail	Illustration
EWR site	*T1*	
Name	*Teespruit*	
River	*Teespruit*	
Co-ordinates	*S 30.852028 E 30.852028*	
MRU	*T*	
IUA	*IUA X1_6*	
SQ Reach	*X12E-01287*	
IEI rating	*Very high (4)*	
WRUI rating	*Moderate (2)*	
Hotspot rating	*High (3)*	
EWR site advantages: ▪ *Reasonably uniform conditions over a range of flows. Suitable nearby locations for accurate discharge measurement using velocity-area method.* ▪ *Site has significant geomorphological features.* ▪ *Clearly defined vegetation zones and fairly good representation of riparian plant indicators.* ▪ *Moderate diversity of macro-invertebrate biotopes.* ▪ *Two flow dependant species present.* ▪ *Diversity of flow related habitat types available.*		**EWR site disadvantages:** ▪ *No gauging stations on Teespruit, which meant that flows had to be estimated by differences measured in the Komati River upstream and downstream of the confluence.* ▪ *High flow channel on left bank High flow channel on left bank.* ▪ *Moderate encroachment of alien invader species (Sesbania punicea).* ▪ *Profile not representative of tributary as a whole.* ▪ *Absent macro-invertebrate biotopes include aquatic vegetation only, and mud habitats poor.* ▪ *Benthic algae limit habitat availability.* ▪ *Fast deep and slow deep habitats limited.* ▪ *Marginal vegetation and undercut banks relatively poorly represented.*

Table 4.8 Characteristics and view of EWR L1

Site information	Detail	Illustration
EWR site	*L1*	
Name	*Kleindoringkop*	
River	*Lomati*	
Co-ordinates	*S 25.649444 E 31.623194*	
MRU	*M*	
IUA	*IUA X1_8*	
SQ Reach	*X14H-01066*	
IEI rating	*High (3)*	
WRUI rating	*Very high (4)*	
Hotspot rating	*Very high (4)*	

EWR site advantages:

- *Gauging station available at Sandbult.*
- *Possibility of releases from upstream Driekoppies Dam for collection of rating data over a range of flows.*
- *Representative of the geomorphological zone.*
- *Clearly defined vegetation zones.*
- *Very good representation of riparian plant indicators.*
- *High diversity of macro-invertebrate biotopes.*
- *Three flow dependant species present.*
- *Diversity of flow related habitat types available.*
- *Marginal vegetation and undercut banks relatively well represented.*

EWR site disadvantages:

- *Gauging weir completed in 2003, so no suitable time series data available.*
- *Cross-section positioned at bottom of steep rapid feature characterised by non-uniform flow conditions, and complex morphology. Rough bed (including boulders) with flow resistance consequently a function of stage.*
- *Difficult to measure discharge accurately at low to medium flows (due to rough bed).*
- *No fine sediment. Bedrock dominated banks have no potential for change in the short-term.*
- *Some deforestation (Breonadia) taking place on RB.*
- *Moderate encroachment of alien invader species (Chromalaena).*
- *Cattle grazing and trampling.*
- *Absent macro-invertebrate biotopes are aquatic vegetation only.*
- *Slow and shallow habitats limited.*
- *Marginal vegetation and undercut banks difficult to sample.*

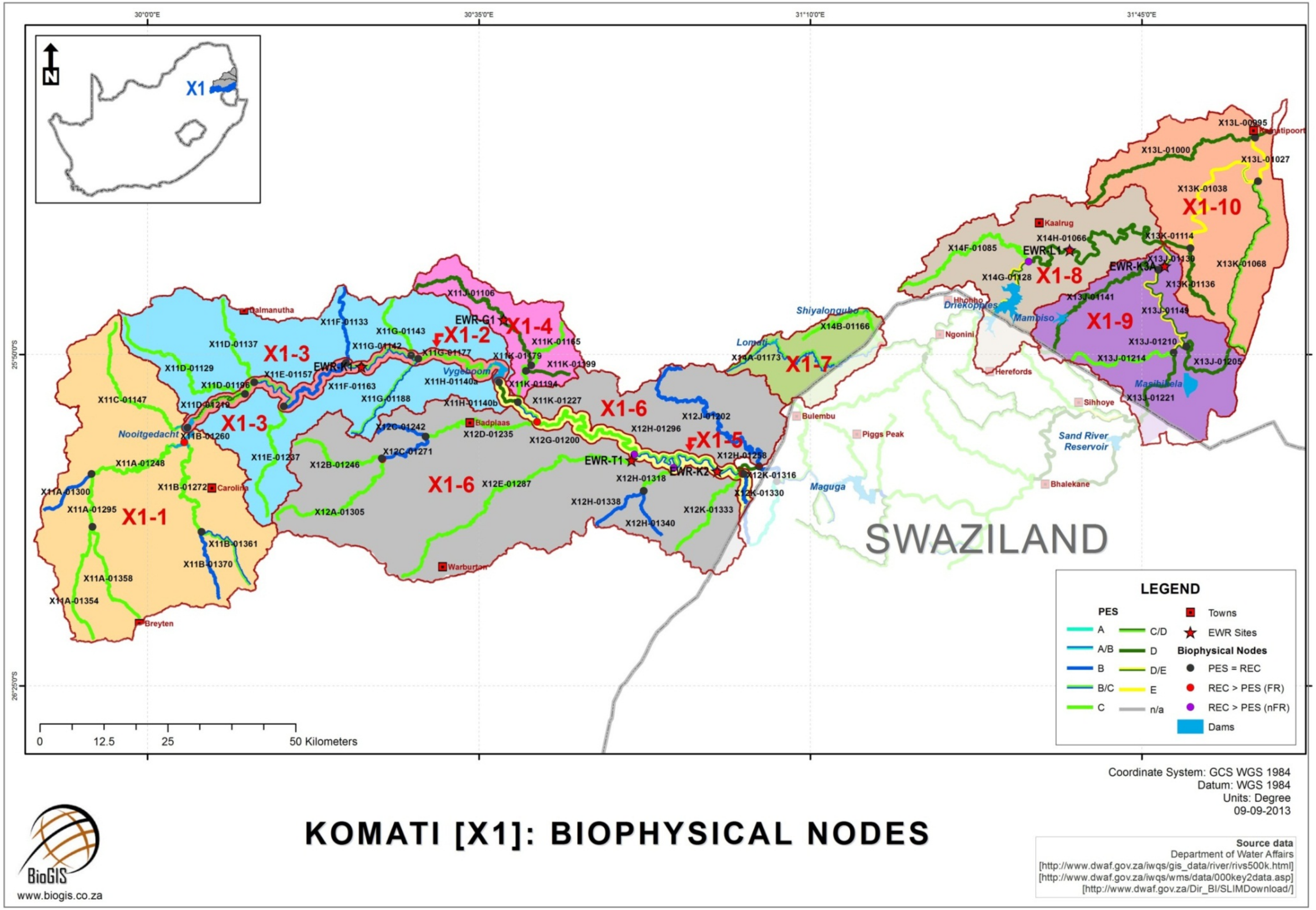


Figure 4.1 Locality of the selected EWR sites in the Komati (X1) catchment

5 REVISED ECOCLASSIFICATION RESULTS: EWR SITES (KEY BIOPHYSICAL NODES): KOMATI (X1) CATCHMENT

A summary of the EcoClassification results (PES and REC) (AfriDev, 2005a) are provided in Appendix A. The current suite of EcoClassification models (Kleynhans and Louw, 2007) were not available during 2005 when the EcoClassification results were generated. The updated EcoStatus models (Kleynhans and Louw, 2007) were populated with the 2005 data, the PES (11) data (DWA, 2013b) and any additional data that may be readily available. The information is summarised in Table 5.1 to Table 5.6. Most of the changes from 2005 to 2014 are due to new or updated EcoStatus models that do not necessarily indicate a change in PES. Table 5.7 illustrates the PES EcoStatus for 2004 (Level IV), 2011 (desktop level) and 2014 (Level IV). Table 5.8 shows a summary table for the 2014 PES which is the data used for scenario evaluation.

5.1 EWR K1 GEVONDEN PES

Table 5.1 EWR K1: PES using the updated EcoStatus suite of models

Component	PES/REC (05)	PES (14)	Comment
Fish	*B/C (81%)*	*C (75.7%)*	*The condition is mostly similar than the 2005 assessment. The difference is related to additional criteria considered in the newer Fish Response Assessment Index (FRAI) version and the latest fish species information of the area. The 2005 results may therefore have been a slight over estimation of the status of the fish in this reach.*
Macro-invertebrates	*B (85%)*	*B/C (80.5%)*	*Conditions are considered stable under current development conditions, although increased tourism development has occurred. Ongoing pressure is related to reduced frequency and size of floods and significantly reduced low-flows because of abstraction from Nooitgedacht Dam, and because of streamflow reduction caused by forestry; gravel roads; spread of alien invasive plants, and septic tanks associated with tourist lodges. Therefore, the macro-invertebrates have deteriorated from a B to a B/C since 2005.*
Riparian vegetation	*C (59.2)*	*C (72.5%)*	*Increase of PES score due to refinement of the Vegetation Response Assessment Index (VEGRAI).*
EcoStatus	**B/C**	**B/C**	**Although there were changes in some of the components, the EcoStatus remained in a B/C EC.**

5.2 EWR K2 KROMDRAAI PES

Table 5.2 EWR K2: PES using the updated EcoStatus suite of models

Component	PES/REC (05)	PES (14)	Comment
Fish	*B/C (81.4%)*	*C (73.2)*	*The condition is mostly similar than the 2005 assessment. The difference is related to additional criteria considered in the newer FRAI version and the latest fish species information of the area. The 2005 results may therefore have been a slight over estimation of the status of the fish in this reach.*
Macro-invertebrates	*C (77.3)*	*C (75.3%)*	*Macro-invertebrate fauna is considered to be in a moderate condition and are unlikely to change because of the current management of releases from Vygeboom Dam. Ongoing pressure is related to reduced frequency and size of floods; significantly reduced low-flows as a result of the Vygeboom Dam; and water quality deterioration from settlements. Therefore, no major change since 2005.*
Riparian vegetation	*C (76.2%)*	*C (75.6%)*	*Difference in PES score due to refinement of the VEGRAI.*
EcoStatus	**C**	**C**	**Although there were changes in some of the components, the EcoStatus remained in a C EC.**

5.3 EWR K3 TONGA PES

Table 5.3 EWR K3: PES using the updated EcoStatus suite of models

Component	PES (05)	REC (05)	PES (14)	Comment
Fish	*E/F (21.1%)*	*D (48.6%)*	*C/D (60.5%)*	*The application of the latest FRAI index indicates that this site falls in a C/D EC. This "improvement" from 2005 is only partly related to the new FRAI version since recent (2013) fish survey data revealed the presence of at least some intolerant species (Barbus eutenia, Opsaridium peringueyi, Chiloglanis pretoriae) not sampled during 2005. It therefore seems that conditions may have improved, and it 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 during the period 2006 to 2013.*
Macro-invertebrates	*E (29.5%)*	*D (44%)*	*D (55%)*	*Based on recent (2013) data, the EC has improved. This may be an indication of improved conditions. Ongoing pressure is related to low flow, with associated deterioration in water quality; abstraction for an expanding sugar industry; inundation caused by weirs, agricultural return flows, cultivation of riparian zones, sand and coal mining. The improvement since 2005 is probably due to stabilized flows from Maguga Dam.*
Riparian vegetation	*D/E (36.6%)*	*D (56.57%)*	*D (51.1%)*	*Based on recent photographs of the site (April 2013) the cover and abundance of both woody and non-woody (particularly reeds) vegetation has improved. It seems that non-flow related impacts have been reduced (especially vegetation removal) and that invasive alien plant species abundance has declined. The quantity of flow (especially low flows) has also increased which has facilitated an increase in marginal and lower zone vegetation cover and abundance. The EC has improved from an E to a D.*
EcoStatus	**E**	**D**	**D**	**Due to the improved constant baseflow releases from Maguga Dam, there has been an improvement in the EcoStatus since 2006.**

5.4 EWR G1 VAALKOP

Table 5.4 EWR G1: PES using the updated EcoStatus suite of models

Component	PES/REC (05)	PES (14)	Comment
Fish	*D (49.2%)*	*D (49.6%)*	*Conditions have remained similar between 2005 and 2014 and the FRAI scores calculated using the two different versions were also very similar and within the same EC.*
Macro-invertebrates	*D (46.4%)*	*D (56.7%)*	*The macro-invertebrate fauna were considered to be in a poor condition due to major reductions in the number of taxa with a preference for high and moderate quality water. However, the conditions are considered stable under current development conditions. Ongoing pressure is related to forestry, mining and trout fishing activities; forestry and mining activities; sediment input related to river crossings and gravel roads that service forestry plantations and mining areas, burning and logging, organic pollution and alien invasive plants.*
Riparian vegetation	*D (46.9%)*	*D (51.1%)*	*Difference in PES score due to refinement of the VEGRAI.*
EcoStatus	**D**	**D**	**Although there were changes in some of the components, the EcoStatus remained in a D EC.**

5.5 EWR T1 TEESPRUIT PES

Table 5.5 EWR T1: PES using the updated EcoStatus suite of models

Component	PES/REC (05)	AEC UP (05)	PES (14)	Comment
Fish	*B/C (81%)*	*B (85.4%)*	*C (73.9%)*	*It is estimated that conditions have remained similar between 2006 and 2014 and that the difference is related to calculation differences between the two FRAI versions.*
Macro-invertebrates	*C (65.1%)*	*B (87.3%)*	*C (73.2%)*	*The river is in reasonable good condition and is considered to be stable under current development conditions. Ongoing pressure is related to reduced low-flows caused by diversion and abstraction of water for irrigation and domestic requirements; organic pollution from a poorly operated sewage works and poor sanitation facilities. Therefore, no major change since 2006.*
Riparian vegetation	*C (74.2%)*	*B (84.6%)*	*C (70.1%)*	*Difference in PES score due to refinement of the VEGRAI.*
EcoStatus	**C**	**B**	**C**	**Although there were changes in some of the components, the EcoStatus remained in a C EC.**

5.6 EWR L1 KLEINDORINGKOP PES

Table 5.6 EWR L1: PES using the updated EcoStatus suite of models

Component	PES/REC (2006)	PES (2014)	Comment
Fish	*C (68.38%)*	*C (64.8%)*	*Conditions have remained fairly stable between 2006 and 2014 with a similar FRAI score calculated.*
Macro-invertebrates	*C (67.1%)*	*C (76.6%)*	*Based on recent (2013) data, ecological conditions are considered to be stable in the short-term. The PES is estimated to be in a higher C due to flow releases from the dam that seems to benefit the macro-invertebrate communities. Ongoing pressure is related to high low-flows and highly variable flows, including periods of zero flow, organic enrichment from poor sanitation facilities, removal of vegetation in the riparian zone, cultivation of the riparian zones, and agricultural return flows. Therefore, no major change since 2006.*
Riparian vegetation	*B/C (78.8%)*	*B/C (79%)*	*Difference in PES score due to refinement of the VEGRAI.*
EcoStatus	**C/D**	**C**	**The EcoStatus is in a C EC due to improvement in macroinvertebrates.**

5.7 PES ECOSTATUS SUMMARY (2005, 2011, 2014)

The table below compares the PES EcoStatus determined during the different studies.

Table 5.7 Comparison of PES EcoStatus

EWR sites	PES (05)	PES (11)	PES (14)
EWR K1	**B/C**	**B/C**	**B/C**
EWR K2	**C**	**B/C**	**C**
EWR K3	**E**	**D/E**	**D**
EWR G1	**D**	**D**	**D**
EWR T1	**C**	**C**	**C**
EWR L1	**C**	**D**	**C**

Table 5.8 Summary of 2014 PES (Level IV) results

Component	EWR K1	EWR K2	EWR K3	EWR G1	EWR T1	EWR L1
Physico chemical	B	B	C	C	C	B/C
Geomorphology	C	C	D	D	C	D
Fish	C	C	C/D	D	C	C
Invertebrates	B/C	C	D	D	C	C
Riparian vegetation	C	C	D	D	C	C
EcoStatus	B/C	C	D	D	C	C

6 EWR RESULTS AT EWR SITES

6.1 2005 EWR RESULTS

As indicated in the inception report, the EWRs undertaken during 2005 (AfriDev, 2005a) were not stored in the SPATSIM format and it will therefore not be possible to use the results for scenario evaluation. Furthermore, the hydrology has changed therefore the EWR rules will have to be recreated using the new hydrology as well as accommodating some of the basic changes in methods since 2006. The basic requirements for setting flows during the 2005 study were extracted from the report (AfriDev, 2005a) and were used as a guideline for recreating flows. These results are summarised in Appendix B of this report.

The major changes in the results were due to the change in present day (PD) hydrology. When determining the EWRs to maintain the PES, the EWRs should not be higher than the present day flow as that would generally imply an improvement. Therefore, wherever the 2005 EWRs were higher than present day hydrology, adjustments were required.

6.2 REVISION OF EWR RESULTS

The results were generated using the measured hydraulic cross-sections and hydraulic modelling at EWR sites where the raw hydraulic cross-sectional data was available. These results and the updated hydrology were used to populate the Revised Desktop Reserve Model (RDRM) (Hughes et al., 2012) in SPATSIM. The model output for every EWR site is attached as Appendix A. The results for the low flows are provided below per EWR site (Table 6.1 to Table 6.6) and the high flows are summarised in Table 6.7 for all the EWR sites. Note that the high flows (floods) were not adjusted and were added to the revised low EWR flows. A summary of the results compared to the natural MAR (NMAR) is provided in Table 6.8.

Table 6.1 EWR K1 Gevonden: Low flow EWR results for PES and REC: B/C

Months	Drought flows: 90% (m^3/s)	Maintenance flows: 60% (m^3/s)
OCTOBER	*1.243*	*1.243*
NOVEMBER	*3.264*	*3.264*
DECEMBER	*5.245*	*5.245*
JANUARY	*5.541*	*5.541*
FEBRUARY	*5.809*	*5.809*
MARCH	*4.797*	*4.797*
APRIL	*4.224*	*4.224*
MAY	*2.332*	*2.332*
JUNE	*2.032*	*2.032*
JULY	*1.665*	*1.665*
AUGUST	*1.307*	*1.307*
SEPTEMBER	*1.189*	*1.189*

Table 6.2 EWR K2 Kromdraai: Low flow EWR results for PES (C) and REC (B)

Months	PES		REC	
	Drought flows: 90% (m^3/s)	Maintenance flows: 60% (m^3/s)	Drought flows: 90% (m^3/s)	Maintenance flows: 60% (m^3/s)
OCTOBER	*0.257*	*0.500*	*0.306*	*0.500*
NOVEMBER	*0.350*	*1.235*	*0.508*	*1.235*
DECEMBER	*0.464*	*1.823*	*0.651*	*2.173*
JANUARY	*0.557*	*1.931*	*0.762*	*2.448*
FEBRUARY	*0.632*	*1.862*	*0.847*	*2.367*
MARCH	*0.614*	*1.669*	*0.871*	*2.223*
APRIL	*0.615*	*1.481*	*0.829*	*1.976*
MAY	*0.489*	*0.848*	*0.596*	*1.197*
JUNE	*0.372*	*0.681*	*0.409*	*0.683*
JULY	*0.322*	*0.500*	*0.343*	*0.500*
AUGUST	*0.265*	*0.396*	*0.293*	*0.396*
SEPTEMBER	*0.230*	*0.382*	*0.270*	*0.382*

Table 6.3 EWR K3 Tonga: Low flow EWR results for PES and REC: D

Months	PES	
	Drought flows: 90% (m^3/s)	Maintenance flows: 60% (m^3/s)
OCTOBER	*0.672*	*2.080*
NOVEMBER	*0.816*	*4.525*
DECEMBER	*1.015*	*5.003*
JANUARY	*0.349*	*6.691*
FEBRUARY	*1.632*	*8.944*
MARCH	*1.871*	*8.159*
APRIL	*1.697*	*7.486*
MAY	*1.710*	*5.328*
JUNE	*1.317*	*3.360*
JULY	*0.956*	*2.919*
AUGUST	*0.772*	*2.373*
SEPTEMBER	*0.614*	*2.051*

Table 6.4 EWR G1 Vaalkop: Low flow EWR results for PES and REC: D

	PES	
Months	Drought flows: 90% (m^3/s)	Maintenance flows: 60% (m^3/s)
OCTOBER	*0.041*	*0.100*
NOVEMBER	*0.070*	*0.215*
DECEMBER	*0.092*	*0.278*
JANUARY	*0.113*	*0.324*
FEBRUARY	*0.124*	*0.359*
MARCH	*0.128*	*0.348*
APRIL	*0.138*	*0.317*
MAY	*0.123*	*0.245*
JUNE	*0.101*	*0.186*
JULY	*0.067*	*0.122*
AUGUST	*0.045*	*0.075*
SEPTEMBER	*0.039*	*0.058*

Table 6.5 EWR T1 Teespruit: Low flow EWR results for PES and REC: C

Months	Drought flows: 90% (m^3/s)	Maintenance flows: 60% (m^3/s)
OCTOBER	0.206	0.308
NOVEMBER	0.231	0.553
DECEMBER	0.256	0.783
JANUARY	0.280	0.918
FEBRUARY	0.302	0.962
MARCH	0.318	0.815
APRIL	0.324	0.746
MAY	0.318	0.616
JUNE	0.296	0.380
JULY	0.269	0.366
AUGUST	0.234	0.334
SEPTEMBER	0.206	0.306

Table 6.6 EWR L1 Kleindoringkop: Low flow EWR results for PES and REC: C

Months	PES	
	Drought flows: 90% (m^3/s)	Maintenance flows: 60% (m^3/s)
OCTOBER	0.502	0.756
NOVEMBER	0.459	1.210
DECEMBER	0.621	1.691
JANUARY	0.854	2.124
FEBRUARY	1.001	2.204
MARCH	1.166	2.339
APRIL	1.058	1.887
MAY	1.030	1.335
JUNE	0.917	1.253
JULY	0.722	1.101
AUGUST	0.558	0.905
SEPTEMBER	0.419	0.749

Table 6.7 High flow EWR results the EWR sites

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
EWR K1 GEVONDEN: PES AND REC: B/C ECOSTATUS								
CLASS I (2.25 - 5 m^3/s)	3	3	3	3	2	May - Aug	3.6	2
CLASS II (5 - 11.1 m^3/s)	2		7.3	1.5	6	Nov - May	7.3	3
CLASS III (11.1 - 22 m^3/s)	1		25.5	0.5	2	Nov - May	25.5	4
CLASS IV (22 - 44.41 m^3/s)	0.6		21:36	0.5	1	Nov - May	21:36	5
K2 KROMDRAAI: PES: C ECOSTATUS								
CLASS I (4.8 - 9.71 m^3/s)	3	3	2	2	3	Apr - Sep	7.3	2
CLASS II (9.71 - 19.42 m^3/s)			1	2	2	Nov - Apr	14	5
CLASS III (19.42 - 38.84 m^3/s)			2	2	2	Nov - Apr	28.1	5

Flood Class (m^3/s)	Macro-invertebrates	Fish	Vegetation	Geomorphology	FINAL[1]	Months	Daily average (m^3/s)	Duration (days)
CLASS IV (38.84 - 77.86 m^3/s)			1	1	1	Nov - Apr	55	6
K2 KROMDRAAI: REC: B ECOSTATUS								
CLASS I (4.8 - 9.71 m^3/s)	4	3	4	4	4	Apr - Sep	7.3	4
CLASS II (9.71 - 19.42 m^3/s)			3		3	Nov - Apr	14	5
CLASS III (19.42 - 38.84 m^3/s)			3		3	Nov - Apr	28.1	5
CLASS IV (38.84 - 77.86 m^3/s)			2		2	Nov - Apr	55	6
EWR K3 TONGA: PES AND REC: D ECOSTATUS								
CLASS I (8 - 16 m^3/s)	2	3	2	2	3	Mar - Nov	11.9	2
CLASS II (16 - 32 m^3/s)			2	2	2	Nov - Apr	24.1	5
CLASS III (32 - 63 m^3/s)			2	2	2	Nov - Apr	46.4	6
CLASS IV (63 - 126 m^3/s)			1	1	1	Nov - Apr	84	7
EWR G1 VAALKOP: PES AND REC: D ECOSTATUS								
CLASS I (0.4 – 0.8 m^3/s)	2		2	2	2	Mar - Nov	0.6	1
CLASS II (0.8 – 1.6 m^3/s)	2	1	2	2	2	Nov - Apr	0.2	1
CLASS III (1.6 – 3.2 m^3/s)			2		2	Nov - Apr	2.4	2
CLASS IV 3.2 – 6.3 m^3/s)			0.5		0.5	Nov - Apr	5	3
EWR T1 TEESPRUIT: PES AND REC: C ECOSTATUS								
CLASS I (1.7 – 3.3 m^3/s)	3	1	2	1	3	Mar - Nov	2.5	1
CLASS II (3.3 – 6.5 m^3/s)			2	2	2	Nov - Apr	4.9	2
CLASS III (6.5 - 13 m^3/s)			2	1	2	Nov - Apr	9.8	3
CLASS IV (13 - 26 m^3/s)			0.5	0.7	0.7	Nov - Apr	20	4
EWR L1 KLEINDORINGKOP: PES AND REC ECOSTATUS: C								
CLASS I (1.7 – 3.4 m^3/s)	3		2		1	Mar - Nov	2.6	1
CLASS II (3.4 – 6.75 m^3/s)	2		2		2	Nov - Apr	5.1	2
CLASS III (6.75 – 13.5 m^3/s)			2	1	2	Nov - Apr	10.1	3
CLASS IV (13.5 - 27 m^3/s)			1	0.5	0.5	Nov - Apr	20..5	4

*1 * Final refers to the agreed on number of events considering the individual requirements for each component.*

Table 6.8 Summary of PES results as a percentage of the natural MAR (nMAR)

				Long term mean					
EWR site	**PES**	**nMAR (MCM)**	**pMAR (MCM)**	**Low flows (MCM)**	**Low flows (%nMAR)**	**High flows (MCM)**	**High flows (%nMAR)**	**Total flows (MCM)**	**Total (%nMAR)**
EWR K1	*B/C*	*158.62*	*108.46*	*63.543*	*11.6*	*51.267*	*9.4*	*114.81*	*21*
EWR K2	*C*	*545.56*	*318.64*	*25.567*	*16.1*	*15.387*	*9.7*	*40.954*	*25.8*
EWR K3	*D*	*1021.67*	*489.84*	*101.098*	*9.9*	*74.456*	*7.3*	*175.554*	*17.2*
EWR G1	*D*	*29.52*	*21.18*	*5.888*	*19.9*	*2.047*	*7*	*7.935*	*26.9*
EWR T1	*C*	*56.36*	*45.13*	*12.747*	*22.6*	*7.147*	*12.7*	*19.894*	*35.3*
EWR L1	*C*	*294.31*	*229.53*	*34.46*	*11.7*	*16.503*	*5.6*	*50.963*	*17.3*

Table 6.9 Summary of REC results as a percentage of the natural MAR (nMAR)

				Long term mean					
EWR site	**REC**	**nMAR (MCM)**	**pMAR (MCM)**	**Low flows (MCM)**	**Low flows (%nMAR)**	**High flows (MCM)**	**High flows (%nMAR)**	**Total flows (MCM)**	**Total (%nMAR)**
EWR K2	*B*	*545.56*	*318.64*	*31.654*	*20*	*17.004*	*10.7*	*48.658*	*30.7*

7 DESKTOP BIOPHYSICAL NODES: RESOURCE UNITS, LOCALITY AND ECOCLASSIFICATION

7.1 DESKTOP RESOURCE UNITS

The Sub-Quaternary river reaches (SQs) as indicated in http://www.dwa.gov.za/iwqs/gis_data /river/rivs500k.html and http://www.dwa.gov.za/iwqs/gis_data/river/River_Report_01.pdf, forms the basis of the PES (11) (DWA, 2013b) assessment. A SQ changes when a significant tributary joins it. This means that a SQ may potentially be subdivided into various EcoRegions, geomorphic zones (slope zones) resource units (natural or management), etc. Such subdivisions are not addressed on a desktop level, and may be required when higher confidence assessments are done. The version of the 1:500 000 coverage that was used for the PES (11) (DWA, 2013b), was a version used by the National Freshwater Ecosystem Priority Areas (NFEPA) project in 2009 (Nel et al., 2011).

The SQs at desktop levels are therefore surrogates for desktop level Resource Units. These SQs are illustrated in Figure 2.1, Figure 3.1 and Figure 4.1.

7.2 DESKTOP BIOPHYSICAL NODES

A desktop biophysical node represents a point at the end of the SQ for all SQs which do not contain key biophysical nodes. These desktop biophysical nodes are represented in Figures 2.1, 3.1 and 4.1. A table with all the nodes, as well as providing the IUA in which they are situated, are attached as Appendix B.

7.3 DESKTOP ECOCLASSIFICATION

The PES (11) (DWA, 2013b) results were used to derive the REC (Table 7.1, 7.2 and 7.3) at the desktop biophysical nodes. In cases where the importance (IEI) is high or very high, an improved REC is recommended. The estimated EWR from the RDRM is linked to the REC and these results are provided in the following chapters. It must however be noted that if the REC is not based on an improved flow regime, the EWR for the PES is used. Information is also supplied on what will be required to achieve the REC as well as whether this is attainable (Column 6 and 7 in Table 5.2).

Table 7.3 summarises the results for the desktop biophysical nodes (DWA, 2013a) and forms the basis for the EWR estimation (see Chapter 8). Note that biophysical nodes which represents rivers with its source and 'end' in the Kruger National Park or other protected areas are not included for EWR estimation and are excluded from the table below. If information is required on any of these nodes, please refer to DWA (2013a).

The description of the columns is as follows:

- *Column 1: SQ number.*
- *Column 2: River name where available.*
- *Column 3: PES according to the results of the PESEIS study completed during 2011.*
- *Column 4: Ecological Importance and Sensitivity according to the results of the PESEIS study completed during 2011.*
- *Column 5: REC generated during this study and documented in this report, as well as in DWA (2013c) as well as the electronic data provided as part of this study.*
- *Column 6: Comments provided to indicate what would be required to improve the REC and whether it is attainable as well as information on whether the actions required would need flow- or non-flow-related measures.*

- *Column 7: A conclusion on whether the improvement is attainable.*
- *Column 8: Provides the EC for which the RDRM must be run. Therefore, if the RDRM category is different than the REC (i.e. the same as the PES), it means that the measures to achieve the REC do not require increased flows.*

Table 7.1 X1 (Komati): Summary of results for the desktop biophysical nodes

1	2	3	4	5	6	7	8
SQ number	**River**	**PES**	**EIS**	**REC**	**REC Comment**	**Improvement attainable?**	**RDRM**
X11A-01300		B	2.6	B			B
X11A-01354		C	2.5	C			C
X11A-01358	Vaalwaterspruit	C	2.6	C			C
X11A-01295	Vaalwaterspruit	C	2.4	C			C
X11A-01248	Vaalwaterspruit	C	2.8	C			C
X11B-01370	Boesmanspruit	B	2.9	B			B
X11B-01361		B/C	2.8	B/C			B/C
X11B-01272	Boesmanspruit	C	3.1	B/C	Very difficult. Many variables will have to drop and the presence of the dam is irreversible. Probably also difficult to release water from the dam.	Difficult	C
X11C-01147	Witkloofspruit	C	3.8	C	Barriers and inundation will have to be significantly improved.	No	C
X11D-01129	Klein-Komati	C	2.9	C			C
X11D-01137	Waarkraalloop	C	2.8	C			C
X11D-01219	Komati	C/D	2.6	C/D			C/D
X11D-01196	Komati	C	2.6	C			C
X11E-01237	Swartspruit	C	3.8	B	Catchment management to control erosion and remove aliens - less sedimentation	Yes	C
X11E-01157	Komati	B/C	3.0	B/C			B/C
X11F-01133	Bankspruit	B	3.2	B			B
X11G-01188	Ndubazi	B/C	3.0	B	Better forestry management. Improve riparian buffer zone		B
X11G-01143	Gemakstroom	C	2.9	C			C
X11K-01165	Poponyane	C	2.6	C			C
X11K-01199		D	2.1	D			D
X11K-01179	Gladdespruit	C	2.7	C			C
X11K-01194	Gladdespruit	C	2.7	C			C
X12A-01305	Buffelspruit	C	3.8	B	Reinstate buffer zone. Will have to significantly improve riparian vegetation to get to a B	Yes	C
X12B-01246	Hlatjiwe	C	2.8	C			C
X12C-01242	Phophenyane	B	3.1	B			B
X12C-01271	Buffelspruit	B	3.0	B			B
X12D-01235	Seekoeispruit	C	3.1	B/C	Have to improve most metrics to a 1. Very difficult. Overall catchment management	Probably not	C
X12E-01287	Teespruit	C	3.7	B	Catchment management and water quality improvement	Probably not	C
X12H-01338	Sandspruit	B	3.2	B			B
X12H-01340		B	3.0	B			B
X12H-01318	Sandspruit	C	2.8	C			C
X12J-01202	Mtsoli	B	4.0	B			B
X12K-01333	Mlondozi	C	3.1	B/C	Improve water quality. Note, top sections in a B. If you can also	Water quality improvement most	C

1	2	3	4	5	6	7	8
SQ number	**River**	**PES**	**EIS**	**REC**	**REC Comment**	**Improvement attainable?**	**RDRM**
					improve riparian vegetation, you can get it to a B.	*likely*	
X12K-01332	*Mhlangampepa*	**B**	*3.5*	**B**			**B**
X12K-01316	*Komati*	**D**	*2.8*	**D**			**D**
X13A-01337	*Maloloja*	**A**	*3.5*	**A**			**A**
X13J-01141	*Mzinti*	**D**	*3.3*	**D**	*Highly populated area - very difficult to improve. Water quality infrastructure improvement could result in half a category improvement.*	*No*	**D**
X13J-01205	*Mbiteni*	**D**	*2.5*	**D**			**D**
X13J-01221	*Komati*	**D**	*2.7*	**D**			**D**
X13K-01136	*Mambane*	**D**	*2.9*	**D**			**D**
X13K-01068	*Nkwakwa*	**C/D**	*3.1*	**C/D**	*Unless barriers and inundation is addressed, improvement not possible.*	*No*	**D**
X13K-01114	*Komati*	**D**	*2.9*	**D**			**D**
X13L-01000	*Ngweti*	**D**	*2.8*	**D**	*Non-Flow - Very difficult*	*No*	**D**
X13L-0995	*Komati*	**D**	*2.7*	**D**			**D**
X14B-01166	*Ugutugulo*	**C**	*3.4*	**B/C**	*Remove alien vegetation. Improve riparian zone buffer. But will also need improvement in flow (EWR releases from dam) or water quality.*	*Difficult*	**B/C**

Table 7.2 X2 (Crocodile): Summary of results for the desktop biophysical nodes

1	2	3	4	5	6	7	8
SQ number	**River**	**PES**	**EIS**	**REC**	**REC Comment**	**Improvement attainable?**	**RDRM**
X21A-01008		**C/D**	*2.0*	**C**			**C/D**
X21B-00929	*Gemsbokspruit*	**C/D**	*4.1*	**C**			**C/D**
X21B-00898	*Lunsklip*	**C/D**	*4.1*	**C**			**C/D**
X21B-00925	*Lunsklip*	**C**	*3.0*	**C**			**C**
X21C-00859	*Alexanderspruit*	**C**	*3.8*	**C**	*As Kwena Dam (barrier affect) is a given (river runs into it), and all other ratings are a 2, it is very difficult to improve to a B/C or B*	*no*	**C**
X21D-00957	*Buffelskloofspruit*	**C**	*3.1*	**B/C**	*Improved agricultural practices in general. Most metrics will require improvement*	*Difficult*	**C**
X21D-00938	*Crocodile*	**C**	*2.9*	**C**			**C**
X21E-00897	*Buffelskloofspruit*	**B**	*3.2*	**B**			**B**
X21E-00947	*Crocodile*	**B**	*3.0*	**B**			**B**
X21F-01046	*Elands*	**C**	*3.8*	**C**			**C**
X21F-01100	*Leeuspruit*	**C**	*2.6*	**C**			**C**
X21F-01096	*Dawsonsspruit*	**A**	*1.6*	**A**			**A**
X21F-01091	*Rietvleispruit*	**C**	*2.4*	**C**			**C**
X21F-01092	*Leeuspruit*	**C/D**	*2.3*	**C/D**			**C/D**
X21F-01081	*Elands*	**C**	*2.5*	**C**			**C**
X21G-01090	*Weltevredespruit*	**C**	*2.8*	**C**			**C**
X21G-01016	*Swartkoppiespruit*	**C**	*3.3*	**C**	*Barriers and water quality (trout dams) difficult to address. Some improvement to forestry buffer zones. This will be insufficient to provide overall improvement.*	*No*	**C**
X21H-01060	*Ngodwana*	**C**	*3.2*	**B**	*Note US of the Dam and PES probably a B, therefore no improvement necessary.*	*n/a*	**B**

1	2	3	4	5	6	7	8
SQ number	**River**	**PES**	**EIS**	**REC**	**REC Comment**	**Improvement attainable?**	**RDRM**
X21J-01013	*Elands*	**C**	*3.1*	**B/C**	*Will need significant improvements in the riparian zone, agricultural practices in terms of return flows, also WWTW of US towns.*	*Difficult*	**C**
X21K-01007	*Lupelule*	**B**	*3.2*	**B**			**B**
X21K-00997	*Elands*	**C**	*2.8*	**C**			**C**
X22A-00875	*Houtbosloop*	**B/C**	*3.2*	**B**	*Riparian zone improvement*	*Yes*	**B/C**
X22A-00887	*Beestekraalspruit*	**B/C**	*3.0*	**B/C**			**B/C**
X22A-00824	*Blystaanspruit*	**B/C**	*3.2*	**B**	*Riparian zone improvement*	*Yes*	**B/C**
X22A-00920		**B**	*2.4*	**B**			**B**
X22A-00919	*Houtbosloop*	**B/C**	*2.8*	**B/C**			**B/C**
X22A-00917	*Houtbosloop*	**C**	*2.6*	**C**			**C**
X22A-00913	*Houtbosloop*	**C**	*3.4*	**B**	*Agricultural practices in general must improve.*	*Yes*	**B**
X22C-00990	*Visspruit*	**B/C**	*2.8*	**B/C**			**B/C**
X22C-01004	*Gladdespruit*	**C**	*3.8*	**B/C**	*Top section probably already in a better state than the C. General improvement will be difficult. Base it on an estimated B/C in upper areas.*	*Difficult*	**C**
X22D-00843	*Nels*	**C**	*2.8*	**C**			**C**
X22D-00846		**C**	*2.7*	**C**			**C**
X22E-00849	*Sand*	**C**	*2.4*	**C**			**C**
X22E-00833	*Kruisfonteinspruit*	**C**	*2.2*	**C**			**C**
X22F-00842	*Nels*	**C**	*3.1*	**B/C**	*Riparian zone improvement & management, erosion control*	*Difficult*	**C**
X22F-00886	*Sand*	**C**	*3.0*	**C**			**C**
X22F-00977	*Nels*	**C/D**	*3.3*	**C/D**	*To improve this 5 km stretch of river, one has to improve the Sand us tributary (see above) which does not warrant improvement. Not feasible.*	*No*	**C/D**
X22H-00836	*Wit*	**D/E**	*3.8*	**D**	*Remove alien vegetation, improve buffer zones and water quality from Wit River. It is assumed these mitigation measures are more likely to happen than EWR releases from the Dam.*	*Yes*	**D**
X22K-01042	*Mbuzulwane*	**B**	*2.7*	**B**			**B**
X22K-01043	*Blinkwater*	**B**	*3.1*	**B**			**B**
X22K-01029	*Blinkwater*	**C**	*2.7*	**C**			**C**
X23B-01052	*Noordkaap*	**D**	*3.5*	**C**	*Riparian zone improvement (forestry areas). Also water quality of mine.*	*Yes*	**D**
X23C-01098	*Suidkaap*	**C**	*3.5*	**B/C**	*Riparian zone improvement (forestry and agriculture)*	*Yes, difficult*	**C**
X23E-01154	*Queens*	**C**	*3.8*	**B/C**	*Riparian zone improvement (forestry and agriculture)*	*Yes, difficult*	**C**
X23F-01120	*Suidkaap*	**C**	*2.8*	**C**			**C**
X24A-00826	*Nsikazi*	**C**	*3.3*	**C**	*Densely populated with associated subsistence agriculture*	*No*	**C**
X24A-00860	*Sithungwane*	**A**	*3.3*	**A**			**A**
X24A-00881	*Nsikazi*	**B**	*3.2*	**B**			**B**
X24B-00903	*Gutshwa*	**D**	*3.3*	**D**	*Densely populated with associated subsistence agriculture*	*No*	**D**
X24B-00928	*Nsikazi*	**A/B**	*3.4*	**A/B/**			**A/B**
X24C-00978	*Nsikazi*	**B**	*3.7*	**B**			**B**

Table 7.3 X3 (Sabie/Sand): Summary of results for the desktop biophysical nodes

1	2	3	4	5	6	7	8
SQ number	**River**	**PES**	**EIS**	**REC**	**REC Comment**	**Improvement attainable?**	**RDRM**
X31A-00741	*Klein Sabie*	**C**	*3.0*	**B/C**	*Requires significant improvement of the riparian zone (in forestry area), reduced sediment (erosion control in forestry area) and improved water quality in lower reaches (Sabie formal and informal settlements)*	*Unlikely*	**C**
X31A-00783		**C**	*2.4*	**C**			**C**
X31A-00786		**B**	*3.3*	**B**			**B**
X31A-00794		**B**	*2.9*	**B**			**B**
X31A-00796		**B**	*2.9*	**B**			**B**
X31A-00803		**B/C**	*2.3*	**B/C**			**B/C**
X31B-00792	*Goudstroom*	**B/C**	*2.7*	**B/C**			**B/C**
X31D-00773	*Sabani*	**C/D**	*2.8*	**C/D**			**C/D**
X31E-00647	*Marite (US of dam)*	**B/C**	*3.4*	**B**	*Improved riparian zone*	*Yes*	**B/C**
X31F-00695	*Motitsi*	**C**	*3.5*	**B**	*Improved riparian zone. Water quality (Graskop influence)*	*Yes*	**C**
X31H-00819	*White Waters*	**C**	*3.1*	**B/C**	*Da Gama Dam probably insufficient outlets to release flows. Improve riparian*	*Difficult*	**C**
X31J-00774	*Noord-Sand*	**D**	*2.9*	**D**			**D**
X31J-00835	*Noord-Sand*	**D**	*2.9*	**D**			**D**
X31K-00713	*Bejani*	**D**	*3.7*	**D**	*High density settlements*	*No*	**D**
X31K-00771	*Phabeni*	**B**	*3.0*	**B**			**B**
X31L-00657	*Matsavana*	**C**	*2.8*	**C**			**C**
X31L-00664	*Saringwa*	**C**	*2.9*	**C**			**C**
X31L-00678	*Saringwa*	**B/C**	*3.3*	**B/C**	*Upper section in Bosbokrand Nature Reserve already in a B and improvement in lower reaches not possible*	*No*	**B/C**
X31M-00673	*Musutlu*	**B/C**	*3.3*	**B/C**	*Lower section in Sabie-Sand. Already in a B and improvement in upper reaches (urbanisation) not possible*	*No*	**B/C**
X32B-00551	*Motlamogatsana*	**C**	*3.4*	**C**	*Large areas of extensive settlements*	*No*	**C**
X32C-00558	*Nwandlamuhari*	**C**	*2.9*	**C**			**C**
X32C-00564	*Mphyanyana*	**C**	*2.9*	**C**			**C**
X32C-00606	*Nwandlamuhari*	**C**	*2.9*	**C**			**C**
X32E-00629	*Nwarhele*	**C/D**	*3.3*	**C**	*Riparian zone improvement will improve upper reaches. Lower reaches very dense settlements - unlikely to improve*	*Yes*	**C/D**
X32F-00628	*Nwarhele*	**C/D**	*2.8*	**C/D**			**C/D**
X32G-00549	*Khokhovela*	**C**	*3.2*	**C**	*90% of reach extensive subsistence agriculture and settlements*	*No*	**C**
X32H-00560	*Phungwe*	**A**	*3.4*	**A**			**A**

8 DESKTOP BIOPHYSICAL NODES: EWR ESTIMATION AND RESULTS

8.1 BACKGROUND

The Desktop Reserve Model (DRM) of Hughes and Hannart (2003) has been extensively used over the last decade for estimating EWR in this and other countries. The estimation of EWRs in this study makes use of the Revised Desktop Reserve Model (RDRM), that more explicitly includes the links and relationships between hydrology, hydraulics and ecological response. The RDRM was developed within a Water Research Commission (WRC) project, documented by Hughes et al. (2012), with more recent updates (Hughes et al., 2014).

8.2 EXTRAPOLATED EWRS AT DESKTOP BIOPHYSICAL NODES

Additional to the 23 EWR sites, 46 biophysical nodes will have a flow requirement which is extrapolated from the EWR at the EWR sites. The EWR sites and its requirements therefore act as surrogates for these nodes. Therefore, if the system is managed for the EWR sites, these 46 biophysical nodes will be catered for. The nodes are listed in Table 8.1 and due to the higher confidence than desktop level, these nodes are also key biophysical nodes.

Table 8.1 Biophysical nodes where EWR results will be extrapolated from EWR sites

Node name	River	Extrapolated from
X11F-01163	Komati	EWR K1
EWR K1	Komati	
X11G-01177	Komati	EWR K1
X11H-01140a	Komati	EWR K1
EWR G1	Mngubhudle	
X11K-01227	Komati	EWR K2
EWR T1	Teespruit	
X12G-01200	Komati	EWR K2
X12H-01296	Komati	EWR K2
EWR K2	Komati	
X13J-01210	Komati	EWR K3A
X13J-01149	Komati	EWR K3A
EWR K3A	Komati	
X14G-01128	Lomati	L1
EWR L1	Lomati	
X11H-01140b	Komati	EWR K2
EWR C1	Crocodile	
EWR C2	Crocodile	
EWR C3	Crocodile	
EWR E2	Elands	
X21G-01073	Elands	EWR E2
EWR E1	Elands	
X21K-00997	Elands	EWR E1
X22B-00987	Crocodile	EWR 4
X22B-00888	Crocodile	EWR 4
X22C-00946	Crocodile	EWR 4
X22J-00993	Crocodile	EWR 4

Node name	River	Extrapolated from
X22J-00958	Crocodile	EWR 4
X22K-00981	Crocodile	EWR 4
EWR C4	Crocodile	
EWR C7	Kaap	
X24C-01033	Crocodile	EWR 6 for B
EWR C5	Crocodile	
X24E-00982	Crocodile	EWR 6 for B
X24F-00953	Crocodile	EWR 6 for B
X24H-00880	Crocodile	EWR 6 for B
EWR C6	Crocodile	
X31A-00778	Sabie	EWR S1
X31A-00799	Sabie	B/C (EWR 1)
X31B-00756	Sabie	C (EWR 2)
EWR S1	Sabie	
EWR S4	Mac-Mac	
EWR S2	Sabie	
X31D-00772	Sabie	C (EWR 2)
EWR S5	Marite	
X31K-00750	Sabie	EWR S3
X31K-00752	Sabie	EWR S3
X31K-00758	Sabie	EWR S3
X31M-00681	Sabie	A/B (EWR 3)
X31M-00739	Sabie	A/B (EWR 3)
X31M-00747	Sabie	A/B (EWR 3)
EWR S7	Tlulandziteka	
X32D-00605	Mutlumuvi	B (EWR 6)
X32G-00565	Sand	EWR 8
X32H-00578	Sand	EWR 8
EWR S8	Sand	
X32J-00730	Sand	EWR 8
X33A-00731	Sabie	EWR 3 & 8
X33A-00737	Sabie	EWR 3 & 8
X33B-00784	Sabie	EWR 3 & 8
X33B-00804	Sabie	EWR 3 & 8
X33B-00829	Sabie	EWR 3 & 8
X33D-00811	Sabie	EWR 3 & 8
X33D-00861	Sabie	EWR 3 & 8
X31E-00647b	Marite (ds of Dam)	EWR 5

8.3 APPROACH

8.3.1 Biophysical nodes and associated information provided

The SQ catchments requiring Desktop EWR assessments were provided by Rivers for Africa, together with the PES and REC. So-called 'biophysical nodes' are located at the SQ catchment *outlets and are labelled according to their quaternary and NFEPA[2] codes. Of the 120 nodes requiring Desktop EWRs, six nodes[3] have an improved REC relative to the PES.*

8.3.2 SPATSIM setup

THE RDRM runs within the Spatial and Time Series Information Modelling (SPATSIM) software. A new SPATSIM application was setup for the Inkomati Catchment (which includes the Inkomati, Crocodile and Sabie Rivers), with Geographical Information System (GIS) coverages for the SQ catchments, rivers, major dams, biophysical nodes, Rapid III and EWR sites (refer to Figure 8.1). Figure 8.1 shows the SQ catchments (Inkomati = yellow, Crocodile = green, Sabie = purple), rivers, major dams, biophysical nodes (light red), Rapid III sites (green) and EWR sites (yellow). The SQ catchments associated with biophysical nodes (requiring Desktop EWRs) are outlined darker, and nodes are located at catchment outlets.

The RDRM application setup is readily transferable to other computers running SPATSIM.

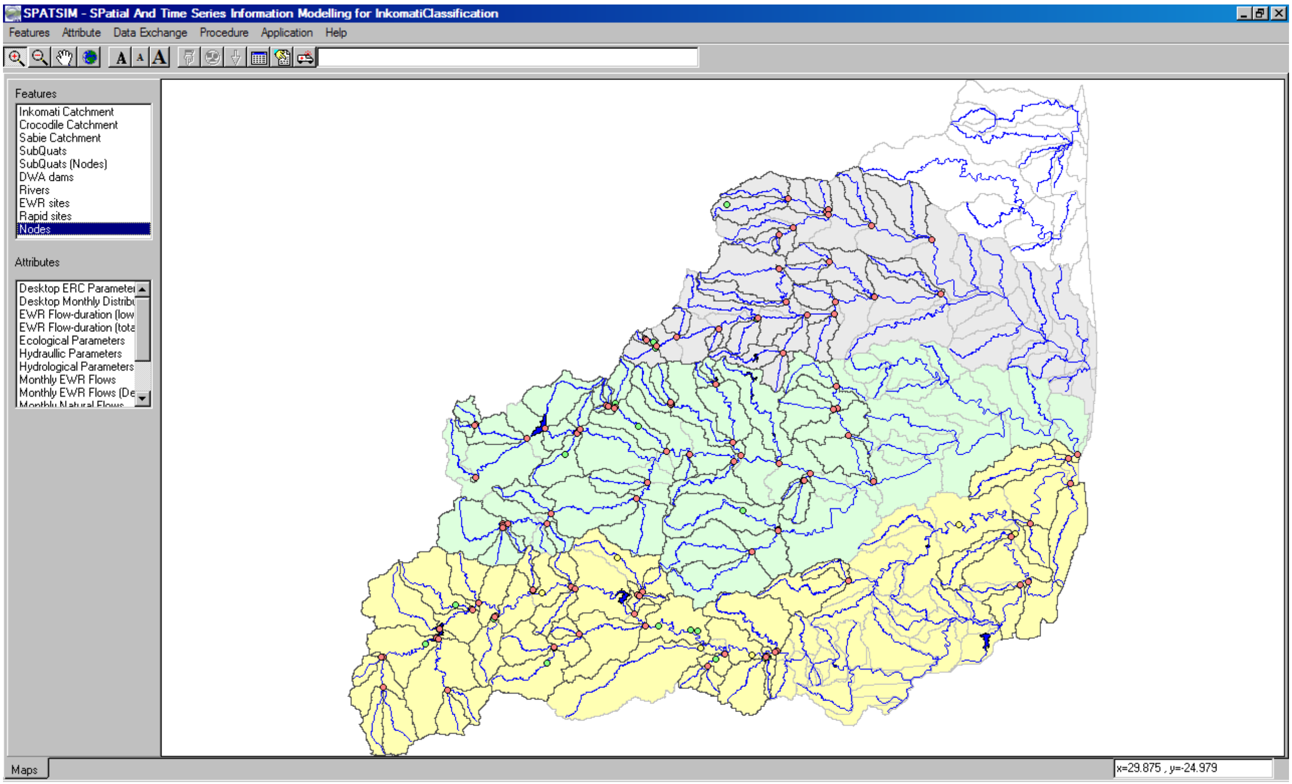


Figure 8.1 The Inkomati Catchment Classification Project visual setup in SPATSIM

8.3.3 Data requirements and assessment

The RDRM, run as a Desktop Application[4], has the following minimum data requirements:

- *Hydrology[5]*
  - *Timeseries of monthly natural flows.*
  - *Baseflow separation parameters (refer to Hughes et al., 2002).*
  - *Percentage point on the low flow-temporal exceedance for the maximum low flow.*
- *Hydraulics*

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2 National Freshwater Ecosystem Priority Areas Project (http://bgis.sanbi.org/nfepa/project.asp). The numerical NFEPA codes are unique to each SQ at a national level.

3 X11G-01188, X14A-01173, X14B-01166, X21H-01060, X22A-00913, X22H-00836

4 It can also be applied at higher levels of Reserve determination (e.g. Rapid III, Intermediate and Comprehensive), with the use of additional information, such as, for example, surveyed cross-sectional river profiles and modelled rating relationships.

5 Provided by IWR Water Resources.

- *Flood region.*
- *Valley slope.*
- *Geomorphological zone (Gz).*
- *Catchment area.*

- *Ecology*
  - *Seasonal perenniality, viz. whether the EWR should have wet, wet and dry, or neither seasons perennial.*
  - *The stress index value (in the range 0 to 10) corresponding to the threshold discharge for the onset of fast flows (i.e. velocities ≥ 0.3 m/s).*
  - *The relative weighting of stress index-discharges for three velocity-depth classes (viz. fast-shallow, fast-intermediate, and fast-deep flows - refer to Table 8.2).*

Default parameter values were used for the following variables:

- *Hydrology*
  - *Percentage point (20%) on the low flow-temporal exceedance.*
  - *Regionalised baseflow separation parameters.*
  - *The (three) high flow EWR parameters.*
- *Ecology*
  - *The low and high flow stress index shifts (from natural) for the four ecological categories (A to D).*

In addition to the monthly natural flows, timeseries of PD flows were also modelled and provided (refer to Footnote 5). The remaining parameters required for Desktop assessment were determined as follows:

- *Hydraulics*
  - *Valley slopes were determined using the Shuttle Remote Topography Mission[6] (SRTM) 90m Digital Elevation Model (DEM). The 1;500,000 rivers coverage published by the Department of Water Affairs (DWA)[7] was re-digitised for the Inkomati Catchment using the SRTM DEM. The reason for this is to ensure that the rivers coverage corresponds to the lowest elevations in the underlying DEM, which is in-turn used to provide elevations for vertices along the river lines, and hence valley slopes. The SRTM DEM was pre-processed[8] and drainage lines (corresponding in position to the 1:500,000 DWA rivers coverage) were digitised for the SQs requiring Desktop EWR estimation. Valley slopes were computed[9] for the rivers coverage, and due to the resolution of the underlying DEM, average slopes[10, 11] were computed upstream of the SQ catchment outlets.*
  - *The classified Gzs7 at a national level are derived directly from valley slopes, and are subject to the resolution issues associated with the 1:500,000 rivers coverage-DEM, discussed above. The GZs corresponding to the 2 km-averaged valley slopes (at the SQ catchment outlets) were determined using the gradient-Gz classification of Rountree and Wadeson (1999)[12].*
  - *Catchment areas were provided by IWR Water Resources.*
- *Ecology*

6 http://www2.jpl.nasa.gov/srtm/
7 http://www.dwaf.gov.za/iwqs/gis_data/
8 sinks filled and/or channels deepened
9 at the (approximately) 90 to 127 m spatial coverage of the SRTM DEM.
10 over 2km; artificially impounded water bodies were excluded from the average slope calculations, using the DWA (major) dams GIS coverage which was verified and refined using Google Earth (GE) imagery.
11 dams were excluded from the average slope calculations, using the DWA (major) dams coverage which was verified and refined (particularly for smaller dams) using Google Earth imagery.
12 This results in Gzs in the hydraulic component of the RDRM that are compatible with the valley slopes from which they are derived, and no corrections are necessary.

- *For each of the SQ catchments (requiring EWR estimates), the fish species present (from the results of the national PES-EIS project (DWA, 2013b)) were classified[13] into the presence or absence of six broad guilds which differ in size (small or large) and their preference for fast-flowing water (i.e. Rheophiles, Semi-rheophiles and Limnophiles)[14]. This was also carried out for the macro-invertebrates using two broad groups: presence/absence of taxa that are either flow-dependent or of "medium" flow-dependence. Stress-index parameter values required in the RDRM were then determined as a function of the six broad fish guilds and the flow-dependent nature of macro-invertebrate taxa, and are given in Table 8.2.*
- *The need for seasonal perenniality can be inferred from the presence/absence of the fish guilds in Table 8.2. For example, if Rheophilics are present, both (wet and dry) seasons must be perennial; for semi-rheophilics, the wet season needs be perennial; and Limnophilics do not require either season to be perennial.*

Table 8.2 Stress-index parameter values for fish guilds used in the RDRM

Fish guild and macro-invertebrate group	Wet season[1] stress-index				Dry season[1] stress-index			
	Fast threshold	Relative weight			Fast threshold	Relative weight		
		FS	FI	FD		FS	FI	FD
LR[2] or FDI[3]	9	4	7	9	9	2	5	7
SR[4] or FDI	9	3	5	8	9	1	3	5
LSR[5] and FDI	9	2	3	4	9	1	2	5
SSR[6] and FDI	9	2	3	4	9	1	2	5
LL[7] and FDI	9	1	2	3	9	1	2	3
SL[8] and FDI	9	1	2	3	9	1	2	3
LSR or MFDI[9]	9	1	2	2	5	1	2	2
SSR or MFDI[9]	9	2	2	1	5	2	2	1
LL and MFDI[9]	5	1	1	1	1	1	1	1
SL and MFDI[9]	5	1	1	1	1	1	1	1
None or only limnophilic fish[10]	4	1	1	1	1	1	1	1

1 Critical period (i.e. month) *2 Large Rheophilics*
3 Flow-Dependent Invertebrates *4 Small Rheophilics*
5 Large Semi-Rheophilics *6 Small Semi-Rheophilics*
7 Large Limnophilics *8 Small Limnophilics*
9 Medium Flow-Dependent Invertebrates (no FDI)
10 No FDI or MDI
Fast: velocity ≥ 0.3 m/s; Shallow: Depth < 0.1m; Intermediate: 0.1 ≤ Depth ≤ 0.3 m; Deep: Depth > 0.3 m; FS: Fast Shallow; FI: Fast Intermediate; FD: Fast Deep

8.3.4 Modelling

Generally, for all biophysical nodes assessed, the EWR requirements were constrained to PD flows. Exceptions, however, are where the REC is higher than the PES (due to improvements in the existing hydrological flow regime), and secondly where there is a disparity between the (hydrologically) modelled perenniality and that inferred from the fish preference for flowing water. For the latter, given that this is a Desktop assessment a conservative approach was adopted where perenniality is included[15] in the EWRs to maintain the flow-dependent nature of the

13 By Dr P. Kotze and Dr A. Deacon.
14 A rheophile is an organism that requires fast-flowing water, whereas limnophiles do not.
15 Albeit at low discharges (high stress values)

expected fish assemblages (and macro-invertebrate taxa). Of the 120 nodes addressed, such inconsistencies accounted for only nine nodes.

For four of the nodes (viz. X11A-013100, X11K-01199, X31M-00673 and X32C-00564) the RDRM could not be used, and the DRM was applied. The reason for this is that if the discharge at which fast flows commence (i.e. velocity > 0.3 m/s) exceeds the maximum baseflow, then no stress-discharge curve is constructed. This reduces the low flow EWRs to zero for all the minimum low flow months in the EWR timeseries, irrespective of natural conditions. This is a somewhat severe condition that requires consideration for possible refinement[16], and the DRM was rather used with the EWRs constrained to PD flows, if appropriate.

For five of the SQs (refer to Figure 8.1) no Desktop EWRs are provided since the catchment areas (source catchments) are less than approximately 3 km^2, and the hydrology was not modelled[17].

8.4 RESULTS

The EWR results are provided in the following formats as text files named according to the biophysical node:

- *Timeseries of average monthly EWR flows (in 10^6 m^3) for the period 1920 to 2004.*
- *Assurance rules for EWR low flows and total flows (in 10^6 m^3).*
- *RDRM generated reports[18].*

A summary of low and high flow EWR requirements, including the naturalised and PD Mean Annual Runoff (MAR) is provided in Table 8.3.

Table 8.3 Summary of Desktop EWRs for the biophysical nodes in the Inkomati Catchment (Inkomati, Crocodile and Sabie Rivers)

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

16 Since the ecological low flow component of the RDRM needs to be extended to include the requirements of biota not dependant on fast flow characteristics.
17 Small flows and inaccurate at this resolution.
18 Not relevant for the DRM.

IUA	SQ node	River name	MAR (10^6 m^3)		REC	Long-term requirements				Desktop method
			Natural	PD		Low flows		Total flows		
						10^6 m^3	MAR	10^6 m^3	MAR	
X1-3	X11D-01219	Komati	73.6	33.0	C/D	6.78	9.2%	9.04	12.3%	RDRM
X1-3	X11E-01157	Komati	118.3	72.4	B/C	20.99	17.7%	30.31	25.6%	RDRM
X1-4	X11K-01165	Poponyane	13.7	10.8	C	2.01	14.7%	3.12	22.7%	RDRM
X1-4	X11K-01179	Gladdespruit	64.4	30.8	C	8.68	13.5%	13.04	20.2%	RDRM
X1-4	X11K-01194	Gladdespruit	71.2	36.8	C	7.86	11.0%	13.59	19.1%	RDRM
X1-4	X11K-01199		2.4	1.5	D	0.36	15.1%	0.53	22.3%	DRM
X1-5	X12K-01316	Komati	577.0	348.9	D	79.99	13.9%	122.33	21.2%	RDRM
X1-6	X12A-01305	Buffelspruit	32.0	24.2	C	7.26	22.7%	9.69	30.3%	RDRM
X1-6	X12B-01246	Hlatjiwe	22.1	17.1	C	5.04	22.8%	6.75	30.5%	RDRM
X1-6	X12C-01242	Phophenyane	6.3	5.9	B	1.80	28.7%	2.35	37.5%	RDRM
X1-6	X12C-01271	Buffelspruit	71.1	56.4	B	22.53	31.7%	28.76	40.5%	RDRM
X1-6	X12D-01235	Seekoeispruit	97.0	80.0	C	22.54	23.2%	29.58	30.5%	RDRM
X1-6	X12H-01318	Sandspruit	13.9	13.3	C	3.36	24.1%	4.43	31.7%	RDRM
X1-6	X12H-01338	Sandspruit	4.4	4.3	B	1.24	27.9%	1.64	36.7%	RDRM
X1-6	X12H-01340		4.8	4.3	B	1.48	30.6%	1.92	39.5%	RDRM
X1-6	X12J-01202	Mtsoli	66.5	58.6	B	15.92	23.9%	22.26	33.5%	RDRM
X1-6	X12K-01332	Mhlangampepa	3.4	3.4	B	1.06	30.7%	1.38	40.0%	RDRM
X1-6	X12K-01333	Mlondozi	22.4	22.3	C	4.56	20.3%	6.34	28.2%	RDRM
X1-7	X14A-01173	Lomati	84.4	72.0	B	23.24	27.5%	30.65	36.3%	RDRM
X1-7	X14B-01166	Ugutugulo	20.9	14.3	B/C	4.88	23.4%	6.61	31.7%	RDRM
X1-9	X13J-01141	Mzinti	6.3	4.2	D	0.66	10.5%	1.21	19.1%	RDRM
X1-9	X13J-01205	Mbiteni	5.9	5.1	D	0.50	8.6%	1.04	17.6%	RDRM
X1-9	X13J-01221	Komati	1000.3	535.0	D	137.12	13.7%	197.35	19.7%	RDRM
X1-10	X13K-01068	Nkwakwa	5.4	5.4	C/D	0.61	11.2%	1.23	22.7%	RDRM
X1-10	X13K-01114	Komati	1341.4	645.6	D	172.51	12.9%	242.23	18.1%	RDRM
X1-10	X13K-01136	Mambane	1.8	1.8	D	0.24	13.1%	0.41	22.4%	RDRM
X1-10	X13L-00995	Komati	1356.6	504.8	D	97.40	7.2%	150.08	11.1%	RDRM
X1-10	X13L-01000	Ngweti	4.6	2.5	D	0.35	7.5%	0.67	14.5%	RDRM
CROCODILE RIVER CATCHMENT										
X2-1	X21A-01008		na	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%	RDRM
X2-1	X21B-00925	Lunsklip	25.8	22.2	C	6.01	23.3%	8.07	31.3%	RDRM
X2-1	X21B-00929	Gemsbokspruit	3.8	3.3	C/D	0.71	18.9%	0.99	26.3%	RDRM
X2-1	X21C-00859	Alexanderspruit	28.8	26.2	C	6.81	23.6%	9.09	31.5%	RDRM
X2-2	X21D-00938	Crocodile	124.8	104.5	C	24.51	19.6%	29.99	24.0%	RDRM
X2-2	X21D-00957	Buffelskloofspruit	16.9	12.9	C	4.22	25.0%	5.50	32.6%	RDRM
X2-2	X21E-00897	Buffelskloofspruit	8.4	6.6	B	2.15	25.6%	2.96	35.3%	RDRM
X2-2	X21E-00947	Crocodile	125.1	104.7	B	30.35	24.3%	36.11	28.9%	RDRM
X2-3	X21F-01046	Elands	35.1	31.6	C	9.49	27.1%	12.35	35.2%	RDRM
X2-3	X21F-01081	Elands	50.8	46.8	C	13.90	27.4%	18.02	35.5%	RDRM
X2-3	X21F-01091	Rietvleispruit	3.3	3.1	C	0.90	27.1%	1.17	35.4%	RDRM
X2-3	X21F-01092	Leeuspruit	11.9	11.2	C/D	2.81	23.6%	3.70	31.2%	RDRM
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%	RDRM
X2-4	X21G-01016	Swartkoppiespruit	11.4	9.7	C	2.77	24.4%	3.70	32.5%	RDRM
X2-4	X21G-01090	Weltevredespruit	5.5	4.7	C	1.31	23.6%	1.77	32.0%	RDRM
X2-4	X21H-01060	Ngodwana	59.6	36.2	B	7.61	12.8%	13.20	22.1%	RDRM
X2-4	X21J-01013	Elands	151.5	124.1	C	33.97	22.4%	46.15	30.5%	RDRM

IUA	SQ node	River name	MAR (10^6 m^3)		REC	Long-term requirements				Desktop method
						Low flows		Total flows		
			Natural	PD		10^6 m^3	MAR	10^6 m^3	MAR	
X2-4	X21K-01007	Lupelule	29.4	22.9	B	6.59	22.4%	9.43	32.1%	RDRM
X2-7	X22A-00824	Blystaanspruit	21.0	15.0	B/C	5.76	27.4%	7.42	35.3%	RDRM
X2-7	X22A-00875	Houtbosloop	6.9	5.0	B/C	1.82	26.2%	2.36	34.2%	RDRM
X2-7	X22A-00887	Beestekraalspruit	3.7	2.7	B/C	0.96	25.9%	1.26	33.9%	RDRM
X2-7	X22A-00913	Houtbosloop	75.3	53.9	B	24.84	33.0%	31.11	41.3%	RDRM
X2-7	X22A-00917	Houtbosloop	14.8	10.6	C	3.31	22.3%	4.40	29.7%	RDRM
X2-7	X22A-00919	Houtbosloop	10.6	7.6	B/C	2.85	26.8%	3.69	34.7%	RDRM
X2-7	X22A-00920		1.7	1.2	B	0.52	30.8%	0.67	39.4%	RDRM
X2-7	X22C-00990	Visspruit	3.4	3.0	B/C	0.67	20.0%	1.05	31.1%	RDRM
X2-8	X22C-01004	Gladdespruit	16.3	10.7	C	1.80	11.1%	3.39	20.9%	RDRM
X2-8	X22D-00843	Nels	20.6	14.9	C	4.51	21.9%	6.09	29.6%	RDRM
X2-8	X22D-00846		13.8	10.0	C	3.32	24.1%	4.39	31.9%	RDRM
X2-8	X22E-00833	Kruisfonteinspruit	11.1	8.2	C	2.08	18.7%	2.96	26.6%	RDRM
X2-8	X22E-00849	Sand	8.7	6.4	C	1.71	19.8%	2.40	27.7%	RDRM
X2-8	X22F-00842	Nels	74.9	45.1	C	8.37	11.2%	14.21	19.0%	RDRM
X2-8	X22F-00886	Sand	48.9	37.3	C	9.48	19.4%	13.41	27.4%	RDRM
X2-8	X22F-00977	Nels	125.4	84.9	C/D	21.08	16.8%	30.24	24.1%	RDRM
X2-8	X22H-00836	Wit	43.0	20.0	D	3.41	7.9%	6.39	14.9%	RDRM
X2-9	X22K-01029	Blinkwater	7.6	6.8	C	1.44	19.0%	2.05	27.2%	RDRM
X2-9	X22K-01042	Mbuzulwane	1.2	1.1	B	0.34	28.7%	0.46	38.5%	RDRM
X2-9	X22K-01043	Blinkwater	5.9	5.4	B	1.43	24.2%	2.07	34.9%	RDRM
X2-10	X23B-01052	Noordkaap	50.9	33.5	D	8.66	17.0%	11.96	23.5%	RDRM
X2-10	X23C-01098	Suidkaap	61.8	37.8	C	20.12	32.6%	24.40	39.5%	RDRM
X2-10	X23E-01154	Queens	39.5	25.0	C	7.26	18.4%	10.71	27.1%	RDRM
X2-10	X23F-01120	Suidkaap	109.8	57.1	C	26.51	24.1%	34.04	31.0%	RDRM
X2-12	X24A-00826	Nsikazi	2.0	1.9	C	0.48	24.2%	0.67	34.0%	RDRM
X2-12	X24A-00881	Nsikazi	11.7	11.3	B	3.44	29.5%	4.75	40.6%	RDRM
X2-12	X24B-00903	Gutshwa	25.4	24.8	D	4.11	16.2%	6.21	24.4%	RDRM
X2-12	X24B-00928	Nsikazi	42.4	41.4	A/B	13.46	31.8%	18.65	44.0%	RDRM
X2-12	X24C-00978	Nsikazi	52.3	42.0	B	16.06	30.7%	21.15	40.5%	RDRM
SABIE RIVER CATCHMENT										
X3-1	X31A-00741	Klein Sabie	14.6	11.8	C	2.15	14.7%	3.37	23.0%	RDRM
X3-1	X31A-00783		12.1	9.5	C	3.17	26.1%	4.09	33.8%	RDRM
X3-1	X31A-00786		4.7	3.6	B	1.82	39.1%	2.22	47.8%	RDRM
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%	RDRM
X3-2	X31E-00647a	Marite	79.9	62.8	B/C	20.58	25.8%	27.74	34.7%	RDRM
X3-2	X31F-00695	Motitsi	43.9	35.8	C	7.82	17.8%	11.62	26.5%	RDRM
X3-4	X31D-00773	Sabani	19.2	7.6	C/D	3.13	16.3%	3.75	19.5%	RDRM
X3-4	X31H-00819	White Waters	28.9	16.2	C	7.51	25.9%	9.09	31.4%	RDRM
X3-4	X31J-00774	Noord-Sand	45.1	20.2	D	4.21	9.3%	7.22	16.0%	RDRM
X3-4	X31J-00835	Noord-Sand	12.0	11.0	D	2.91	24.2%	3.76	31.3%	RDRM
X3-4	X31K-00713	Bejani	2.4	2.4	D	0.40	16.9%	0.61	25.7%	RDRM
X3-4	X31L-00657	Matsavana	3.8	2.6	C	0.17	4.3%	0.65	16.8%	RDRM
X3-4	X31L-00664	Saringwa	10.9	9.5	C	1.47	13.5%	2.67	24.5%	RDRM
X3-4	X31L-00678	Saringwa	3.2	3.2	B/C	0.59	18.2%	1.00	30.8%	RDRM

IUA	SQ node	River name	MAR (10^6 m^3)		REC	Long-term requirements				Desktop method
			Natural	PD		Low flows		Total flows		
						10^6 m^3	MAR	10^6 m^3	MAR	
X3-4	*X31M-00673*	*Musutlu*	*1.8*	*1.8*	*B/C*	*0.19*	*10.6%*	*0.34*	*19.0%*	*DRM*
X3-6	*X31K-00771*	*Phabeni*	*2.5*	*2.5*	*B*	*0.70*	*27.8%*	*0.97*	*39.0%*	*RDRM*
X3-7	*X32E-00629*	*Nwarhele*	*10.6*	*9.9*	*C/D*	*1.93*	*18.2%*	*2.76*	*26.1%*	*RDRM*
X3-7	*X32F-00628*	*Nwarhele*	*14.8*	*14.0*	*C/D*	*3.44*	*23.3%*	*4.63*	*31.3%*	*RDRM*
X3-8	*X32B-00551*	*Motlamogatsana*	*15.4*	*10.4*	*C*	*2.75*	*17.9%*	*3.95*	*25.7%*	*RDRM*
X3-8	*X32C-00558*	*Nwandlamuhari*	*49.7*	*25.0*	*C*	*7.64*	*15.4%*	*10.02*	*20.2%*	*RDRM*
X3-8	*X32C-00564*	*Mphyanyana*	*3.1*	*2.0*	*C*	*0.05*	*1.6%*	*0.33*	*10.5%*	*DRM*
X3-8	*X32C-00606*	*Nwandlamuhari*	*53.2*	*33.7*	*C*	*8.77*	*16.5%*	*12.54*	*23.6%*	*RDRM*
X3-8	*X32G-00549*	*Khokhovela*	*3.9*	*3.8*	*C*	*0.41*	*10.4%*	*0.67*	*17.0%*	*RDRM*
X3-9	*X32H-00560*	*Phungwe*	*7.6*	*7.3*	*A*	*1.19*	*15.7%*	*1.98*	*26.1%*	*RDRM*

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

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10 APPENDIX A EWR RESULTS AT KOMATI EWR SITES

A report is generated as part of the RDERM to provide:

- *the hydrology summary;*
- *the parameters that were adjusted from the default;*
- *and the final output results (EWR rules) for all categories.*

This report is provided for all the EWR sites in the following sections.

10.1 EWR K1: GEVONDEN

```
DATE: 02/20/2014

Revised Desktop Model outputs for site: K1

HYDROLOGY DATA SUMMARY
Natural Flows:                          Present Day Flows:
   Area     MAR   Ann.SD    Q75   Ann.     Area     MAR   Ann.SD    Q75   Ann.
  (km^2)      (m^3 * 10^6)        CV     (km^2)      (m^3 * 10^6)        CV
    0.00  158.62  104.56    3.21  0.66      0.00  108.46   90.48    1.43  0.83

% Zero flows =   0.0                    % Zero flows =   0.0
Baseflow Parameters: A = 0.960, B = 0.44Baseflow Parameters: A = 0.960, B = 0.440
BFI = 0.40 : Hydro Index =   3.9        BFI = 0.34 : Hydro Index =   5.6

MONTH   MEAN      SD     CV             MONTH   MEAN      SD     CV
       (m^3 * 10^6)                            (m^3 * 10^6)
 Oct    5.17    5.97    1.15             Oct    2.64    4.19    1.59
 Nov   14.94   17.65    1.18             Nov    7.85   11.61    1.48
 Dec   22.46   22.59    1.01             Dec   14.49   18.59    1.28
 Jan   27.66   27.12    0.98             Jan   19.45   22.39    1.15
 Feb   30.50   36.54    1.20             Feb   23.66   33.97    1.44
 Mar   22.64   26.82    1.18             Mar   18.05   25.03    1.39
 Apr   13.97   12.70    0.91             Apr   10.31   11.26    1.09
 May    7.76    6.95    0.90             May    5.15    5.87    1.14
 Jun    4.58    2.37    0.52             Jun    2.64    1.83    0.70
 Jul    3.42    1.38    0.40             Jul    1.69    0.91    0.54
 Aug    2.78    1.09    0.39             Aug    1.28    0.69    0.54
 Sep    2.73    1.81    0.66             Sep    1.24    0.83    0.67

Critical months: WET : Feb, DRY : Sep
Using  20th percentile of FDC of separated baseflows
Max. baseflows (m3/s): WET :      4.707, DRY :      1.166

HYDRAULICS DATA SUMMARY
Geomorph. Zone  4
Flood Zone      4
Max. Channel width (m) 43.45
Max. Channel Depth (m)  3.17

Observed Channel XS used
Observed Rating Curve used
(Gradients and Roughness n values calibrated)

Max. Gradient         0.00900
Min. Gradient         0.00900
Gradient Shape Factor      20
Max. Mannings n         0.150
Min. Mannings n         0.030
n Shape Factor             45


FLOW - STRESSOR RESPONSE DATA SUMMARY
Table of Stress weightings
Season          Wet   Dry
Stress at 0 FS:  9     9
FS Weight:       0     0
FI Weight:       0     0
FD Weight:       1     1

Table of initial SHIFT factors for the Stress Frequency Curves

Category  High SHIFT  Low SHIFT
```

A	0.044	0.260
A/B	0.066	0.390
B	0.088	0.520
B/C	0.110	0.650
C	0.132	0.780
C/D	0.154	0.910
D	0.176	1.040

Perenniality Rules
Non-Perennial Allowed

Alignment of maximum stress to Present Day stress
Not Aligned

Table of flows (m3/2) v stress index

Stress	Wet Season Flow	Dry Season Flow
0	4.976	1.167
1	4.263	1.054
2	3.571	1.015
3	2.743	0.980
4	2.219	0.956
5	1.871	0.931
6	1.566	0.881
7	1.308	0.785
8	0.865	0.596
9	0.433	0.298
10	0.000	0.000

HIGH FLOW ESTIMATION SUMMARY DETAILS
No High flows when natural high flows are < 17% of total flows
Adjusted hydrological variability for high flows is 3.54
Maximum high flows are 250% greater than normal high flows

Table of normal high flow requirements (Mill. m3)

Category	A	A/B	B	B/C	C	C/D	D
Annual	19.915	18.682	17.476	16.298	15.146	14.021	12.922
Oct	0.741	0.695	0.650	0.607	0.564	0.522	0.481
Nov	3.536	3.317	3.103	2.893	2.689	2.489	2.294
Dec	4.142	3.886	3.635	3.390	3.150	2.916	2.688
Jan	4.033	3.783	3.539	3.301	3.067	2.840	2.617
Feb	3.324	3.119	2.917	2.721	2.528	2.341	2.157
Mar	2.303	2.160	2.021	1.884	1.751	1.621	1.494
Apr	1.836	1.722	1.611	1.502	1.396	1.293	1.191
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aug	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FINAL RESERVE SUMMARY DETAILS
EWR (low and total Flows) are constrained to be below Present Day Flows

Long term mean flow requirements (Mill. m3 and %MAR)

Category	Low Flows		Total Flows	
	Mill. m3	%MAR	Mill. m3	%MAR
A	38.735	24.4	56.814	35.8
A/B	35.047	22.1	52.670	33.2
B	31.654	20.0	48.658	30.7
B/C	27.382	17.3	43.678	27.5
C	25.567	16.1	40.954	25.8
C/D	24.022	15.1	38.434	24.2
D	22.378	14.1	35.812	22.6

FLOW DURATION and RESERVE ASSURANCE TABLES
Columns are FDC precentage points:

Natural Total flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	8.675	6.380	4.470	4.000	3.395	3.070	2.700	2.490	2.095	1.388
Nov	37.940	21.340	14.000	9.920	8.180	6.610	5.560	4.710	4.035	1.951
Dec	57.305	39.320	24.590	16.520	12.190	10.550	8.980	7.220	5.510	2.278
Jan	71.665	45.890	30.790	21.420	15.985	13.610	10.365	8.690	7.355	4.791
Feb	78.695	37.310	33.410	22.580	15.655	12.980	11.195	8.550	7.515	4.467
Mar	44.140	31.020	20.860	16.620	13.120	11.970	9.775	7.690	6.200	4.376
Apr	28.680	17.390	13.970	12.480	10.690	8.640	7.315	6.500	4.515	3.359
May	13.015	9.840	8.195	7.180	6.470	5.620	4.980	4.290	3.255	1.988
Jun	8.060	6.220	5.230	4.510	3.940	3.590	3.225	2.730	2.415	1.677
Jul	5.095	4.290	3.850	3.410	3.190	2.790	2.565	2.350	2.100	1.603

Aug	3.895	3.420	3.035	2.830	2.630	2.280	2.210	2.000	1.800	1.555
Sep	3.795	3.140	2.850	2.640	2.435	2.190	2.005	1.840	1.580	1.278

Natural Baseflow flow duration curve (mill. m3)

Oct	4.183	3.648	2.950	2.716	2.455	2.283	2.137	1.956	1.743	1.319
Nov	7.776	5.483	4.169	3.724	3.208	2.978	2.794	2.575	2.199	1.750
Dec	11.608	8.212	6.557	4.763	4.158	3.686	3.472	3.160	2.892	1.729
Jan	14.193	10.600	7.782	6.512	5.618	4.936	4.201	3.787	3.273	2.263
Feb	16.461	11.375	8.829	7.712	6.340	5.360	4.550	4.081	3.710	2.982
Mar	13.767	10.827	8.867	7.723	6.653	5.632	4.717	4.224	3.844	2.906
Apr	12.066	9.822	8.290	7.170	6.104	5.569	4.560	4.181	3.589	2.850
May	9.543	7.449	6.930	6.250	5.400	4.789	4.264	3.727	3.069	1.988
Jun	7.011	5.970	4.875	4.350	3.880	3.520	3.155	2.720	2.408	1.677
Jul	4.853	4.184	3.680	3.360	3.090	2.790	2.565	2.350	2.100	1.603
Aug	3.800	3.310	3.035	2.830	2.630	2.280	2.210	2.000	1.771	1.555
Sep	3.639	2.999	2.700	2.493	2.311	2.080	1.930	1.810	1.580	1.278

Category Low Flow Assurance curves (mill. m3)

A Category

Oct	3.151	3.107	2.170	1.940	1.490	1.340	1.095	0.960	0.820	0.528
Nov	5.220	4.317	3.783	3.435	3.082	2.856	2.513	2.106	1.733	0.688
Dec	6.610	5.954	5.296	4.308	3.878	3.524	3.109	2.689	2.294	0.905
Jan	7.416	6.873	6.022	5.175	4.651	4.165	3.625	3.211	2.691	2.204
Feb	7.023	6.442	5.776	5.077	4.463	3.926	3.498	3.163	2.726	2.169
Mar	7.613	7.267	7.169	6.799	6.050	5.157	4.331	3.652	3.125	2.494
Apr	6.747	6.377	5.925	5.366	5.068	4.638	3.940	3.464	2.265	1.711
May	6.227	5.636	5.280	4.370	3.870	3.440	2.715	2.030	1.595	1.024
Jun	4.644	3.840	3.270	2.380	2.160	1.770	1.605	1.370	1.060	0.764
Jul	2.825	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

A/B Category

Oct	3.017	2.979	2.170	1.940	1.490	1.340	1.095	0.960	0.820	0.528
Nov	4.758	3.998	3.548	3.242	2.879	2.611	2.243	1.822	1.504	0.688
Dec	5.743	5.189	4.696	3.965	3.557	3.197	2.784	2.331	1.993	0.905
Jan	6.061	5.584	5.088	4.562	4.128	3.727	3.257	2.790	2.341	1.947
Feb	5.314	5.082	4.728	4.310	3.876	3.500	3.172	2.724	2.375	2.148
Mar	6.433	6.356	6.340	6.234	5.530	4.675	3.875	3.164	2.715	2.375
Apr	5.728	5.329	4.983	4.763	4.515	4.185	3.533	3.001	2.265	1.711
May	5.513	4.994	4.818	4.370	3.870	3.440	2.715	2.030	1.595	1.024
Jun	4.305	3.840	3.270	2.380	2.160	1.770	1.605	1.370	1.060	0.764
Jul	2.825	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

B Category

Oct	2.878	2.831	2.170	1.940	1.490	1.340	1.095	0.960	0.820	0.528
Nov	4.411	3.711	3.288	2.977	2.594	2.265	1.893	1.522	1.274	0.688
Dec	5.154	4.603	4.168	3.573	3.175	2.775	2.341	1.950	1.693	0.905
Jan	5.199	4.671	4.334	3.978	3.619	3.238	2.727	2.338	1.993	1.675
Feb	4.288	4.136	3.906	3.640	3.365	3.043	2.628	2.286	2.027	1.861
Mar	5.841	5.788	5.734	5.604	4.928	4.059	3.262	2.645	2.306	2.050
Apr	5.057	4.567	4.224	4.173	3.970	3.613	2.965	2.510	2.128	1.711
May	5.014	4.486	4.243	3.921	3.570	3.206	2.713	2.030	1.595	1.024
Jun	4.031	3.836	3.270	2.380	2.160	1.770	1.605	1.370	1.060	0.764
Jul	2.825	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

B/C Category

Oct	2.586	2.534	2.170	1.940	1.490	1.340	1.095	0.956	0.820	0.528
Nov	3.896	3.275	2.887	2.549	2.132	1.811	1.480	1.223	1.046	0.688
Dec	4.457	3.949	3.572	3.028	2.585	2.199	1.836	1.572	1.397	0.905
Jan	4.357	3.850	3.622	3.304	2.894	2.522	2.147	1.890	1.649	1.404
Feb	3.426	3.342	3.213	2.965	2.654	2.347	2.073	1.853	1.685	1.575
Mar	4.954	4.909	4.864	4.740	4.007	3.214	2.556	2.130	1.901	1.720
Apr	4.324	3.829	3.522	3.395	3.182	2.828	2.329	2.023	1.766	1.649
May	4.373	3.880	3.620	3.274	2.864	2.502	2.152	1.829	1.497	1.024
Jun	3.582	3.376	3.076	2.380	2.160	1.770	1.605	1.315	1.060	0.764
Jul	2.818	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

C Category

Oct	2.434	2.368	2.121	1.884	1.490	1.306	1.001	0.784	0.680	0.528
Nov	3.694	3.077	2.661	2.311	1.911	1.557	1.265	1.033	0.870	0.688
Dec	4.249	3.749	3.341	2.768	2.342	1.930	1.610	1.366	1.199	0.905
Jan	4.188	3.710	3.439	3.070	2.674	2.297	1.937	1.689	1.450	1.208

Feb	3.334	3.248	3.084	2.799	2.485	2.174	1.901	1.678	1.508	1.398
Mar	4.531	4.490	4.481	4.340	3.636	2.827	2.224	1.833	1.620	1.482
Apr	4.134	3.669	3.351	3.143	2.938	2.530	2.069	1.751	1.575	1.458
May	4.160	3.674	3.396	3.029	2.637	2.270	1.943	1.627	1.309	1.024
Jun	3.391	3.175	2.843	2.380	2.149	1.766	1.422	1.121	0.965	0.764
Jul	2.688	2.180	1.825	1.660	1.405	1.340	1.180	0.980	0.862	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.819	0.709	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.874	0.690	0.596	0.561

C/D Category

Oct	2.354	2.288	2.042	1.801	1.481	1.166	0.854	0.635	0.529	0.469
Nov	3.577	2.975	2.558	2.206	1.774	1.398	1.100	0.866	0.702	0.590
Dec	4.121	3.630	3.202	2.638	2.178	1.748	1.425	1.179	1.009	0.732
Jan	4.071	3.600	3.286	2.913	2.497	2.111	1.750	1.498	1.255	1.015
Feb	3.252	3.165	2.937	2.646	2.326	2.011	1.735	1.507	1.334	1.221
Mar	4.375	4.303	4.286	4.134	3.383	2.564	1.958	1.567	1.351	1.258
Apr	4.013	3.555	3.200	2.964	2.749	2.309	1.848	1.507	1.388	1.268
May	4.032	3.554	3.252	2.878	2.461	2.084	1.756	1.436	1.116	0.880
Jun	3.283	3.070	2.732	2.380	2.006	1.595	1.249	0.948	0.790	0.650
Jul	2.600	2.180	1.825	1.660	1.405	1.340	1.036	0.813	0.692	0.610
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.883	0.667	0.554	0.538
Sep	1.958	1.450	1.245	1.140	1.075	0.990	0.741	0.553	0.458	0.422

D Category

Oct	2.273	2.207	1.963	1.714	1.370	1.025	0.708	0.487	0.378	0.321
Nov	3.460	2.867	2.455	2.097	1.624	1.240	0.935	0.698	0.535	0.443
Dec	3.990	3.491	3.062	2.503	2.003	1.567	1.241	0.992	0.819	0.556
Jan	3.949	3.453	3.130	2.755	2.315	1.927	1.562	1.307	1.060	0.823
Feb	3.171	3.022	2.789	2.494	2.167	1.850	1.568	1.336	1.160	1.045
Mar	4.219	4.118	4.092	3.922	3.115	2.301	1.693	1.300	1.081	1.038
Apr	3.887	3.413	3.046	2.764	2.548	2.089	1.627	1.262	1.201	1.079
May	3.902	3.420	3.107	2.724	2.279	1.898	1.568	1.245	0.923	0.693
Jun	3.173	2.958	2.620	2.268	1.842	1.424	1.075	0.776	0.616	0.483
Jul	2.510	2.180	1.825	1.660	1.405	1.226	0.873	0.646	0.521	0.443
Aug	1.890	1.530	1.320	1.230	1.125	1.029	0.734	0.515	0.400	0.379
Sep	1.892	1.450	1.245	1.140	1.075	0.902	0.607	0.416	0.319	0.283

Category Total Flow Assurance curves (mill. m3)

A Category

Oct	4.733	3.130	2.170	1.940	1.490	1.340	1.095	0.960	0.820	0.528
Nov	13.122	10.560	6.445	4.940	4.050	3.200	2.560	2.300	1.753	0.688
Dec	15.868	13.268	11.064	8.963	6.340	5.820	4.660	3.700	2.351	0.905
Jan	16.431	13.995	11.639	9.708	8.691	7.270	5.900	4.870	2.747	2.204
Feb	14.453	12.313	10.406	8.813	7.793	7.043	5.986	4.617	2.771	2.169
Mar	12.760	11.333	10.376	9.387	8.357	7.316	6.027	4.660	3.157	2.494
Apr	10.851	9.619	8.481	7.429	6.893	5.570	4.495	3.780	2.265	1.711
May	6.227	5.636	5.280	4.370	3.870	3.440	2.715	2.030	1.595	1.024
Jun	4.644	3.840	3.270	2.380	2.160	1.770	1.605	1.370	1.060	0.764
Jul	2.825	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

A/B Category

Oct	4.572	3.130	2.170	1.940	1.490	1.340	1.095	0.960	0.820	0.528
Nov	12.171	9.855	6.445	4.940	4.050	3.200	2.560	2.300	1.549	0.688
Dec	14.428	12.050	10.107	8.332	6.340	5.820	4.660	3.700	2.047	0.905
Jan	14.517	12.265	10.356	8.814	7.918	7.270	5.900	4.445	2.393	1.947
Feb	12.285	10.589	9.071	7.815	7.000	6.423	5.506	4.088	2.418	2.148
Mar	11.261	10.171	9.348	8.662	7.694	6.700	5.491	4.109	2.745	2.375
Apr	9.577	8.370	7.381	6.699	6.241	5.570	4.495	3.755	2.265	1.711
May	5.513	4.994	4.818	4.370	3.870	3.440	2.715	2.030	1.595	1.024
Jun	4.305	3.840	3.270	2.380	2.160	1.770	1.605	1.370	1.060	0.764
Jul	2.825	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

B Category

Oct	4.332	3.130	2.170	1.940	1.490	1.340	1.095	0.960	0.820	0.528
Nov	11.346	9.190	6.445	4.940	4.050	3.200	2.560	2.300	1.317	0.688
Dec	13.278	11.021	9.230	7.659	6.340	5.820	4.660	3.540	1.743	0.905
Jan	13.110	10.921	9.262	7.955	7.165	6.556	5.375	3.886	2.042	1.675
Feb	10.808	9.288	7.968	6.918	6.288	5.778	4.810	3.562	2.067	1.861
Mar	10.357	9.356	8.548	7.875	6.952	5.954	4.773	3.529	2.334	2.050
Apr	8.658	7.412	6.468	5.983	5.584	5.123	4.170	3.215	2.150	1.711
May	5.014	4.486	4.243	3.921	3.570	3.206	2.713	2.030	1.595	1.024
Jun	4.031	3.836	3.270	2.380	2.160	1.770	1.605	1.370	1.060	0.764
Jul	2.825	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

B/C Category

Oct	3.942	3.130	2.170	1.940	1.490	1.340	1.095	0.960	0.820	0.528
Nov	10.363	8.384	6.445	4.940	4.050	3.200	2.560	2.300	1.086	0.688
Dec	12.033	9.934	8.292	6.837	5.981	5.377	4.372	3.055	1.443	0.905
Jan	11.734	9.678	8.218	7.013	6.201	5.617	4.616	3.334	1.695	1.404
Feb	9.507	8.146	7.001	6.023	5.380	4.898	4.109	3.043	1.722	1.575
Mar	9.166	8.237	7.489	6.858	5.894	4.981	3.965	2.954	1.927	1.720
Apr	7.682	6.482	5.614	5.083	4.687	4.237	3.453	2.680	1.787	1.649
May	4.373	3.880	3.620	3.274	2.864	2.502	2.152	1.829	1.497	1.024
Jun	3.582	3.376	3.076	2.380	2.160	1.770	1.605	1.315	1.060	0.764
Jul	2.818	2.180	1.825	1.660	1.405	1.340	1.180	1.110	0.920	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.900	0.785	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.915	0.760	0.700	0.579

C Category

Oct	3.694	3.130	2.170	1.940	1.490	1.340	1.095	0.960	0.688	0.528
Nov	9.704	7.826	6.358	4.940	4.050	3.200	2.560	2.209	0.907	0.688
Dec	11.290	9.312	7.728	6.309	5.498	4.883	3.967	2.745	1.243	0.905
Jan	11.044	9.127	7.711	6.517	5.747	5.173	4.232	3.031	1.492	1.208
Feb	8.985	7.713	6.605	5.641	5.018	4.545	3.793	2.784	1.543	1.398
Mar	8.445	7.582	6.920	6.308	5.391	4.469	3.534	2.600	1.644	1.482
Apr	7.255	6.134	5.296	4.713	4.337	3.839	3.114	2.362	1.595	1.458
May	4.160	3.674	3.396	3.029	2.637	2.270	1.943	1.627	1.309	1.024
Jun	3.391	3.175	2.843	2.380	2.149	1.766	1.422	1.121	0.965	0.764
Jul	2.688	2.180	1.825	1.660	1.405	1.340	1.180	0.980	0.862	0.721
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.960	0.819	0.709	0.659
Sep	1.975	1.450	1.245	1.140	1.075	0.990	0.874	0.690	0.596	0.561

C/D Category

Oct	3.521	3.130	2.170	1.940	1.490	1.340	1.095	0.864	0.536	0.469
Nov	9.141	7.371	6.025	4.940	4.050	3.200	2.560	1.955	0.737	0.590
Dec	10.639	8.779	7.263	5.915	5.099	4.482	3.607	2.455	1.049	0.732
Jan	10.418	8.614	7.240	6.105	5.341	4.773	3.874	2.740	1.294	1.015
Feb	8.484	7.298	6.196	5.277	4.670	4.205	3.486	2.531	1.366	1.221
Mar	7.999	7.166	6.543	5.956	5.007	4.084	3.171	2.276	1.373	1.258
Apr	6.902	5.837	5.000	4.417	4.043	3.521	2.815	2.072	1.406	1.268
May	4.032	3.554	3.252	2.878	2.461	2.084	1.756	1.436	1.116	0.880
Jun	3.283	3.070	2.732	2.380	2.006	1.595	1.249	0.948	0.790	0.650
Jul	2.600	2.180	1.825	1.660	1.405	1.340	1.036	0.813	0.692	0.610
Aug	1.890	1.530	1.320	1.230	1.125	1.060	0.883	0.667	0.554	0.538
Sep	1.958	1.450	1.245	1.140	1.075	0.990	0.741	0.553	0.458	0.422

D Category

Oct	3.348	3.056	2.170	1.940	1.490	1.340	1.068	0.697	0.385	0.321
Nov	8.588	6.918	5.650	4.675	3.923	3.200	2.560	1.702	0.566	0.443
Dec	9.997	8.237	6.805	5.523	4.696	4.087	3.252	2.168	0.856	0.556
Jan	9.798	8.074	6.774	5.696	4.936	4.380	3.520	2.452	1.096	0.823
Feb	7.992	6.831	5.793	4.918	4.328	3.872	3.182	2.280	1.190	1.045
Mar	7.558	6.757	6.173	5.601	4.611	3.702	2.811	1.954	1.102	1.038
Apr	6.550	5.517	4.705	4.103	3.742	3.206	2.518	1.784	1.217	1.079
May	3.902	3.420	3.107	2.724	2.279	1.898	1.568	1.245	0.923	0.693
Jun	3.173	2.958	2.620	2.268	1.842	1.424	1.075	0.776	0.616	0.483
Jul	2.510	2.180	1.825	1.660	1.405	1.226	0.873	0.646	0.521	0.443
Aug	1.890	1.530	1.320	1.230	1.125	1.029	0.734	0.515	0.400	0.379
Sep	1.892	1.450	1.245	1.140	1.075	0.902	0.607	0.416	0.319	0.283

10.2 EWR K2 KROMDRAAI

DATE: 02/21/2014
Revised Desktop Model outputs for site: K2

HYDROLOGY DATA SUMMARY

Natural Flows:

Area (km^2)	MAR (m^3 * 10^6)	Ann.SD (m^3 * 10^6)	Q75	Ann. CV
0.00	545.56	259.83	14.88	0.48

% Zero flows = 0.0
Baseflow Parameters: A = 0.960, B = 0.44
BFI = 0.44 : Hydro Index = 2.6

Present Day Flows:

Area (km^2)	MAR (m^3 * 10^6)	Ann.SD (m^3 * 10^6)	Q75	Ann. CV
0.00	318.64	224.62	6.28	0.70

% Zero flows = 0.0
Baseflow Parameters: A = 0.960, B = 0.440
BFI = 0.39 : Hydro Index = 4.0

Natural Flows:

MONTH	MEAN (m^3 * 10^6)	SD	CV
Oct	18.92	13.85	0.73
Nov	42.99	30.60	0.71
Dec	65.48	40.78	0.62
Jan	82.78	53.12	0.64
Feb	95.49	80.81	0.85

Present Day Flows:

MONTH	MEAN (m^3 * 10^6)	SD	CV
Oct	7.23	7.97	1.10
Nov	15.53	18.53	1.19
Dec	31.60	31.57	1.00
Jan	48.53	45.63	0.94
Feb	66.16	74.77	1.13

```
 Mar   82.63   71.65    0.87            Mar   58.50   66.23    1.13
 Apr   57.52   36.59    0.64            Apr   38.71   34.39    0.89
 May   36.40   18.55    0.51            May   21.46   16.10    0.75
 Jun   23.12    9.48    0.41            Jun   12.17    6.73    0.55
 Jul   16.23    5.73    0.35            Jul    7.95    3.29    0.41
 Aug   12.51    4.55    0.36            Aug    5.84    2.66    0.45
 Sep   11.48    5.51    0.48            Sep    4.96    2.34    0.47

Critical months: WET : Mar, DRY : Sep
Using  20th percentile of FDC of separated baseflows
Max. baseflows (m3/s): WET :     13.851, DRY :      5.347
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HYDRAULICS DATA SUMMARY

```
Geomorph. Zone  4
Flood Zone      4
Max. Channel width (m) 30.46
Max. Channel Depth (m)  2.07

Observed Channel XS used
Observed Rating Curve used
(Gradients and Roughness n values calibrated)

Max. Gradient         0.00900
Min. Gradient         0.00400
Gradient Shape Factor      20
Max. Mannings n         0.100
Min. Mannings n         0.050
n Shape Factor             20
```

FLOW - STRESSOR RESPONSE DATA SUMMARY

```
Table of Stress weightings
Season          Wet   Dry
Stress at 0 FS:  9     9
FS Weight:       0     1
FI Weight:       0     3
FD Weight:       1     5

Table of initial SHIFT factors for the Stress Frequency Curves

Category  High SHIFT  Low SHIFT
    A        0.467      0.173
  A/B        0.700      0.260
    B        0.933      0.347
  B/C        1.167      0.433
    C        1.400      0.520
  C/D        1.633      0.607
    D        1.867      0.693

Perenniality Rules
All Seasons Perennial Forced

Alignment of maximum stress to Present Day stress
Not Aligned

Table of flows (m3/2) v stress index
         Wet Season  Dry Season
Stress      Flow        Flow
   0      13.904       5.493
   1       8.955       4.095
   2       5.790       2.856
   3       4.054       2.320
   4       3.354       1.886
   5       2.795       1.571
   6       2.236       1.257
   7       1.677       0.943
   8       1.118       0.629
   9       0.559       0.314
  10       0.000       0.000
```

HIGH FLOW ESTIMATION SUMMARY DETAILS

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No High flows when natural high flows are <  31% of total flows
Adjusted hydrological variability for high flows is   0.95
Maximum high flows are 250% greater than normal high flows

Table of normal high flow requirements (Mill. m3)
Category    A       A/B       B       B/C       C       C/D       D
Annual   54.054   51.378   48.699   46.017   43.332   40.645   37.955
   Oct    0.000    0.000    0.000    0.000    0.000    0.000    0.000
   Nov    8.049    7.651    7.252    6.852    6.453    6.052    5.652
   Dec   10.994   10.450    9.905    9.359    8.813    8.267    7.720
```

Jan	11.021	10.475	9.929	9.382	8.835	8.287	7.738
Feb	10.461	9.943	9.425	8.906	8.386	7.866	7.345
Mar	7.820	7.433	7.046	6.658	6.269	5.880	5.491
Apr	5.708	5.426	5.143	4.859	4.576	4.292	4.008
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aug	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FINAL RESERVE SUMMARY DETAILS

EWR (low and total Flows) are constrained to be below Present Day Flows

Long term mean flow requirements (Mill. m3 and %MAR)

Category	Low Flows		Total Flows	
	Mill. m3	%MAR	Mill. m3	%MAR
A	109.326	20.0	164.142	30.1
A/B	90.471	16.6	145.014	26.6
B	76.365	14.0	129.574	23.8
B/C	63.543	11.6	114.812	21.0
C	50.872	9.3	99.867	18.3
C/D	38.201	7.0	84.393	15.5
D	26.546	4.9	69.684	12.8

FLOW DURATION and RESERVE ASSURANCE TABLES

Columns are FDC precentage points:

	10	20	30	40	50	60	70	80	90	99
Natural Total flow duration curve (mill. m3)										
Oct	34.790	25.120	20.435	16.000	13.945	12.430	11.135	10.310	8.670	7.103
Nov	84.405	67.890	52.360	37.630	32.575	28.030	23.435	19.480	16.895	9.572
Dec	118.110	101.400	89.225	66.470	55.180	44.460	37.665	31.460	23.055	13.462
Jan	159.805	133.290	96.665	81.730	67.295	57.930	46.825	42.330	30.820	20.029
Feb	203.390	136.210	97.825	83.430	70.195	59.570	51.200	43.820	33.935	23.607
Mar	161.460	107.220	90.545	70.850	59.535	51.300	44.345	39.790	33.630	19.403
Apr	106.995	75.560	65.350	53.980	49.890	42.080	38.130	32.220	25.330	17.149
May	61.620	45.980	41.145	36.150	33.405	30.020	26.265	22.610	17.500	12.318
Jun	35.830	31.330	26.475	24.590	21.065	19.460	17.065	15.020	13.095	9.093
Jul	24.365	21.670	18.205	17.010	15.220	13.850	12.845	11.150	9.975	7.939
Aug	18.525	15.110	13.930	12.360	11.355	10.480	9.960	9.400	8.195	6.658
Sep	17.710	13.550	12.245	10.790	10.075	9.580	8.860	8.300	7.215	5.911
Natural Baseflow flow duration curve (mill. m3)										
Oct	18.345	15.039	13.164	11.128	10.523	9.820	9.307	8.560	7.565	6.268
Nov	22.784	19.834	18.241	16.416	14.047	12.112	11.310	10.904	9.387	7.153
Dec	28.217	25.509	23.415	20.607	18.531	17.206	14.372	12.638	11.204	8.034
Jan	36.013	31.144	27.327	24.570	22.651	20.291	17.609	15.192	13.294	9.773
Feb	50.164	35.703	29.673	26.082	24.995	22.278	20.165	17.631	15.512	11.801
Mar	46.645	36.990	30.652	28.173	26.196	22.618	20.993	18.940	16.754	12.509
Apr	44.260	34.858	31.071	27.157	25.069	22.340	21.343	19.290	16.752	12.534
May	37.631	32.305	29.436	25.640	23.423	21.434	18.513	17.274	15.881	11.298
Jun	31.236	26.780	23.937	21.090	19.646	17.780	16.465	14.540	12.215	9.093
Jul	22.440	19.960	18.145	16.810	14.950	13.840	12.845	11.150	9.855	7.939
Aug	18.115	14.990	13.930	12.360	11.355	10.480	9.910	9.400	8.195	6.658
Sep	15.262	13.260	11.570	10.370	9.890	9.450	8.800	8.230	7.215	5.911
Category Low Flow Assurance curves (mill. m3)										
A Category										
Oct	9.161	8.514	7.915	5.710	4.925	4.530	3.930	3.330	2.805	2.408
Nov	10.789	10.261	10.091	9.251	7.809	6.714	6.060	5.510	4.255	2.607
Dec	13.150	12.989	12.748	11.638	10.141	8.981	7.633	6.944	5.875	3.531
Jan	15.314	15.080	14.245	13.038	11.748	10.211	8.885	7.976	7.393	5.739
Feb	18.990	15.585	14.182	12.339	11.387	9.789	8.792	7.913	7.351	6.778
Mar	17.263	16.542	15.375	14.288	12.781	10.909	10.032	9.171	8.498	6.761
Apr	16.255	16.255	15.360	13.567	12.340	10.750	10.097	9.632	8.514	6.225
May	15.273	15.156	14.748	13.496	12.045	10.516	9.233	8.681	7.735	5.367
Jun	13.334	12.960	12.542	11.397	10.165	8.947	8.145	7.110	5.635	3.751
Jul	11.088	10.703	9.160	8.150	7.225	6.480	6.115	5.250	4.380	3.103
Aug	9.035	7.700	6.780	5.970	5.125	4.700	4.360	3.930	3.330	2.384
Sep	7.725	6.240	5.210	4.660	4.320	4.040	3.850	3.380	2.870	2.244
A/B Category										
Oct	7.456	7.036	6.615	5.710	4.925	4.530	3.930	3.330	2.805	2.408
Nov	8.603	8.275	8.127	7.494	6.437	5.653	5.158	4.901	4.255	2.607
Dec	10.286	10.158	9.930	9.158	8.214	7.540	6.493	5.885	5.348	3.531
Jan	11.594	11.371	10.786	9.999	9.339	8.555	7.553	6.778	6.232	5.739
Feb	14.420	12.040	10.783	9.333	9.078	8.195	7.469	6.741	6.219	5.817
Mar	12.426	12.031	11.333	10.612	10.005	9.251	8.522	7.836	7.203	6.646
Apr	12.433	12.433	11.746	10.164	9.831	9.020	8.583	8.184	7.171	6.225
May	11.579	11.407	11.040	10.240	9.537	8.811	7.848	7.393	6.924	5.367

Jun	10.353	10.084	9.735	8.951	8.218	7.514	6.926	6.315	5.635	3.751
Jul	8.881	8.643	8.359	7.953	7.054	6.434	5.876	5.222	4.380	3.103
Aug	7.368	6.973	6.780	5.970	5.125	4.700	4.360	3.930	3.330	2.384
Sep	6.396	6.127	5.210	4.660	4.320	4.040	3.850	3.380	2.870	2.244

B Category

Oct	6.214	5.872	5.525	5.017	4.494	4.088	3.727	3.330	2.805	2.408
Nov	7.130	6.876	6.779	6.328	5.477	4.772	4.292	4.015	3.613	2.607
Dec	8.462	8.368	8.268	7.744	6.985	6.390	5.433	4.844	4.326	3.531
Jan	9.420	9.271	8.965	8.464	7.937	7.274	6.358	5.610	5.072	4.766
Feb	11.734	9.964	8.977	7.906	7.722	6.983	6.319	5.608	5.086	4.683
Mar	9.859	9.700	9.419	8.982	8.498	7.897	7.224	6.540	5.907	5.422
Apr	10.242	10.242	9.835	8.614	8.362	7.677	7.226	6.761	5.839	5.379
May	9.410	9.299	9.172	8.673	8.104	7.500	6.619	6.147	5.665	5.083
Jun	8.491	8.292	8.103	7.569	6.988	6.373	5.816	5.218	4.630	3.751
Jul	7.362	7.173	6.982	6.717	6.002	5.439	4.902	4.281	3.912	3.103
Aug	6.142	5.821	5.773	5.402	4.818	4.297	3.946	3.653	3.327	2.384
Sep	5.344	5.126	4.821	4.512	4.157	3.788	3.437	3.127	2.868	2.244

B/C Category

Oct	5.265	4.993	4.715	4.236	3.733	3.328	2.962	2.609	2.379	2.177
Nov	6.039	5.861	5.786	5.358	4.567	3.902	3.429	3.130	2.741	2.505
Dec	7.181	7.129	7.057	6.577	5.859	5.275	4.375	3.803	3.305	2.803
Jan	7.999	7.896	7.653	7.211	6.698	6.046	5.167	4.443	3.911	3.700
Feb	9.953	8.503	7.667	6.745	6.489	5.830	5.174	4.477	3.953	3.548
Mar	8.394	8.267	8.042	7.693	7.208	6.606	5.932	5.246	4.612	4.126
Apr	8.735	8.735	8.396	7.357	7.028	6.393	5.886	5.341	4.529	4.069
May	7.987	7.920	7.830	7.398	6.848	6.247	5.394	4.903	4.405	3.924
Jun	7.208	7.058	6.917	6.430	5.869	5.267	4.710	4.123	3.558	3.157
Jul	6.242	6.101	5.955	5.689	5.012	4.460	3.930	3.342	2.973	2.729
Aug	5.205	4.962	4.927	4.564	4.007	3.501	3.141	2.835	2.534	2.384
Sep	4.517	4.358	4.118	3.807	3.451	3.081	2.728	2.416	2.159	1.975

C Category

Oct	4.429	4.181	3.905	3.449	2.967	2.565	2.196	1.847	1.604	1.408
Nov	5.088	4.898	4.804	4.382	3.652	3.028	2.563	2.244	1.870	1.650
Dec	6.047	5.978	5.879	5.407	4.725	4.153	3.315	2.762	2.283	1.864
Jan	6.747	6.640	6.394	5.956	5.449	4.813	3.972	3.275	2.750	2.506
Feb	8.402	7.114	6.407	5.585	5.274	4.671	4.024	3.344	2.821	2.414
Mar	7.092	6.965	6.740	6.392	5.908	5.307	4.634	3.949	3.317	2.832
Apr	7.320	7.320	6.991	6.102	5.714	5.119	4.544	3.918	3.226	2.761
May	6.740	6.661	6.550	6.122	5.582	4.988	4.165	3.657	3.146	2.666
Jun	6.071	5.926	5.764	5.289	4.742	4.155	3.599	3.026	2.486	2.111
Jul	5.253	5.114	4.941	4.656	4.015	3.477	2.956	2.401	2.035	1.798
Aug	4.377	4.141	4.082	3.720	3.190	2.703	2.335	2.015	1.714	1.575
Sep	3.808	3.649	3.409	3.098	2.741	2.371	2.018	1.706	1.448	1.264

C/D Category

Oct	3.593	3.369	3.095	2.663	2.202	1.801	1.430	1.085	0.829	0.640
Nov	4.137	3.936	3.822	3.407	2.737	2.154	1.697	1.358	0.998	0.779
Dec	4.914	4.834	4.701	4.237	3.592	3.032	2.255	1.720	1.262	0.908
Jan	5.498	5.384	5.135	4.702	4.201	3.579	2.778	2.107	1.589	1.313
Feb	6.851	5.725	5.147	4.425	4.078	3.512	2.874	2.211	1.688	1.280
Mar	5.790	5.663	5.439	5.091	4.608	4.008	3.336	2.653	2.022	1.537
Apr	5.905	5.905	5.586	4.847	4.420	3.846	3.201	2.496	1.922	1.452
May	5.492	5.402	5.269	4.847	4.316	3.729	2.936	2.410	1.886	1.408
Jun	4.934	4.794	4.611	4.147	3.615	3.043	2.489	1.929	1.414	1.064
Jul	4.264	4.127	3.929	3.623	3.019	2.493	1.982	1.461	1.097	0.866
Aug	3.550	3.336	3.237	2.876	2.374	1.904	1.528	1.196	0.895	0.735
Sep	3.099	2.940	2.700	2.388	2.031	1.661	1.308	0.995	0.737	0.553

D Category

Oct	2.782	2.591	2.341	1.959	1.550	1.184	0.841	0.526	0.281	0.111
Nov	3.211	3.025	2.896	2.515	1.936	1.424	1.005	0.668	0.343	0.135
Dec	3.813	3.724	3.570	3.139	2.556	2.028	1.351	0.858	0.442	0.166
Jan	4.272	4.152	3.908	3.495	3.008	2.411	1.684	1.064	0.566	0.237
Feb	5.326	4.384	3.919	3.295	2.925	2.375	1.757	1.129	0.611	0.244
Mar	4.502	4.375	4.151	3.802	3.318	2.717	2.044	1.359	0.727	0.241
Apr	4.528	4.528	4.226	3.613	3.171	2.600	1.946	1.253	0.696	0.276
May	4.268	4.167	4.014	3.608	3.095	2.517	1.783	1.228	0.683	0.268
Jun	3.822	3.694	3.503	3.073	2.576	2.036	1.501	0.971	0.503	0.193
Jul	3.302	3.176	2.976	2.675	2.138	1.654	1.181	0.721	0.378	0.154
Aug	2.748	2.565	2.448	2.117	1.673	1.253	0.900	0.583	0.303	0.129
Sep	2.407	2.262	2.041	1.756	1.429	1.090	0.766	0.480	0.244	0.075

Category Total Flow Assurance curves (mill. m3)

A Category

Oct	9.161	8.514	7.915	5.710	4.925	4.530	3.930	3.330	2.805	2.408
Nov	29.597	19.800	15.075	11.870	10.020	8.460	7.195	5.510	4.255	2.607
Dec	38.837	35.068	31.193	22.200	18.435	14.430	12.005	9.810	5.875	3.531

Jan	41.064	37.213	32.735	27.846	22.860	20.543	15.305	12.797	7.545	5.739
Feb	43.432	36.594	31.733	26.395	21.934	19.596	16.619	12.490	7.496	6.778
Mar	35.535	32.247	28.495	24.796	20.666	18.241	15.883	12.592	8.606	6.761
Apr	29.592	27.719	24.936	21.236	18.096	16.101	14.367	12.130	8.593	6.225
May	15.273	15.156	14.748	13.496	12.045	10.516	9.233	8.681	7.735	5.367
Jun	13.334	12.960	12.542	11.397	10.165	8.947	8.145	7.110	5.635	3.751
Jul	11.088	10.703	9.160	8.150	7.225	6.480	6.115	5.250	4.380	3.103
Aug	9.035	7.700	6.780	5.970	5.125	4.700	4.360	3.930	3.330	2.384
Sep	7.725	6.240	5.210	4.660	4.320	4.040	3.850	3.380	2.870	2.244

A/B Category

Oct	7.456	7.036	6.615	5.710	4.925	4.530	3.930	3.330	2.805	2.408
Nov	26.479	19.800	15.075	11.870	10.020	8.460	7.195	5.510	4.255	2.607
Dec	34.702	31.143	27.461	22.200	18.435	14.430	12.005	9.810	5.492	3.531
Jan	36.070	32.408	28.360	24.074	19.901	18.375	15.305	11.361	6.377	5.739
Feb	37.653	32.009	27.465	22.694	19.103	17.516	14.908	11.091	6.356	5.817
Mar	29.794	26.959	23.804	20.600	17.500	16.219	14.083	11.088	7.305	6.646
Apr	25.109	23.329	20.848	17.454	15.301	14.107	12.642	10.558	7.246	6.225
May	11.579	11.407	11.040	10.240	9.537	8.811	7.848	7.393	6.924	5.367
Jun	10.353	10.084	9.735	8.951	8.218	7.514	6.926	6.315	5.635	3.751
Jul	8.881	8.643	8.359	7.953	7.054	6.434	5.876	5.222	4.380	3.103
Aug	7.368	6.973	6.780	5.970	5.125	4.700	4.360	3.930	3.330	2.384
Sep	6.396	6.127	5.210	4.660	4.320	4.040	3.850	3.380	2.870	2.244

B Category

Oct	6.214	5.872	5.525	5.017	4.494	4.088	3.727	3.330	2.805	2.408
Nov	24.074	19.800	15.075	11.870	10.020	8.460	7.195	5.510	3.713	2.607
Dec	31.605	28.259	24.885	21.052	16.972	14.430	12.005	9.177	4.463	3.531
Jan	32.619	29.212	25.623	21.805	17.948	16.582	13.786	9.954	5.208	4.766
Feb	33.755	28.892	24.789	20.570	17.225	15.818	13.370	9.731	5.216	4.683
Mar	26.321	23.849	21.239	18.449	15.602	14.503	12.495	9.622	6.004	5.422
Apr	22.257	20.569	18.463	15.524	13.548	12.498	11.074	9.011	5.909	5.379
May	9.410	9.299	9.172	8.673	8.104	7.500	6.619	6.147	5.665	5.083
Jun	8.491	8.292	8.103	7.569	6.988	6.373	5.816	5.218	4.630	3.751
Jul	7.362	7.173	6.982	6.717	6.002	5.439	4.902	4.281	3.912	3.103
Aug	6.142	5.821	5.773	5.402	4.818	4.297	3.946	3.653	3.327	2.384
Sep	5.344	5.126	4.821	4.512	4.157	3.788	3.437	3.127	2.868	2.244

B/C Category

Oct	5.265	4.993	4.715	4.236	3.733	3.328	2.962	2.609	2.379	2.177
Nov	22.050	19.623	15.075	11.870	10.020	8.460	7.195	5.510	2.836	2.505
Dec	29.049	25.925	22.759	19.153	15.296	14.049	11.378	7.898	3.434	2.803
Jan	29.921	26.738	23.394	19.817	16.158	14.842	12.187	8.548	4.040	3.700
Feb	30.762	26.388	22.608	18.712	15.468	14.179	11.837	8.373	4.076	3.548
Mar	23.950	21.637	19.211	16.638	13.921	12.848	10.913	8.159	4.704	4.126
Apr	20.089	18.494	16.549	13.887	11.928	10.949	9.522	7.467	4.596	4.069
May	7.987	7.920	7.830	7.398	6.848	6.247	5.394	4.903	4.405	3.924
Jun	7.208	7.058	6.917	6.430	5.869	5.267	4.710	4.123	3.558	3.157
Jul	6.242	6.101	5.955	5.689	5.012	4.460	3.930	3.342	2.973	2.729
Aug	5.205	4.962	4.927	4.564	4.007	3.501	3.141	2.835	2.534	2.384
Sep	4.517	4.358	4.118	3.807	3.451	3.081	2.728	2.416	2.159	1.975

C Category

Oct	4.429	4.181	3.905	3.449	2.967	2.565	2.196	1.847	1.604	1.408
Nov	20.165	17.857	15.075	11.870	10.020	8.460	7.169	5.067	1.958	1.650
Dec	26.639	23.677	20.665	17.249	13.612	12.416	9.909	6.617	2.405	1.864
Jan	27.390	24.382	21.216	17.827	14.357	13.095	10.582	7.141	2.872	2.506
Feb	27.997	23.956	20.476	16.854	13.730	12.533	10.298	7.013	2.936	2.414
Mar	21.740	19.555	17.258	14.815	12.229	11.185	9.324	6.692	3.404	2.832
Apr	18.012	16.510	14.668	12.250	10.328	9.409	7.967	5.920	3.289	2.761
May	6.740	6.661	6.550	6.122	5.582	4.988	4.165	3.657	3.146	2.666
Jun	6.071	5.926	5.764	5.289	4.742	4.155	3.599	3.026	2.486	2.111
Jul	5.253	5.114	4.941	4.656	4.015	3.477	2.956	2.401	2.035	1.798
Aug	4.377	4.141	4.082	3.720	3.190	2.703	2.335	2.015	1.714	1.575
Sep	3.808	3.649	3.409	3.098	2.741	2.371	2.018	1.706	1.448	1.264

C/D Category

Oct	3.593	3.369	3.095	2.663	2.202	1.801	1.430	1.085	0.829	0.640
Nov	18.278	16.091	13.976	11.539	8.840	7.828	6.226	4.006	1.081	0.779
Dec	24.230	21.436	18.570	15.345	11.927	10.782	8.440	5.337	1.376	0.908
Jan	24.860	22.026	19.037	15.837	12.556	11.348	8.978	5.733	1.704	1.313
Feb	25.230	21.522	18.344	14.995	12.009	10.886	8.759	5.653	1.796	1.280
Mar	19.529	17.472	15.304	12.992	10.537	9.521	7.736	5.226	2.103	1.537
Apr	15.933	14.525	12.787	10.614	8.747	7.869	6.412	4.374	1.981	1.452
May	5.492	5.402	5.269	4.847	4.316	3.729	2.936	2.410	1.886	1.408
Jun	4.934	4.794	4.611	4.147	3.615	3.043	2.489	1.929	1.414	1.064
Jul	4.264	4.127	3.929	3.623	3.019	2.493	1.982	1.461	1.097	0.866
Aug	3.550	3.336	3.237	2.876	2.374	1.904	1.528	1.196	0.895	0.735
Sep	3.099	2.940	2.700	2.388	2.031	1.661	1.308	0.995	0.737	0.553

D Category

Oct	2.782	2.591	2.341	1.959	1.550	1.184	0.841	0.526	0.281	0.111
Nov	16.417	14.376	12.378	10.109	7.635	6.723	5.234	3.141	0.421	0.135
Dec	21.850	19.227	16.521	13.512	10.339	9.265	7.127	4.236	0.548	0.166
Jan	22.353	19.693	16.891	13.893	10.810	9.666	7.474	4.450	0.673	0.237
Feb	22.488	19.136	16.242	13.165	10.331	9.262	7.252	4.343	0.713	0.244
Mar	17.332	15.403	13.363	11.180	8.855	7.865	6.152	3.762	0.803	0.241
Apr	13.893	12.577	10.951	8.998	7.213	6.358	4.945	3.007	0.751	0.276
May	4.268	4.167	4.014	3.608	3.095	2.517	1.783	1.228	0.683	0.268
Jun	3.822	3.694	3.503	3.073	2.576	2.036	1.501	0.971	0.503	0.193
Jul	3.302	3.176	2.976	2.675	2.138	1.654	1.181	0.721	0.378	0.154
Aug	2.748	2.565	2.448	2.117	1.673	1.253	0.900	0.583	0.303	0.129
Sep	2.407	2.262	2.041	1.756	1.429	1.090	0.766	0.480	0.244	0.075

10.3 K3 TONGA

DATE: 03/11/2014
Revised Desktop Model outputs for site: K3

HYDROLOGY DATA SUMMARY

```
Natural Flows:                          Present Day Flows:
   Area     MAR   Ann.SD    Q75   Ann.     Area     MAR   Ann.SD    Q75   Ann.
  (km^2)       (m^3 * 10^6)        CV     (km^2)       (m^3 * 10^6)        CV
    0.00 1021.67  536.31   29.71  0.52      0.00  489.84  458.29   10.13  0.94

% Zero flows =   0.0                    % Zero flows =   2.5
Baseflow Parameters: A = 0.960, B = 0.44Baseflow Parameters: A = 0.960, B = 0.440
BFI = 0.45 : Hydro Index =   2.6        BFI = 0.35 : Hydro Index =   5.2

MONTH   MEAN      SD     CV             MONTH   MEAN      SD     CV
       (m^3 * 10^6)                            (m^3 * 10^6)
 Oct   31.81   18.54    0.58             Oct   11.31    5.40    0.48
 Nov   63.14   37.87    0.60             Nov   15.44   18.26    1.18
 Dec  101.01   60.33    0.60             Dec   28.07   38.87    1.38
 Jan  143.49   99.92    0.70             Jan   59.91   85.79    1.43
 Feb  182.72  163.72    0.90             Feb  106.55  155.67    1.46
 Mar  172.27  152.80    0.89             Mar  110.12  150.94    1.37
 Apr  121.42   87.85    0.72             Apr   72.50   85.36    1.18
 May   74.82   39.69    0.53             May   35.94   35.37    0.98
 Jun   48.06   19.23    0.40             Jun   17.73   12.51    0.71
 Jul   34.04   11.24    0.33             Jul   11.53    3.44    0.30
 Aug   26.09    8.36    0.32             Aug   10.49    2.36    0.23
 Sep   22.80    9.03    0.40             Sep   10.25    2.24    0.22

Critical months: WET : Mar, DRY : Sep
Using  20th percentile of FDC of separated baseflows
Max. baseflows (m3/s): WET :     26.897, DRY :     10.702
```

HYDRAULICS DATA SUMMARY

```
Geomorph. Zone  5
Flood Zone      4
Max. Channel width (m) 167.57
Max. Channel Depth (m)  5.21

Observed Channel XS used
Observed Rating Curve used
(Gradients and Roughness n values calibrated)

Max. Gradient         0.00300
Min. Gradient         0.00100
Gradient Shape Factor      20
Max. Mannings n         0.095
Min. Mannings n         0.045
n Shape Factor             15
```

FLOW - STRESSOR RESPONSE DATA SUMMARY

```
Table of Stress weightings
Season          Wet   Dry
Stress at 0 FS:  9     9
FS Weight:       0     1
FI Weight:       5     3
FD Weight:       8     5

Table of initial SHIFT factors for the Stress Frequency Curves

Category  High SHIFT  Low SHIFT
    A       0.850      0.081
  A/B       0.127      0.122
    B       1.700      0.163
```

B/C	2.125	0.203
C	2.550	0.244
C/D	2.975	0.284
D	3.400	0.325

Perenniality Rules
Non-Perennial Allowed

Alignment of maximum stress to Present Day stress
Not Aligned

Table of flows (m3/2) v stress index

Stress	Wet Season Flow	Dry Season Flow
0	27.157	10.745
1	12.455	6.333
2	6.783	4.456
3	5.935	3.929
4	5.087	3.368
5	4.239	2.806
6	3.392	2.245
7	2.544	1.684
8	1.696	1.123
9	0.848	0.561
10	0.000	0.000

HIGH FLOW ESTIMATION SUMMARY DETAILS
No High flows when natural high flows are < 19% of total flows
Adjusted hydrological variability for high flows is 1.70
Maximum high flows are 250% greater than normal high flows

Table of normal high flow requirements (Mill. m3)

Category	A	A/B	B	B/C	C	C/D	D
Annual	112.407	106.221	100.098	94.037	88.037	82.098	76.219
Oct	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nov	10.664	10.077	9.496	8.921	8.352	7.788	7.231
Dec	18.406	17.393	16.390	15.398	14.415	13.443	12.480
Jan	21.244	20.075	18.918	17.772	16.638	15.516	14.405
Feb	21.078	19.918	18.770	17.634	16.508	15.395	14.292
Mar	19.305	18.242	17.191	16.150	15.119	14.099	13.090
Apr	13.986	13.217	12.455	11.701	10.954	10.215	9.484
May	7.724	7.299	6.878	6.462	6.050	5.641	5.237
Jun	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aug	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FINAL RESERVE SUMMARY DETAILS
EWR (low and total Flows) are constrained to be below Present Day Flows

Long term mean flow requirements (Mill. m3 and %MAR)

Category	Low Flows		Total Flows	
	Mill. m3	%MAR	Mill. m3	%MAR
A	189.057	18.5	269.254	26.4
A/B	182.606	17.9	257.557	25.2
B	150.684	14.7	231.281	22.6
B/C	137.467	13.5	217.379	21.3
C	125.939	12.3	204.870	20.1
C/D	113.855	11.1	190.812	18.7
D	101.098	9.9	175.554	17.2

FLOW DURATION and RESERVE ASSURANCE TABLES
Columns are FDC precentage points:

Natural Total flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	58.395	42.460	35.570	28.290	25.775	23.240	20.915	18.710	16.370	14.020
Nov	110.415	90.000	77.885	59.490	49.300	46.890	39.455	31.310	27.460	18.054
Dec	201.655	151.620	123.605	109.930	85.225	68.300	60.940	54.770	36.505	21.980
Jan	259.370	215.280	164.515	143.080	113.845	92.610	78.125	67.310	53.875	36.077
Feb	438.880	253.130	181.920	134.910	122.995	106.810	93.390	80.620	60.695	41.745
Mar	386.945	232.820	162.240	138.290	119.685	102.720	83.020	74.340	63.150	35.103
Apr	226.965	164.040	133.875	112.850	96.000	89.710	73.285	61.900	48.745	32.317
May	115.170	92.460	81.230	74.910	71.395	64.590	54.175	44.540	34.195	28.080
Jun	68.405	61.460	55.135	48.620	46.640	42.870	40.150	31.420	25.445	20.285
Jul	49.600	42.670	38.355	35.200	32.280	30.940	28.770	25.630	20.095	15.880
Aug	37.870	31.680	28.770	25.790	25.165	23.190	21.695	19.830	16.775	13.637
Sep	33.555	26.760	23.850	22.160	20.665	19.270	18.080	17.350	14.740	11.931

Natural Baseflow flow duration curve (mill. m3)

Oct	35.932	29.183	24.912	23.560	20.917	19.919	18.443	17.090	15.230	12.368
Nov	41.401	36.586	31.724	28.450	26.542	24.250	21.717	20.217	17.083	14.005
Dec	52.240	44.387	39.722	35.503	32.688	30.574	27.013	23.016	20.006	15.034
Jan	68.613	55.339	48.518	42.921	39.512	36.576	33.375	28.609	25.488	18.718
Feb	102.567	68.532	53.416	47.913	42.827	40.842	38.619	34.682	28.185	20.072
Mar	105.107	70.854	58.079	48.846	45.871	42.997	40.866	37.754	31.761	23.459
Apr	91.158	67.502	57.900	50.552	45.234	43.160	40.422	37.034	31.491	23.166
May	77.897	64.599	53.683	47.679	43.343	41.290	37.716	34.330	29.371	22.075
Jun	61.964	50.626	44.855	42.890	40.427	38.680	34.803	28.670	25.206	18.506
Jul	46.220	39.320	36.958	34.610	31.980	30.910	28.452	24.196	20.060	15.880
Aug	36.436	31.490	28.770	25.660	25.085	23.190	21.695	19.610	16.775	13.637
Sep	31.216	26.760	23.794	22.160	20.270	19.270	17.955	17.350	14.357	11.931

Category Low Flow Assurance curves (mill. m3)

A Category

Oct	14.620	13.980	10.985	10.700	10.620	10.570	10.480	9.990	9.060	0.000
Nov	21.892	16.680	14.070	12.500	12.130	11.730	10.335	9.110	2.505	0.000
Dec	26.561	25.201	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	32.128	29.326	27.215	24.210	20.509	17.057	12.340	9.540	0.935	0.000
Feb	33.788	29.573	26.663	23.709	19.462	16.111	15.172	12.020	4.740	0.000
Mar	38.015	33.855	30.890	27.076	22.217	17.942	17.076	15.260	7.570	0.000
Apr	35.702	32.230	30.690	29.188	22.961	20.803	17.838	15.110	10.835	4.638
May	34.599	32.044	29.420	26.309	21.793	17.868	15.370	11.640	11.115	5.011
Jun	28.606	21.680	16.910	15.000	14.075	12.220	11.010	10.620	10.400	9.745
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	9.870	9.760	9.114
Aug	11.910	10.280	10.160	10.100	10.070	10.040	10.010	9.930	9.810	7.693
Sep	13.700	10.330	10.230	10.180	10.150	10.100	10.005	9.860	9.312	0.009

A/B Category

Oct	14.620	13.980	10.985	10.700	10.620	10.570	10.480	9.990	9.060	0.000
Nov	18.722	16.680	14.070	12.500	12.130	11.730	10.335	9.110	2.505	0.000
Dec	22.607	22.603	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	26.642	25.732	25.096	23.921	20.835	17.920	12.340	9.540	0.935	0.000
Feb	26.675	25.434	24.344	23.300	21.472	19.802	17.837	12.020	4.740	0.000
Mar	29.601	28.989	27.974	26.519	24.665	22.543	20.334	15.260	7.570	0.000
Apr	28.960	28.960	28.960	28.960	25.212	24.354	20.697	15.110	10.835	4.638
May	28.287	27.697	26.886	25.859	24.047	22.002	15.370	11.640	11.115	5.011
Jun	24.620	21.680	16.910	15.000	14.075	12.220	11.010	10.620	10.400	9.745
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	9.870	9.760	9.114
Aug	11.910	10.280	10.160	10.100	10.070	10.040	10.010	9.930	9.810	7.693
Sep	13.700	10.330	10.230	10.180	10.150	10.100	10.005	9.860	9.610	0.009

B Category

Oct	14.301	13.185	10.985	10.700	10.367	9.619	8.546	7.502	7.305	0.000
Nov	15.618	14.648	13.598	12.500	12.016	10.838	9.604	8.514	2.505	0.000
Dec	18.552	17.347	16.233	15.237	14.161	12.924	11.417	9.420	2.870	0.000
Jan	21.501	19.234	17.401	16.410	15.508	14.221	12.340	9.540	0.935	0.000
Feb	20.374	18.225	16.159	15.374	14.428	13.464	12.391	11.160	4.740	0.000
Mar	22.351	20.234	17.952	17.200	16.242	15.145	14.004	12.913	7.570	0.000
Apr	22.059	20.695	20.678	20.661	17.429	17.351	14.272	13.288	10.835	4.638
May	22.455	20.055	17.895	17.039	16.059	14.933	13.628	11.640	11.115	5.011
Jun	20.034	18.129	16.513	15.000	14.075	12.220	11.010	10.620	10.169	9.723
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	9.870	8.956	8.509
Aug	11.910	10.280	10.160	10.100	10.070	10.040	9.823	8.594	7.941	6.313
Sep	12.795	10.330	10.230	10.180	10.044	9.198	8.318	7.477	6.736	0.009

B/C Category

Oct	12.664	12.131	10.985	10.700	9.489	8.611	7.449	6.347	5.931	0.000
Nov	13.750	13.403	12.812	11.872	11.010	9.723	8.385	7.196	2.505	0.000
Dec	16.194	15.738	15.285	14.215	13.000	11.635	10.014	8.414	2.870	0.000
Jan	18.409	17.199	16.374	15.318	14.273	12.854	11.339	9.540	0.935	0.000
Feb	16.549	15.979	15.190	14.357	13.300	12.211	11.008	9.662	4.740	0.000
Mar	17.858	17.503	16.914	16.069	14.993	13.761	12.478	11.254	7.570	0.000
Apr	19.284	19.284	19.284	19.284	16.028	15.650	12.512	11.081	10.835	4.638
May	18.954	17.676	16.825	15.912	14.808	13.547	12.096	10.803	10.019	5.011
Jun	17.278	16.289	15.542	14.898	13.951	12.220	11.010	9.346	8.482	8.043
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	8.535	7.359	6.840
Aug	11.910	10.280	10.160	10.100	10.070	9.748	8.574	7.256	6.475	5.010
Sep	11.332	10.330	10.230	10.021	9.187	8.232	7.237	6.288	5.452	0.009

C Category

Oct	12.012	11.461	10.714	9.882	8.597	7.594	6.345	5.187	4.553	0.000
Nov	13.043	12.660	12.004	10.965	9.988	8.598	7.158	5.872	2.505	0.000
Dec	15.357	14.861	14.322	13.150	11.823	10.334	8.601	6.921	2.870	0.000
Jan	17.450	16.234	15.344	14.191	13.021	11.474	9.823	7.950	0.935	0.000
Feb	15.665	15.074	14.235	13.319	12.156	10.947	9.615	8.156	4.740	0.000
Mar	16.901	16.507	15.855	14.919	13.727	12.363	10.942	9.586	7.570	0.000
Apr	17.846	17.846	17.846	17.846	14.622	13.932	10.824	9.302	8.679	4.638
May	17.960	16.678	15.768	14.763	13.541	12.146	10.553	9.128	8.179	5.011
Jun	16.381	15.377	14.565	13.804	12.735	11.391	9.696	7.781	6.791	6.287

Jul	14.589	12.320	11.160	10.670	10.250	10.160	8.869	7.029	5.758	5.167
Aug	11.910	10.280	10.160	10.100	9.888	8.614	7.317	5.913	5.005	3.705
Sep	10.753	10.330	9.976	9.247	8.319	7.257	6.151	5.094	4.164	0.009

C/D Category

Oct	11.371	10.783	9.975	9.068	7.716	6.587	5.248	4.033	3.178	0.000
Nov	12.348	11.911	11.180	10.070	8.978	7.483	5.939	4.553	2.505	0.000
Dec	14.537	13.982	13.350	12.099	10.660	9.045	7.198	5.435	2.870	0.000
Jan	16.511	15.275	14.315	13.080	11.785	10.107	8.317	6.349	0.935	0.000
Feb	14.802	14.183	13.291	12.296	11.027	9.695	8.232	6.658	4.679	0.000
Mar	15.966	15.533	14.816	13.788	12.478	10.978	9.417	7.926	6.613	0.000
Apr	16.456	16.447	16.438	16.429	13.234	12.231	9.243	7.625	6.477	4.520
May	16.988	15.692	14.722	13.631	12.289	10.760	9.021	7.462	6.346	4.665
Jun	15.502	14.469	13.584	12.726	11.533	10.056	8.229	6.224	5.105	4.535
Jul	13.812	12.320	11.160	10.670	10.250	9.126	7.439	5.530	4.161	3.497
Aug	11.699	10.280	10.160	9.825	8.882	7.490	6.068	4.576	3.538	2.403
Sep	10.187	9.849	9.289	8.485	7.462	6.290	5.070	3.906	2.880	0.009

D Category

Oct	10.679	10.071	9.221	8.240	6.824	5.570	4.144	2.873	1.800	0.000
Nov	11.600	11.126	10.341	9.161	7.956	6.358	4.712	3.229	2.017	0.000
Dec	13.657	13.064	12.359	11.032	9.482	7.744	5.785	3.941	2.636	0.000
Jan	15.514	14.279	13.265	11.952	10.534	8.727	6.801	4.740	0.935	0.000
Feb	13.911	13.266	12.328	11.258	9.884	8.431	6.839	5.153	3.787	0.000
Mar	15.009	14.538	13.758	12.638	11.212	9.580	7.881	6.258	4.829	0.000
Apr	15.277	14.990	14.989	14.989	11.828	10.514	7.670	5.939	4.269	2.723
May	15.963	14.676	13.655	12.481	11.022	9.360	7.479	5.787	4.507	2.953
Jun	14.565	13.523	12.583	11.630	10.316	8.709	6.753	4.660	3.413	2.779
Jul	12.975	12.320	11.160	10.670	9.362	7.817	5.999	4.023	2.560	1.824
Aug	10.968	10.280	10.106	8.933	7.864	6.356	4.810	3.232	2.068	1.097
Sep	9.570	9.201	8.589	7.712	6.594	5.315	3.984	2.712	1.592	0.009

Category Total Flow Assurance curves (mill. m3)

A Category

Oct	14.620	13.980	10.985	10.700	10.620	10.570	10.480	9.990	9.060	0.000
Nov	22.430	16.680	14.070	12.500	12.130	11.730	10.335	9.110	2.505	0.000
Dec	68.840	28.230	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	80.926	69.872	51.795	26.430	20.835	17.920	12.340	9.540	0.935	0.000
Feb	82.206	69.802	59.354	49.710	38.640	23.900	17.870	12.020	4.740	0.000
Mar	82.358	70.699	60.831	50.889	41.618	34.110	23.680	15.260	7.570	0.000
Apr	67.829	58.924	52.382	46.441	37.018	33.915	20.865	15.110	10.835	4.638
May	52.342	46.786	39.040	31.160	26.390	22.070	15.370	11.640	11.115	5.011
Jun	28.606	21.680	16.910	15.000	14.075	12.220	11.010	10.620	10.400	9.745
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	9.870	9.760	9.114
Aug	11.910	10.280	10.160	10.100	10.070	10.040	10.010	9.930	9.810	7.693
Sep	13.700	10.330	10.230	10.180	10.150	10.100	10.005	9.860	9.312	0.009

A/B Category

Oct	14.620	13.980	10.985	10.700	10.620	10.570	10.480	9.990	9.060	0.000
Nov	22.430	16.680	14.070	12.500	12.130	11.730	10.335	9.110	2.505	0.000
Dec	62.560	28.230	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	72.756	64.047	51.795	26.430	20.835	17.920	12.340	9.540	0.935	0.000
Feb	72.428	63.450	55.236	47.871	38.640	23.900	17.870	12.020	4.740	0.000
Mar	71.504	63.805	56.266	49.022	42.999	34.110	23.680	15.260	7.570	0.000
Apr	59.319	54.184	49.458	45.263	38.496	36.190	20.865	15.110	10.835	4.638
May	45.053	41.627	38.207	31.160	26.390	22.070	15.370	11.640	11.115	5.011
Jun	24.620	21.680	16.910	15.000	14.075	12.220	11.010	10.620	10.400	9.745
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	9.870	9.760	9.114
Aug	11.910	10.280	10.160	10.100	10.070	10.040	10.010	9.930	9.810	7.693
Sep	13.700	10.330	10.230	10.180	10.150	10.100	10.005	9.860	9.610	0.009

B Category

Oct	14.301	13.185	10.985	10.700	10.367	9.619	8.546	7.502	7.305	0.000
Nov	22.430	16.680	14.070	12.500	12.130	11.730	10.335	9.110	2.505	0.000
Dec	56.202	28.230	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	64.956	55.340	46.742	26.430	20.835	17.920	12.340	9.540	0.935	0.000
Feb	63.490	54.049	45.270	38.528	33.293	23.900	17.870	12.020	4.740	0.000
Mar	61.839	53.044	44.614	38.406	33.519	31.262	23.680	15.260	7.570	0.000
Apr	50.669	44.466	39.995	36.025	29.946	29.027	20.865	15.110	10.835	4.638
May	38.254	33.183	28.563	25.524	22.972	21.382	15.370	11.640	11.115	5.011
Jun	20.034	18.129	16.513	15.000	14.075	12.220	11.010	10.620	10.169	9.723
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	9.870	8.956	8.509
Aug	11.910	10.280	10.160	10.100	10.070	10.040	9.823	8.594	7.941	6.313
Sep	12.795	10.330	10.230	10.180	10.044	9.198	8.318	7.477	6.736	0.009

B/C Category

Oct	12.664	12.131	10.985	10.700	9.489	8.611	7.449	6.347	5.931	0.000
Nov	22.430	16.680	14.070	12.500	12.130	11.730	10.335	9.110	2.505	0.000
Dec	51.564	28.230	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	59.233	51.119	43.938	26.430	20.835	17.920	12.340	9.540	0.935	0.000

Feb	57.054	49.634	42.538	36.109	31.022	23.900	17.870	12.020	4.740	0.000
Mar	54.955	48.326	41.961	35.991	31.224	28.901	23.680	15.260	7.570	0.000
Apr	46.160	41.615	37.430	33.717	27.787	26.619	20.865	15.110	10.835	4.638
May	33.797	30.009	26.847	23.884	21.302	19.605	15.370	11.640	10.108	5.011
Jun	17.278	16.289	15.542	14.898	13.951	12.220	11.010	9.346	8.482	8.043
Jul	14.705	12.320	11.160	10.670	10.250	10.160	10.000	8.535	7.359	6.840
Aug	11.910	10.280	10.160	10.100	10.070	9.748	8.574	7.256	6.475	5.010
Sep	11.332	10.330	10.230	10.021	9.187	8.232	7.237	6.288	5.452	0.009

C Category

Oct	12.012	11.461	10.714	9.882	8.597	7.594	6.345	5.187	4.553	0.000
Nov	22.430	16.680	14.070	12.500	12.130	11.730	10.335	9.110	2.505	0.000
Dec	48.470	28.230	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	55.669	47.990	41.149	26.430	20.835	17.920	12.340	9.540	0.935	0.000
Feb	53.586	46.582	39.838	33.683	28.748	23.900	17.870	12.020	4.740	0.000
Mar	51.631	45.364	39.304	33.570	28.922	26.537	22.254	15.260	7.570	0.000
Apr	43.008	38.753	34.835	31.359	25.631	24.202	19.019	14.094	8.830	4.638
May	31.856	28.224	25.150	22.225	19.621	17.818	14.920	11.640	8.263	5.011
Jun	16.381	15.377	14.565	13.804	12.735	11.391	9.696	7.781	6.791	6.287
Jul	14.589	12.320	11.160	10.670	10.250	10.160	8.869	7.029	5.758	5.167
Aug	11.910	10.280	10.160	10.100	9.888	8.614	7.317	5.913	5.005	3.705
Sep	10.753	10.330	9.976	9.247	8.319	7.257	6.151	5.094	4.164	0.009

C/D Category

Oct	11.371	10.783	9.975	9.068	7.716	6.587	5.248	4.033	3.178	0.000
Nov	22.430	16.680	14.070	12.500	12.130	11.730	10.335	7.961	2.505	0.000
Dec	45.416	28.230	19.535	17.940	15.680	13.400	12.065	9.420	2.870	0.000
Jan	52.152	44.888	38.379	26.430	20.835	17.920	12.340	9.540	0.935	0.000
Feb	50.164	43.565	37.167	31.287	26.499	23.900	17.870	12.020	4.740	0.000
Mar	48.353	42.443	36.684	31.180	26.648	24.196	19.965	14.094	6.807	0.000
Apr	39.921	35.943	32.281	29.030	23.500	21.808	16.885	12.094	6.618	4.520
May	29.947	26.460	23.471	20.590	17.959	16.049	13.242	9.930	6.424	4.665
Jun	15.502	14.469	13.584	12.726	11.533	10.056	8.229	6.224	5.105	4.535
Jul	13.812	12.320	11.160	10.670	10.250	9.126	7.439	5.530	4.161	3.497
Aug	11.699	10.280	10.160	9.825	8.882	7.490	6.068	4.576	3.538	2.403
Sep	10.187	9.849	9.289	8.485	7.462	6.290	5.070	3.906	2.880	0.009

D Category

Oct	10.679	10.071	9.221	8.240	6.824	5.570	4.144	2.873	1.800	0.000
Nov	22.430	16.680	14.070	12.500	12.130	11.730	10.121	6.393	2.116	0.000
Dec	42.325	28.230	19.535	17.940	15.680	13.400	12.065	9.401	2.718	0.000
Jan	48.602	41.772	35.606	26.430	20.835	17.920	12.340	9.540	0.935	0.000
Feb	46.741	40.544	34.495	28.889	24.248	21.830	17.532	11.406	3.984	0.000
Mar	45.077	39.521	34.059	28.785	24.368	21.852	17.674	11.985	5.010	0.000
Apr	37.062	33.090	29.698	26.688	21.359	19.405	14.765	10.089	4.399	2.723
May	27.994	24.672	21.778	18.941	16.286	14.270	11.397	8.079	4.579	2.953
Jun	14.565	13.523	12.583	11.630	10.316	8.709	6.753	4.660	3.413	2.779
Jul	12.975	12.320	11.160	10.670	9.362	7.817	5.999	4.023	2.560	1.824
Aug	10.968	10.280	10.106	8.933	7.864	6.356	4.810	3.232	2.068	1.097
Sep	9.570	9.201	8.589	7.712	6.594	5.315	3.984	2.712	1.592	0.009

10.4 EWR G1 VAALKOP

DATE: 02/20/2014
Revised Desktop Model outputs for site: G1

HYDROLOGY DATA SUMMARY

Natural Flows:

Area (km^2)	MAR (m^3 * 10^6)	Ann.SD (m^3 * 10^6)	Q75 (m^3 * 10^6)	Ann. CV
0.00	29.52	12.20	0.61	0.41

% Zero flows = 0.0
Baseflow Parameters: A = 0.960, B = 0.44
BFI = 0.37 : Hydro Index = 3.0

Present Day Flows:

Area (km^2)	MAR (m^3 * 10^6)	Ann.SD (m^3 * 10^6)	Q75 (m^3 * 10^6)	Ann. CV
0.00	21.18	10.22	0.41	0.48

% Zero flows = 0.0
Baseflow Parameters: A = 0.960, B = 0.440
BFI = 0.35 : Hydro Index = 3.8

MONTH	MEAN (m^3 * 10^6)	SD	CV	MONTH	MEAN (m^3 * 10^6)	SD	CV
Oct	0.85	0.67	0.79	Oct	0.54	0.44	0.82
Nov	2.23	1.45	0.65	Nov	1.36	0.99	0.72
Dec	3.74	2.18	0.58	Dec	2.35	1.59	0.68
Jan	4.78	2.59	0.54	Jan	3.34	2.19	0.66
Feb	5.41	3.72	0.69	Feb	4.02	3.14	0.78
Mar	4.74	3.37	0.71	Mar	3.63	2.83	0.78
Apr	3.26	2.04	0.62	Apr	2.59	1.78	0.69
May	1.93	0.95	0.49	May	1.51	0.90	0.60
Jun	1.09	0.50	0.46	Jun	0.82	0.45	0.55
Jul	0.64	0.30	0.46	Jul	0.47	0.27	0.57
Aug	0.44	0.23	0.54	Aug	0.29	0.20	0.69

```
 Sep    0.40    0.26    0.66            Sep    0.26    0.23    0.87

Critical months: WET : Mar, DRY : Sep
Using  20th percentile of FDC of separated baseflows
Max. baseflows (m3/s): WET :      0.731, DRY :      0.172
```

HYDRAULICS DATA SUMMARY

```
Geomorph. Zone  4
Flood Zone      4
Max. Channel width (m) 12.12
Max. Channel Depth (m)  1.67

Observed Channel XS used
Observed Rating Curve used
(Gradients and Roughness n values calibrated)

Max. Gradient         0.01800
Min. Gradient         0.00700
Gradient Shape Factor      20
Max. Mannings n         0.550
Min. Mannings n         0.025
n Shape Factor             65
```

FLOW - STRESSOR RESPONSE DATA SUMMARY

Table of Stress weightings

Season	Wet	Dry
Stress at 0 FS:	9	9
FS Weight:	0	0
FI Weight:	0	0
FD Weight:	1	1

Table of initial SHIFT factors for the Stress Frequency Curves

Category	High SHIFT	Low SHIFT
A	0.031	0.100
A/B	0.047	0.150
B	0.063	0.200
B/C	0.078	0.250
C	0.094	0.300
C/D	0.109	0.350
D	0.125	0.400

Perenniality Rules
All Seasons Perennial Forced

Alignment of maximum stress to Present Day stress
Not Aligned

Table of flows (m3/2) v stress index

	Wet Season	Dry Season
Stress	Flow	Flow
0	0.746	0.184
1	0.622	0.174
2	0.554	0.165
3	0.497	0.153
4	0.415	0.131
5	0.373	0.117
6	0.299	0.094
7	0.246	0.070
8	0.173	0.047
9	0.087	0.023
10	0.000	0.000

HIGH FLOW ESTIMATION SUMMARY DETAILS

No High flows when natural high flows are < 34% of total flows
Adjusted hydrological variability for high flows is   0.15
Maximum high flows are 250% greater than normal high flows

Table of normal high flow requirements (Mill. m3)

Category	A	A/B	B	B/C	C	C/D	D
Annual	2.098	2.031	1.961	1.888	1.811	1.730	1.646
Oct	0.102	0.099	0.095	0.092	0.088	0.084	0.080
Nov	0.353	0.341	0.330	0.317	0.304	0.291	0.277
Dec	0.392	0.379	0.366	0.352	0.338	0.323	0.307
Jan	0.374	0.362	0.350	0.337	0.323	0.309	0.293
Feb	0.368	0.356	0.344	0.331	0.318	0.304	0.289
Mar	0.304	0.294	0.284	0.273	0.262	0.250	0.238
Apr	0.206	0.199	0.192	0.185	0.178	0.170	0.161
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Jul	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aug	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FINAL RESERVE SUMMARY DETAILS

EWR (low and total Flows) are constrained to be below Present Day Flows

Long term mean flow requirements (Mill. m3 and %MAR)

Category	Low Flows		Total Flows	
	Mill. m3	%MAR	Mill. m3	%MAR
A	8.255	28.0	10.839	36.7
A/B	7.893	26.7	10.403	35.2
B	7.520	25.5	9.951	33.7
B/C	7.137	24.2	9.482	32.1
C	6.722	22.8	8.974	30.4
C/D	6.298	21.3	8.450	28.6
D	5.888	19.9	7.935	26.9

FLOW DURATION and RESERVE ASSURANCE TABLES

Columns are FDC precentage points:

Natural Total flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	1.810	1.270	1.040	0.760	0.575	0.500	0.435	0.380	0.280	0.217
Nov	4.415	3.700	2.745	2.300	1.870	1.440	1.220	1.050	0.765	0.366
Dec	7.055	5.600	4.820	3.760	3.235	2.730	2.445	1.750	1.360	0.834
Jan	8.460	6.950	6.240	5.000	4.190	3.730	3.115	2.540	1.945	0.952
Feb	10.480	7.390	6.505	5.200	4.530	3.980	3.110	2.540	2.075	1.365
Mar	8.690	6.810	5.365	4.360	3.785	3.040	2.705	2.470	1.815	1.230
Apr	5.960	4.390	3.415	3.200	2.885	2.540	2.300	1.860	1.300	0.944
May	3.290	2.670	2.225	2.020	1.780	1.540	1.380	1.150	0.820	0.616
Jun	1.870	1.450	1.280	1.150	1.015	0.850	0.785	0.680	0.545	0.341
Jul	1.085	0.870	0.735	0.640	0.580	0.540	0.470	0.400	0.320	0.247
Aug	0.695	0.570	0.465	0.420	0.370	0.320	0.285	0.260	0.250	0.209
Sep	0.690	0.510	0.395	0.370	0.330	0.270	0.250	0.230	0.210	0.189

Natural Baseflow flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	0.746	0.627	0.469	0.395	0.350	0.313	0.280	0.257	0.222	0.200
Nov	1.041	0.879	0.764	0.646	0.546	0.510	0.427	0.383	0.313	0.240
Dec	1.455	1.246	1.114	0.949	0.830	0.765	0.627	0.534	0.449	0.310
Jan	1.810	1.573	1.434	1.232	1.131	0.946	0.819	0.703	0.620	0.426
Feb	2.233	1.854	1.595	1.435	1.258	1.135	0.998	0.903	0.736	0.464
Mar	2.238	1.906	1.689	1.507	1.318	1.182	1.052	0.956	0.825	0.541
Apr	2.007	1.841	1.570	1.468	1.317	1.155	1.067	0.952	0.800	0.534
May	1.808	1.610	1.426	1.350	1.200	1.091	0.996	0.861	0.719	0.514
Jun	1.504	1.284	1.140	1.010	0.922	0.820	0.736	0.628	0.530	0.341
Jul	1.025	0.810	0.720	0.640	0.580	0.540	0.462	0.400	0.320	0.247
Aug	0.670	0.570	0.460	0.410	0.370	0.320	0.285	0.260	0.250	0.209
Sep	0.608	0.440	0.376	0.340	0.295	0.270	0.243	0.230	0.210	0.189

Category Low Flow Assurance curves (mill. m3)

A Category

	10	20	30	40	50	60	70	80	90	99
Oct	0.562	0.554	0.443	0.367	0.313	0.275	0.237	0.214	0.110	0.077
Nov	0.759	0.759	0.691	0.579	0.491	0.426	0.350	0.302	0.253	0.177
Dec	1.086	1.085	1.015	0.886	0.756	0.654	0.528	0.432	0.362	0.270
Jan	1.344	1.323	1.272	1.138	1.010	0.854	0.676	0.546	0.473	0.409
Feb	1.498	1.384	1.277	1.162	1.010	0.879	0.732	0.617	0.501	0.419
Mar	1.631	1.575	1.481	1.366	1.177	1.031	0.856	0.714	0.593	0.495
Apr	1.454	1.445	1.355	1.269	1.120	0.972	0.843	0.718	0.586	0.497
May	1.345	1.345	1.292	1.202	1.057	0.949	0.801	0.654	0.500	0.367
Jun	1.074	1.074	0.990	0.890	0.780	0.620	0.540	0.410	0.330	0.194
Jul	0.757	0.660	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.516	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.433	0.350	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070

A/B Category

	10	20	30	40	50	60	70	80	90	99
Oct	0.544	0.531	0.424	0.351	0.297	0.262	0.226	0.204	0.110	0.077
Nov	0.724	0.724	0.660	0.553	0.465	0.405	0.332	0.288	0.240	0.177
Dec	1.036	1.034	0.968	0.843	0.714	0.624	0.499	0.411	0.343	0.257
Jan	1.279	1.255	1.211	1.080	0.951	0.817	0.638	0.519	0.445	0.385
Feb	1.429	1.310	1.216	1.101	0.950	0.841	0.689	0.586	0.469	0.394
Mar	1.542	1.488	1.411	1.289	1.104	0.990	0.803	0.681	0.554	0.462
Apr	1.380	1.368	1.290	1.202	1.054	0.930	0.794	0.683	0.550	0.468
May	1.277	1.277	1.230	1.139	0.996	0.907	0.754	0.622	0.500	0.367
Jun	1.021	1.021	0.955	0.854	0.754	0.620	0.540	0.410	0.330	0.194
Jul	0.729	0.660	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.502	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.420	0.350	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070

B Category

Oct	0.523	0.503	0.407	0.333	0.282	0.248	0.214	0.194	0.110	0.077
Nov	0.689	0.686	0.632	0.522	0.441	0.384	0.315	0.273	0.228	0.177
Dec	0.983	0.980	0.924	0.793	0.677	0.591	0.472	0.390	0.323	0.243
Jan	1.215	1.190	1.152	1.011	0.905	0.773	0.602	0.491	0.417	0.357
Feb	1.360	1.244	1.154	1.028	0.904	0.794	0.650	0.554	0.437	0.363
Mar	1.458	1.415	1.342	1.198	1.062	0.926	0.762	0.642	0.514	0.421
Apr	1.308	1.299	1.225	1.122	1.003	0.879	0.749	0.647	0.513	0.434
May	1.211	1.211	1.169	1.065	0.947	0.857	0.712	0.588	0.479	0.367
Jun	0.968	0.968	0.911	0.802	0.716	0.620	0.531	0.410	0.330	0.194
Jul	0.700	0.660	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.478	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.406	0.350	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070

B/C Category

Oct	0.499	0.474	0.390	0.314	0.266	0.235	0.203	0.184	0.110	0.077
Nov	0.652	0.648	0.602	0.491	0.418	0.362	0.298	0.259	0.216	0.177
Dec	0.929	0.926	0.873	0.743	0.644	0.555	0.448	0.368	0.304	0.230
Jan	1.154	1.126	1.081	0.945	0.863	0.724	0.570	0.462	0.389	0.329
Feb	1.295	1.178	1.079	0.959	0.864	0.742	0.616	0.519	0.405	0.332
Mar	1.382	1.341	1.248	1.110	1.020	0.862	0.723	0.597	0.476	0.381
Apr	1.242	1.229	1.145	1.046	0.958	0.821	0.709	0.608	0.477	0.400
May	1.146	1.146	1.097	0.995	0.905	0.802	0.674	0.551	0.445	0.367
Jun	0.915	0.915	0.860	0.751	0.682	0.587	0.503	0.410	0.330	0.194
Jul	0.667	0.631	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.456	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.388	0.338	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070

C Category

Oct	0.468	0.450	0.370	0.295	0.250	0.221	0.192	0.174	0.110	0.077
Nov	0.613	0.613	0.567	0.462	0.393	0.340	0.281	0.243	0.203	0.173
Dec	0.871	0.869	0.817	0.701	0.608	0.519	0.422	0.345	0.284	0.216
Jan	1.082	1.050	1.005	0.894	0.816	0.675	0.538	0.430	0.359	0.299
Feb	1.214	1.093	0.998	0.908	0.817	0.691	0.580	0.479	0.371	0.299
Mar	1.297	1.242	1.149	1.063	0.962	0.799	0.684	0.551	0.432	0.339
Apr	1.165	1.142	1.061	0.991	0.905	0.764	0.669	0.565	0.438	0.364
May	1.068	1.068	1.019	0.942	0.855	0.747	0.635	0.510	0.408	0.353
Jun	0.859	0.859	0.805	0.709	0.643	0.549	0.474	0.391	0.311	0.194
Jul	0.625	0.596	0.545	0.460	0.410	0.370	0.308	0.240	0.180	0.119
Aug	0.428	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.362	0.325	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070

C/D Category

Oct	0.437	0.428	0.345	0.276	0.234	0.208	0.181	0.164	0.110	0.077
Nov	0.579	0.579	0.530	0.434	0.368	0.319	0.265	0.229	0.191	0.164
Dec	0.815	0.814	0.765	0.662	0.566	0.487	0.397	0.322	0.264	0.203
Jan	0.997	0.975	0.941	0.848	0.758	0.632	0.505	0.399	0.329	0.271
Feb	1.118	1.005	0.935	0.864	0.759	0.647	0.543	0.441	0.336	0.267
Mar	1.189	1.137	1.080	1.016	0.888	0.753	0.639	0.506	0.386	0.299
Apr	1.071	1.052	0.994	0.943	0.841	0.715	0.628	0.524	0.397	0.330
May	0.991	0.991	0.955	0.894	0.794	0.699	0.595	0.470	0.369	0.321
Jun	0.804	0.804	0.753	0.670	0.599	0.514	0.445	0.364	0.287	0.194
Jul	0.582	0.564	0.514	0.444	0.393	0.350	0.290	0.240	0.180	0.119
Aug	0.404	0.402	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.337	0.311	0.255	0.228	0.190	0.150	0.140	0.130	0.100	0.070

D Category

Oct	0.413	0.404	0.321	0.256	0.218	0.194	0.169	0.153	0.110	0.077
Nov	0.545	0.545	0.495	0.404	0.342	0.298	0.247	0.213	0.178	0.153
Dec	0.768	0.767	0.719	0.617	0.524	0.456	0.368	0.298	0.243	0.188
Jan	0.927	0.920	0.891	0.792	0.700	0.592	0.467	0.366	0.297	0.242
Feb	1.040	0.945	0.888	0.808	0.699	0.606	0.500	0.400	0.298	0.234
Mar	1.096	1.071	1.029	0.946	0.814	0.707	0.585	0.459	0.339	0.258
Apr	0.995	0.990	0.944	0.882	0.775	0.670	0.580	0.480	0.355	0.295
May	0.933	0.933	0.904	0.836	0.732	0.655	0.548	0.427	0.329	0.286
Jun	0.757	0.757	0.708	0.625	0.554	0.481	0.412	0.335	0.262	0.194
Jul	0.548	0.532	0.479	0.414	0.365	0.327	0.271	0.229	0.180	0.119
Aug	0.382	0.379	0.314	0.269	0.230	0.200	0.170	0.150	0.120	0.089
Sep	0.321	0.293	0.250	0.212	0.182	0.150	0.140	0.130	0.100	0.070

Category Total Flow Assurance curves (mill. m3)

A Category

Oct	0.809	0.783	0.650	0.500	0.375	0.310	0.275	0.230	0.110	0.077
Nov	1.612	1.549	1.405	1.193	0.851	0.756	0.614	0.457	0.258	0.177
Dec	2.033	1.963	1.808	1.567	1.155	1.021	0.821	0.604	0.368	0.270
Jan	2.249	2.161	2.029	1.790	1.392	1.205	0.955	0.710	0.478	0.409
Feb	2.389	2.209	2.023	1.803	1.386	1.224	1.007	0.778	0.506	0.419
Mar	2.366	2.255	2.096	1.895	1.487	1.316	1.084	0.847	0.598	0.495
Apr	1.952	1.906	1.772	1.627	1.330	1.165	0.997	0.809	0.589	0.497
May	1.345	1.345	1.292	1.202	1.057	0.949	0.801	0.654	0.500	0.367
Jun	1.074	1.074	0.990	0.890	0.780	0.620	0.540	0.410	0.330	0.194

Jul	0.757	0.660	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.516	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.433	0.350	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070
A/B Category										
Oct	0.783	0.752	0.624	0.500	0.375	0.310	0.275	0.230	0.110	0.077
Nov	1.550	1.489	1.351	1.148	0.813	0.725	0.587	0.437	0.245	0.177
Dec	1.953	1.883	1.736	1.504	1.100	0.980	0.783	0.577	0.348	0.257
Jan	2.155	2.066	1.945	1.711	1.321	1.157	0.909	0.678	0.450	0.385
Feb	2.291	2.109	1.937	1.721	1.314	1.175	0.956	0.742	0.474	0.394
Mar	2.253	2.147	2.007	1.802	1.404	1.266	1.023	0.809	0.558	0.462
Apr	1.862	1.815	1.694	1.549	1.258	1.117	0.943	0.771	0.553	0.468
May	1.277	1.277	1.230	1.139	0.996	0.907	0.754	0.622	0.500	0.367
Jun	1.021	1.021	0.955	0.854	0.754	0.620	0.540	0.410	0.330	0.194
Jul	0.729	0.660	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.502	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.420	0.350	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070
B Category										
Oct	0.754	0.717	0.600	0.499	0.371	0.310	0.275	0.230	0.110	0.077
Nov	1.486	1.424	1.299	1.097	0.777	0.693	0.561	0.418	0.232	0.177
Dec	1.868	1.800	1.665	1.430	1.051	0.934	0.746	0.550	0.328	0.243
Jan	2.061	1.974	1.860	1.620	1.261	1.101	0.864	0.644	0.421	0.357
Feb	2.192	2.015	1.851	1.627	1.255	1.117	0.908	0.705	0.442	0.363
Mar	2.145	2.051	1.917	1.693	1.351	1.192	0.974	0.767	0.518	0.421
Apr	1.774	1.730	1.614	1.457	1.199	1.059	0.893	0.731	0.516	0.434
May	1.211	1.211	1.169	1.065	0.947	0.857	0.712	0.588	0.479	0.367
Jun	0.968	0.968	0.911	0.802	0.716	0.620	0.531	0.410	0.330	0.194
Jul	0.700	0.660	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.478	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.406	0.350	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070
B/C Category										
Oct	0.721	0.680	0.576	0.474	0.360	0.310	0.272	0.224	0.110	0.077
Nov	1.420	1.359	1.244	1.044	0.741	0.660	0.536	0.398	0.220	0.177
Dec	1.782	1.716	1.587	1.356	1.003	0.885	0.711	0.522	0.309	0.230
Jan	1.969	1.880	1.763	1.531	1.207	1.040	0.822	0.609	0.394	0.329
Feb	2.096	1.920	1.749	1.535	1.202	1.053	0.863	0.664	0.410	0.332
Mar	2.043	1.954	1.801	1.586	1.299	1.119	0.928	0.717	0.480	0.381
Apr	1.690	1.644	1.520	1.368	1.147	0.995	0.848	0.689	0.480	0.400
May	1.146	1.146	1.097	0.995	0.905	0.802	0.674	0.551	0.445	0.367
Jun	0.915	0.915	0.860	0.751	0.682	0.587	0.503	0.410	0.330	0.194
Jul	0.667	0.631	0.545	0.460	0.410	0.370	0.310	0.240	0.180	0.119
Aug	0.456	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.388	0.338	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070
C Category										
Oct	0.681	0.647	0.548	0.448	0.340	0.303	0.258	0.212	0.110	0.077
Nov	1.349	1.295	1.183	0.992	0.704	0.625	0.509	0.377	0.207	0.173
Dec	1.688	1.627	1.501	1.289	0.952	0.836	0.675	0.492	0.289	0.216
Jan	1.863	1.774	1.659	1.456	1.145	0.978	0.780	0.571	0.364	0.299
Feb	1.983	1.805	1.641	1.462	1.141	0.989	0.818	0.618	0.375	0.299
Mar	1.931	1.829	1.680	1.519	1.229	1.045	0.880	0.666	0.435	0.339
Apr	1.594	1.540	1.420	1.301	1.087	0.931	0.802	0.643	0.440	0.364
May	1.068	1.068	1.019	0.942	0.855	0.747	0.635	0.510	0.408	0.353
Jun	0.859	0.859	0.805	0.709	0.643	0.549	0.474	0.391	0.311	0.194
Jul	0.625	0.596	0.545	0.460	0.410	0.370	0.308	0.240	0.180	0.119
Aug	0.428	0.410	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.362	0.325	0.255	0.230	0.190	0.150	0.140	0.130	0.100	0.070
C/D Category										
Oct	0.640	0.617	0.516	0.422	0.320	0.286	0.244	0.201	0.110	0.077
Nov	1.283	1.231	1.119	0.940	0.664	0.592	0.482	0.356	0.195	0.164
Dec	1.596	1.537	1.419	1.224	0.896	0.790	0.638	0.463	0.269	0.203
Jan	1.744	1.666	1.566	1.385	1.073	0.921	0.735	0.534	0.333	0.271
Feb	1.853	1.685	1.550	1.393	1.068	0.931	0.770	0.574	0.340	0.267
Mar	1.795	1.699	1.587	1.452	1.144	0.988	0.827	0.616	0.390	0.299
Apr	1.481	1.432	1.338	1.239	1.014	0.874	0.755	0.598	0.400	0.330
May	0.991	0.991	0.955	0.894	0.794	0.699	0.595	0.470	0.369	0.321
Jun	0.804	0.804	0.753	0.670	0.599	0.514	0.445	0.364	0.287	0.194
Jul	0.582	0.564	0.514	0.444	0.393	0.350	0.290	0.240	0.180	0.119
Aug	0.404	0.402	0.325	0.280	0.240	0.200	0.170	0.150	0.120	0.089
Sep	0.337	0.311	0.255	0.228	0.190	0.150	0.140	0.130	0.100	0.070
D Category										
Oct	0.607	0.583	0.483	0.396	0.300	0.269	0.229	0.188	0.110	0.077
Nov	1.214	1.165	1.055	0.886	0.624	0.558	0.454	0.334	0.181	0.153
Dec	1.510	1.455	1.341	1.152	0.838	0.744	0.598	0.432	0.247	0.188
Jan	1.637	1.577	1.485	1.303	0.999	0.867	0.686	0.494	0.302	0.242
Feb	1.739	1.592	1.473	1.311	0.994	0.877	0.716	0.526	0.302	0.234

Mar	1.673	1.605	1.512	1.361	1.058	0.931	0.763	0.564	0.343	0.258
Apr	1.385	1.352	1.271	1.163	0.940	0.822	0.701	0.551	0.357	0.295
May	0.933	0.933	0.904	0.836	0.732	0.655	0.548	0.427	0.329	0.286
Jun	0.757	0.757	0.708	0.625	0.554	0.481	0.412	0.335	0.262	0.194
Jul	0.548	0.532	0.479	0.414	0.365	0.327	0.271	0.229	0.180	0.119
Aug	0.382	0.379	0.314	0.269	0.230	0.200	0.170	0.150	0.120	0.089
Sep	0.321	0.293	0.250	0.212	0.182	0.150	0.140	0.130	0.100	0.070

10.5 EWR T1 TEEWATERSPRUIT

```
TITLE: RDMR Report
DATE: 02/20/2014

Revised Desktop Model outputs for site: T1
```

HYDROLOGY DATA SUMMARY

```
Natural Flows:                          Present Day Flows:
   Area     MAR   Ann.SD    Q75   Ann.     Area     MAR   Ann.SD    Q75   Ann.
  (km^2)      (m^3 * 10^6)        CV     (km^2)      (m^3 * 10^6)        CV
    0.00   56.36   30.79    2.19  0.55      0.00   45.13   28.59    1.45  0.63

% Zero flows =   0.0                    % Zero flows =   0.0
Baseflow Parameters: A = 0.960, B = 0.44Baseflow Parameters: A = 0.960, B = 0.440
BFI = 0.53 : Hydro Index =   2.4        BFI = 0.47 : Hydro Index =   3.1

MONTH   MEAN      SD     CV             MONTH   MEAN      SD     CV
        (m^3 * 10^6)                            (m^3 * 10^6)
 Oct    2.13    0.94    0.44             Oct    1.45    0.86    0.60
 Nov    3.27    1.58    0.48             Nov    2.42    1.46    0.60
 Dec    4.87    2.72    0.56             Dec    3.84    2.49    0.65
 Jan    6.90    5.80    0.84             Jan    5.67    5.31    0.94
 Feb    9.13    9.22    1.01             Feb    7.72    8.35    1.08
 Mar    9.03    9.23    1.02             Mar    7.82    8.55    1.09
 Apr    6.64    4.84    0.73             Apr    5.61    4.68    0.83
 May    4.68    2.28    0.49             May    3.78    2.21    0.58
 Jun    3.36    1.27    0.38             Jun    2.54    1.22    0.48
 Jul    2.54    0.79    0.31             Jul    1.81    0.74    0.41
 Aug    2.03    0.61    0.30             Aug    1.33    0.57    0.43
 Sep    1.78    0.60    0.34             Sep    1.14    0.55    0.48

Critical months: WET : Apr, DRY : Sep
Using  20th percentile of FDC of separated baseflows
Max. baseflows (m3/s): WET :      1.568, DRY :      0.849
```

HYDRAULICS DATA SUMMARY

```
Geomorph. Zone  4
Flood Zone      4
Max. Channel width (m) 25.30
Max. Channel Depth (m)  2.37

Observed Channel XS used
Observed Rating Curve used
(Gradients and Roughness n values calibrated)

Max. Gradient         0.00400
Min. Gradient         0.10000
Gradient Shape Factor      20
Max. Mannings n         0.150
Min. Mannings n         0.030
n Shape Factor             20
```

FLOW - STRESSOR RESPONSE DATA SUMMARY

```
Table of Stress weightings
Season          Wet   Dry
Stress at 0 FS:  9     9
FS Weight:       3     1
FI Weight:       5     3
FD Weight:       8     5

Table of initial SHIFT factors for the Stress Frequency Curves

Category  High SHIFT  Low SHIFT
    A        0.250      0.083
  A/B        0.375      0.125
    B        0.500      0.167
  B/C        0.625      0.208
    C        0.750      0.250
  C/D        0.875      0.292
    D        1.000      0.333
```

Perenniality Rules
All Seasons Perennial Forced

Alignment of maximum stress to Present Day stress
Not Aligned

Table of flows (m3/2) v stress index

Stress	Wet Season Flow	Dry Season Flow
0	1.641	0.893
1	1.296	0.679
2	0.926	0.492
3	0.620	0.400
4	0.451	0.339
5	0.376	0.289
6	0.301	0.232
7	0.226	0.174
8	0.150	0.116
9	0.075	0.058
10	0.000	0.000

HIGH FLOW ESTIMATION SUMMARY DETAILS
No High flows when natural high flows are < 20% of total flows
Adjusted hydrological variability for high flows is 50.00
Maximum high flows are 250% greater than normal high flows

Table of normal high flow requirements (Mill. m3)

Category	A	A/B	B	B/C	C	C/D	D
Annual	11.396	10.411	9.485	8.614	7.796	7.029	6.308
Oct	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nov	0.920	0.840	0.766	0.695	0.629	0.567	0.509
Dec	1.816	1.659	1.511	1.373	1.242	1.120	1.005
Jan	2.299	2.101	1.914	1.738	1.573	1.418	1.273
Feb	2.212	2.021	1.841	1.672	1.514	1.365	1.225
Mar	1.760	1.608	1.465	1.330	1.204	1.085	0.974
Apr	1.439	1.315	1.198	1.088	0.984	0.887	0.797
May	0.950	0.868	0.790	0.718	0.650	0.586	0.526
Jun	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aug	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FINAL RESERVE SUMMARY DETAILS
EWR (low and total Flows) are constrained to be below Present Day Flows

Long term mean flow requirements (Mill. m3 and %MAR)

Category	Low Flows		Total Flows	
	Mill. m3	%MAR	Mill. m3	%MAR
A	20.040	35.6	30.375	53.9
A/B	17.886	31.7	27.415	48.6
B	15.879	28.2	24.574	43.6
B/C	14.206	25.2	22.103	39.2
C	12.747	22.6	19.894	35.3
C/D	11.471	20.4	17.914	31.8
D	10.384	18.4	16.167	28.7

FLOW DURATION and RESERVE ASSURANCE TABLES
Columns are FDC precentage points:

Natural Total flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	3.355	2.770	2.545	2.000	1.845	1.740	1.595	1.410	1.255	1.051
Nov	5.375	4.430	3.710	3.400	2.805	2.610	2.285	2.050	1.720	1.353
Dec	8.245	6.400	5.225	4.920	4.150	3.860	3.375	2.860	2.305	1.627
Jan	11.645	7.640	6.865	6.130	5.285	4.690	4.220	3.680	3.025	2.143
Feb	17.580	10.480	9.285	6.860	5.920	5.290	4.540	4.180	3.260	2.295
Mar	19.575	11.940	8.070	6.930	5.790	4.970	4.560	4.210	3.745	2.246
Apr	10.990	8.320	7.070	6.210	5.110	4.630	4.235	3.770	3.260	2.112
May	8.000	5.660	5.265	4.890	4.285	3.770	3.315	2.920	2.545	1.745
Jun	5.125	4.220	4.005	3.600	3.210	2.890	2.625	2.250	1.970	1.346
Jul	3.605	3.340	2.930	2.650	2.445	2.230	1.960	1.850	1.655	1.210
Aug	2.710	2.520	2.365	2.170	1.915	1.790	1.675	1.540	1.370	1.026
Sep	2.615	2.200	1.960	1.760	1.615	1.550	1.480	1.330	1.170	0.927

Natural Baseflow flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	2.614	2.262	1.926	1.781	1.645	1.566	1.495	1.310	1.191	0.944
Nov	2.857	2.428	2.157	1.938	1.812	1.700	1.608	1.456	1.337	0.967
Dec	3.324	2.767	2.500	2.192	2.091	1.913	1.816	1.680	1.496	1.110

Jan	3.903	3.122	2.803	2.540	2.336	2.139	2.063	1.919	1.631	1.201
Feb	4.759	3.723	3.129	2.840	2.665	2.483	2.261	2.176	1.851	1.368
Mar	5.408	3.973	3.381	3.067	2.839	2.613	2.372	2.225	1.964	1.548
Apr	4.793	3.981	3.457	3.053	2.846	2.659	2.401	2.208	2.008	1.633
May	4.427	3.832	3.347	2.900	2.740	2.595	2.349	2.208	1.989	1.610
Jun	3.815	3.488	3.012	2.745	2.575	2.373	2.178	2.029	1.835	1.319
Jul	3.413	2.930	2.644	2.470	2.335	2.120	1.930	1.840	1.630	1.210
Aug	2.633	2.440	2.275	2.060	1.915	1.780	1.675	1.540	1.365	1.026
Sep	2.482	2.200	1.940	1.760	1.610	1.550	1.478	1.330	1.170	0.927

Category Low Flow Assurance curves (mill. m3)

A Category

Oct	1.943	1.814	1.630	1.320	1.185	1.080	0.955	0.780	0.610	0.443
Nov	2.048	1.911	1.763	1.523	1.345	1.184	1.055	0.967	0.911	0.656
Dec	2.409	2.253	2.056	1.773	1.559	1.341	1.200	1.103	1.017	0.890
Jan	2.838	2.559	2.285	2.017	1.709	1.452	1.317	1.200	1.090	1.050
Feb	3.232	2.677	2.305	2.008	1.702	1.424	1.270	1.166	1.052	1.012
Mar	4.041	3.159	2.731	2.422	1.977	1.644	1.462	1.383	1.210	1.163
Apr	3.335	3.048	2.668	2.265	1.902	1.582	1.420	1.287	1.182	1.143
May	3.203	3.035	2.685	2.262	1.922	1.628	1.456	1.356	1.219	1.027
Jun	2.739	2.693	2.386	2.082	1.775	1.499	1.336	1.217	1.129	0.684
Jul	2.507	2.412	2.165	1.900	1.705	1.446	1.260	1.170	0.975	0.580
Aug	1.965	1.780	1.640	1.460	1.225	1.100	0.995	0.860	0.710	0.396
Sep	1.795	1.530	1.305	1.130	1.000	0.940	0.865	0.720	0.570	0.358

A/B Category

Oct	1.715	1.593	1.414	1.259	1.169	1.040	0.938	0.780	0.610	0.443
Nov	1.807	1.676	1.528	1.329	1.210	1.074	0.966	0.886	0.836	0.656
Dec	2.124	1.971	1.777	1.537	1.378	1.206	1.085	1.001	0.933	0.827
Jan	2.499	2.232	1.968	1.735	1.484	1.294	1.171	1.077	1.000	0.964
Feb	2.844	2.325	1.977	1.714	1.441	1.254	1.113	1.033	0.965	0.931
Mar	3.560	2.746	2.340	2.083	1.670	1.440	1.272	1.235	1.108	1.072
Apr	2.930	2.641	2.282	1.922	1.578	1.390	1.226	1.135	1.088	1.056
May	2.816	2.637	2.299	1.927	1.618	1.424	1.266	1.207	1.116	1.027
Jun	2.398	2.343	2.049	1.781	1.515	1.323	1.176	1.085	1.034	0.684
Jul	2.203	2.106	1.898	1.686	1.481	1.289	1.132	1.055	0.975	0.580
Aug	1.752	1.735	1.640	1.460	1.225	1.100	0.995	0.860	0.710	0.396
Sep	1.586	1.507	1.305	1.130	1.000	0.940	0.865	0.720	0.570	0.358

B Category

Oct	1.493	1.378	1.241	1.130	1.064	0.962	0.866	0.743	0.610	0.443
Nov	1.572	1.449	1.347	1.202	1.097	0.986	0.889	0.816	0.756	0.654
Dec	1.843	1.700	1.553	1.366	1.238	1.095	0.993	0.922	0.847	0.752
Jan	2.164	1.921	1.705	1.504	1.321	1.160	1.066	0.993	0.911	0.872
Feb	2.460	1.994	1.697	1.453	1.267	1.103	1.008	0.953	0.883	0.848
Mar	3.086	2.357	2.003	1.813	1.466	1.256	1.146	1.140	1.018	0.981
Apr	2.526	2.263	1.942	1.591	1.388	1.198	1.108	1.048	1.000	0.968
May	2.433	2.261	1.966	1.626	1.418	1.242	1.141	1.114	1.025	0.992
Jun	2.073	2.013	1.765	1.523	1.337	1.170	1.066	1.001	0.946	0.684
Jul	1.904	1.815	1.650	1.471	1.319	1.156	1.033	0.972	0.903	0.580
Aug	1.523	1.500	1.455	1.318	1.175	1.047	0.946	0.860	0.710	0.396
Sep	1.381	1.300	1.221	1.125	1.000	0.924	0.838	0.720	0.570	0.358

B/C Category

Oct	1.327	1.252	1.122	1.033	0.987	0.890	0.800	0.671	0.610	0.443
Nov	1.393	1.308	1.219	1.092	1.011	0.911	0.821	0.739	0.674	0.583
Dec	1.625	1.516	1.383	1.231	1.127	1.008	0.917	0.838	0.758	0.677
Jan	1.890	1.689	1.492	1.340	1.187	1.064	0.984	0.905	0.820	0.781
Feb	2.140	1.719	1.452	1.279	1.117	1.006	0.930	0.872	0.800	0.765
Mar	2.700	2.040	1.696	1.614	1.291	1.143	1.057	1.042	0.927	0.890
Apr	2.177	1.932	1.612	1.405	1.199	1.097	1.023	0.961	0.913	0.881
May	2.108	1.953	1.666	1.428	1.245	1.129	1.053	1.019	0.933	0.898
Jun	1.811	1.750	1.522	1.346	1.186	1.068	0.984	0.915	0.857	0.684
Jul	1.677	1.606	1.454	1.314	1.185	1.060	0.954	0.886	0.812	0.580
Aug	1.358	1.353	1.309	1.192	1.078	0.966	0.874	0.790	0.710	0.396
Sep	1.229	1.187	1.119	1.026	0.944	0.856	0.775	0.690	0.570	0.358

C Category

Oct	1.213	1.140	1.019	0.957	0.914	0.825	0.729	0.599	0.552	0.443
Nov	1.264	1.181	1.107	1.009	0.934	0.844	0.748	0.659	0.591	0.513
Dec	1.455	1.347	1.245	1.123	1.037	0.933	0.837	0.751	0.669	0.591
Jan	1.659	1.472	1.331	1.202	1.087	0.983	0.899	0.816	0.728	0.690
Feb	1.859	1.457	1.278	1.128	1.016	0.928	0.851	0.791	0.717	0.682
Mar	2.385	1.740	1.488	1.453	1.174	1.053	0.967	0.942	0.836	0.798
Apr	1.842	1.600	1.420	1.216	1.098	1.011	0.936	0.874	0.826	0.793
May	1.813	1.658	1.460	1.255	1.131	1.041	0.964	0.922	0.842	0.798
Jun	1.591	1.502	1.345	1.195	1.081	0.986	0.900	0.827	0.767	0.684
Jul	1.489	1.413	1.301	1.184	1.086	0.980	0.871	0.797	0.721	0.580
Aug	1.234	1.222	1.185	1.093	0.995	0.895	0.797	0.706	0.628	0.396
Sep	1.127	1.084	1.022	0.956	0.873	0.794	0.705	0.614	0.533	0.358

C/D Category

Oct	1.104	1.050	0.941	0.887	0.850	0.758	0.653	0.528	0.474	0.419
Nov	1.144	1.083	1.024	0.934	0.868	0.774	0.671	0.579	0.508	0.439
Dec	1.301	1.223	1.138	1.035	0.962	0.856	0.753	0.664	0.580	0.503
Jan	1.453	1.321	1.201	1.099	1.007	0.902	0.811	0.726	0.637	0.599
Feb	1.610	1.286	1.134	1.023	0.939	0.850	0.770	0.709	0.634	0.599
Mar	2.100	1.545	1.340	1.335	1.084	0.964	0.877	0.842	0.745	0.707
Apr	1.551	1.414	1.233	1.106	1.013	0.926	0.850	0.787	0.739	0.705
May	1.555	1.467	1.285	1.137	1.044	0.953	0.874	0.826	0.751	0.701
Jun	1.396	1.337	1.201	1.087	1.000	0.903	0.814	0.740	0.678	0.627
Jul	1.326	1.276	1.180	1.085	1.006	0.898	0.785	0.708	0.630	0.574
Aug	1.125	1.120	1.091	1.009	0.923	0.821	0.715	0.621	0.541	0.396
Sep	1.029	1.001	0.954	0.886	0.814	0.729	0.631	0.537	0.454	0.358

D Category

Oct	1.032	0.979	0.874	0.827	0.787	0.685	0.578	0.458	0.395	0.343
Nov	1.065	1.004	0.949	0.871	0.803	0.700	0.594	0.500	0.426	0.357
Dec	1.201	1.122	1.049	0.963	0.888	0.775	0.669	0.578	0.491	0.415
Jan	1.322	1.195	1.100	1.020	0.928	0.817	0.724	0.637	0.546	0.507
Feb	1.454	1.138	1.028	0.948	0.863	0.772	0.690	0.628	0.552	0.517
Mar	1.919	1.375	1.240	1.240	0.996	0.875	0.787	0.742	0.655	0.616
Apr	1.371	1.233	1.116	1.023	0.929	0.841	0.764	0.701	0.652	0.618
May	1.393	1.313	1.162	1.053	0.959	0.866	0.785	0.730	0.660	0.604
Jun	1.271	1.195	1.093	1.008	0.920	0.819	0.728	0.653	0.589	0.528
Jul	1.220	1.162	1.083	1.008	0.927	0.814	0.699	0.619	0.539	0.492
Aug	1.048	1.039	1.010	0.939	0.854	0.743	0.634	0.538	0.455	0.396
Sep	0.964	0.935	0.887	0.828	0.755	0.659	0.558	0.461	0.376	0.310

Category Total Flow Assurance curves (mill. m3)

A Category

Oct	1.943	1.814	1.630	1.320	1.185	1.080	0.955	0.780	0.610	0.443
Nov	3.767	3.029	2.714	2.444	1.980	1.800	1.525	1.280	0.924	0.656
Dec	5.802	4.461	3.932	3.591	3.180	2.900	2.465	1.897	1.042	0.890
Jan	7.134	5.355	4.660	4.319	4.005	3.608	3.037	2.206	1.122	1.050
Feb	7.365	5.367	4.591	4.223	3.911	3.498	2.925	2.134	1.082	1.012
Mar	7.329	5.298	4.549	4.183	3.733	3.294	2.779	2.153	1.234	1.163
Apr	6.023	4.798	4.155	3.706	3.338	2.931	2.497	1.916	1.202	1.143
May	4.977	4.190	3.666	3.213	2.870	2.518	2.167	1.772	1.232	1.027
Jun	2.739	2.693	2.386	2.082	1.775	1.499	1.336	1.217	1.129	0.684
Jul	2.507	2.412	2.165	1.900	1.705	1.446	1.260	1.170	0.975	0.580
Aug	1.965	1.780	1.640	1.460	1.225	1.100	0.995	0.860	0.710	0.396
Sep	1.795	1.530	1.305	1.130	1.000	0.940	0.865	0.720	0.570	0.358

A/B Category

Oct	1.715	1.593	1.414	1.259	1.169	1.040	0.938	0.780	0.610	0.443
Nov	3.377	2.698	2.397	2.171	1.980	1.800	1.525	1.254	0.848	0.656
Dec	5.223	3.988	3.491	3.198	3.033	2.761	2.326	1.727	0.956	0.827
Jan	6.423	4.786	4.138	3.838	3.580	3.263	2.743	1.996	1.029	0.964
Feb	6.620	4.782	4.065	3.737	3.459	3.149	2.626	1.917	0.992	0.931
Mar	6.564	4.701	4.001	3.693	3.274	2.947	2.474	1.939	1.131	1.072
Apr	5.386	4.239	3.640	3.238	2.890	2.622	2.210	1.710	1.106	1.056
May	4.437	3.691	3.196	2.795	2.484	2.237	1.916	1.587	1.128	1.027
Jun	2.398	2.343	2.049	1.781	1.515	1.323	1.176	1.085	1.034	0.684
Jul	2.203	2.106	1.898	1.686	1.481	1.289	1.132	1.055	0.975	0.580
Aug	1.752	1.735	1.640	1.460	1.225	1.100	0.995	0.860	0.710	0.396
Sep	1.586	1.507	1.305	1.130	1.000	0.940	0.865	0.720	0.570	0.358

B Category

Oct	1.493	1.378	1.241	1.130	1.064	0.962	0.866	0.743	0.610	0.443
Nov	3.002	2.380	2.138	1.968	1.861	1.704	1.462	1.150	0.767	0.654
Dec	4.667	3.537	3.115	2.879	2.746	2.512	2.124	1.583	0.868	0.752
Jan	5.739	4.247	3.683	3.420	3.231	2.954	2.498	1.830	0.937	0.872
Feb	5.901	4.232	3.599	3.297	3.105	2.829	2.385	1.759	0.908	0.848
Mar	5.822	4.138	3.516	3.279	2.928	2.629	2.241	1.780	1.038	0.981
Apr	4.763	3.719	3.179	2.790	2.583	2.321	2.004	1.572	1.017	0.968
May	3.910	3.222	2.783	2.418	2.207	1.983	1.733	1.460	1.035	0.992
Jun	2.073	2.013	1.765	1.523	1.337	1.170	1.066	1.001	0.946	0.684
Jul	1.904	1.815	1.650	1.471	1.319	1.156	1.033	0.972	0.903	0.580
Aug	1.523	1.500	1.455	1.318	1.175	1.047	0.946	0.860	0.710	0.396
Sep	1.381	1.300	1.221	1.125	1.000	0.924	0.838	0.720	0.570	0.358

B/C Category

Oct	1.327	1.252	1.122	1.033	0.987	0.890	0.800	0.671	0.610	0.443
Nov	2.692	2.153	1.937	1.789	1.705	1.563	1.341	1.043	0.683	0.583
Dec	4.189	3.184	2.801	2.605	2.497	2.295	1.944	1.438	0.777	0.677
Jan	5.138	3.802	3.288	3.080	2.922	2.693	2.284	1.666	0.844	0.781
Feb	5.264	3.752	3.180	2.953	2.787	2.574	2.181	1.604	0.823	0.765
Mar	5.186	3.657	3.071	2.946	2.618	2.390	2.052	1.624	0.946	0.890
Apr	4.209	3.255	2.736	2.494	2.285	2.117	1.836	1.437	0.928	0.881

May	3.449	2.826	2.408	2.147	1.961	1.802	1.590	1.333	0.943	0.898
Jun	1.811	1.750	1.522	1.346	1.186	1.068	0.984	0.915	0.857	0.684
Jul	1.677	1.606	1.454	1.314	1.185	1.060	0.954	0.886	0.812	0.580
Aug	1.358	1.353	1.309	1.192	1.078	0.966	0.874	0.790	0.710	0.396
Sep	1.229	1.187	1.119	1.026	0.944	0.856	0.775	0.690	0.570	0.358

C Category

Oct	1.213	1.140	1.019	0.957	0.914	0.825	0.729	0.599	0.552	0.443
Nov	2.440	1.946	1.757	1.639	1.562	1.434	1.219	0.935	0.600	0.513
Dec	3.776	2.857	2.528	2.367	2.277	2.097	1.766	1.294	0.686	0.591
Jan	4.598	3.385	2.956	2.777	2.657	2.458	2.076	1.504	0.750	0.690
Feb	4.686	3.297	2.842	2.643	2.527	2.347	1.983	1.453	0.738	0.682
Mar	4.634	3.204	2.732	2.658	2.376	2.182	1.868	1.468	0.853	0.798
Apr	3.681	2.797	2.437	2.202	2.080	1.934	1.673	1.305	0.840	0.793
May	3.026	2.448	2.131	1.906	1.779	1.650	1.450	1.207	0.851	0.798
Jun	1.591	1.502	1.345	1.195	1.081	0.986	0.900	0.827	0.767	0.684
Jul	1.489	1.413	1.301	1.184	1.086	0.980	0.871	0.797	0.721	0.580
Aug	1.234	1.222	1.185	1.093	0.995	0.895	0.797	0.706	0.628	0.396
Sep	1.127	1.084	1.022	0.956	0.873	0.794	0.705	0.614	0.533	0.358

C/D Category

Oct	1.104	1.050	0.941	0.887	0.850	0.758	0.653	0.528	0.474	0.419
Nov	2.204	1.773	1.610	1.502	1.434	1.306	1.095	0.828	0.516	0.439
Dec	3.393	2.585	2.295	2.156	2.080	1.906	1.590	1.154	0.595	0.503
Jan	4.103	3.046	2.666	2.518	2.423	2.231	1.872	1.347	0.657	0.599
Feb	4.159	2.945	2.543	2.389	2.301	2.130	1.791	1.306	0.653	0.599
Mar	4.128	2.864	2.461	2.422	2.168	1.982	1.689	1.317	0.760	0.707
Apr	3.209	2.493	2.150	1.994	1.899	1.758	1.514	1.176	0.751	0.705
May	2.650	2.180	1.891	1.723	1.629	1.502	1.312	1.082	0.759	0.701
Jun	1.396	1.337	1.201	1.087	1.000	0.903	0.814	0.740	0.678	0.627
Jul	1.326	1.276	1.180	1.085	1.006	0.898	0.785	0.708	0.630	0.574
Aug	1.125	1.120	1.091	1.009	0.923	0.821	0.715	0.621	0.541	0.396
Sep	1.029	1.001	0.954	0.886	0.814	0.729	0.631	0.537	0.454	0.358

D Category

Oct	1.032	0.979	0.874	0.827	0.787	0.685	0.578	0.458	0.395	0.343
Nov	2.016	1.624	1.475	1.381	1.311	1.178	0.975	0.723	0.433	0.357
Dec	3.079	2.344	2.088	1.969	1.892	1.717	1.421	1.017	0.505	0.415
Jan	3.700	2.743	2.415	2.294	2.198	2.010	1.676	1.194	0.564	0.507
Feb	3.742	2.627	2.294	2.174	2.085	1.920	1.607	1.164	0.569	0.517
Mar	3.739	2.560	2.247	2.215	1.968	1.788	1.516	1.168	0.668	0.616
Apr	2.859	2.201	1.939	1.820	1.724	1.587	1.360	1.049	0.663	0.618
May	2.375	1.952	1.705	1.579	1.484	1.358	1.178	0.960	0.667	0.604
Jun	1.271	1.195	1.093	1.008	0.920	0.819	0.728	0.653	0.589	0.528
Jul	1.220	1.162	1.083	1.008	0.927	0.814	0.699	0.619	0.539	0.492
Aug	1.048	1.039	1.010	0.939	0.854	0.743	0.634	0.538	0.455	0.396
Sep	0.964	0.935	0.887	0.828	0.755	0.659	0.558	0.461	0.376	0.310

10.6 EWR L1 LEEUDORINGKOP

DATE: 02/21/2014
Revised Desktop Model outputs for site: L1

HYDROLOGY DATA SUMMARY

Natural Flows:					Present Day Flows:				
Area	MAR	Ann.SD	Q75	Ann.	Area	MAR	Ann.SD	Q75	Ann.
(km^2)	(m^3 * 10^6)			CV	(km^2)	(m^3 * 10^6)			CV
0.00	294.31	183.16	9.72	0.62	0.00	229.53	168.21	9.87	0.73

% Zero flows = 0.0 | % Zero flows = 0.0
Baseflow Parameters: A = 0.960, B = 0.44 | Baseflow Parameters: A = 0.960, B = 0.440
BFI = 0.49 : Hydro Index = 2.6 | BFI = 0.52 : Hydro Index = 2.9

MONTH	MEAN	SD	CV	MONTH	MEAN	SD	CV
	(m^3 * 10^6)				(m^3 * 10^6)		
Oct	9.36	4.56	0.49	Oct	10.74	2.11	0.20
Nov	15.53	8.69	0.56	Nov	14.77	5.95	0.40
Dec	26.72	18.69	0.70	Dec	17.09	13.52	0.79
Jan	39.98	34.09	0.85	Jan	26.82	30.47	1.14
Feb	51.89	53.99	1.04	Feb	36.69	51.66	1.41
Mar	50.88	54.22	1.07	Mar	39.44	55.88	1.42
Apr	35.26	33.99	0.96	Apr	25.86	34.68	1.34
May	21.03	11.59	0.55	May	15.67	11.32	0.72
Jun	14.64	5.15	0.35	Jun	11.43	4.14	0.36
Jul	11.40	3.32	0.29	Jul	10.40	1.26	0.12
Aug	9.35	2.53	0.27	Aug	10.19	0.62	0.06
Sep	8.27	2.67	0.32	Sep	10.44	0.92	0.09

Critical months: WET : Mar, DRY : Sep

Using 20th percentile of FDC of separated baseflows
Max. baseflows (m3/s): WET : 9.233, DRY : 3.908

HYDRAULICS DATA SUMMARY

Geomorph. Zone 5
Flood Zone 4
Max. Channel width (m) 53.57
Max. Channel Depth (m) 2.31

Observed Channel XS used
Observed Rating Curve used
(Gradients and Roughness n values calibrated)

Max. Gradient	0.02100
Min. Gradient	0.01500
Gradient Shape Factor	20
Max. Mannings n	0.480
Min. Mannings n	0.070
n Shape Factor	20

FLOW - STRESSOR RESPONSE DATA SUMMARY

Table of Stress weightings

Season	Wet	Dry
Stress at 0 FS:	9	9
FS Weight:	3	1
FI Weight:	0	0
FD Weight:	8	5

Table of initial SHIFT factors for the Stress Frequency Curves

Category	High SHIFT	Low SHIFT
A	0.271	0.200
A/B	0.407	0.300
B	0.543	0.400
B/C	0.679	0.500
C	0.814	0.600
C/D	0.950	0.700
D	0.950	0.800

Perenniality Rules
Non-Perennial Allowed

Alignment of maximum stress to Present Day stress
Not Aligned

Table of flows (m3/2) v stress index

Stress	Wet Season Flow	Dry Season Flow
0	9.460	4.032
1	4.821	2.873
2	4.223	2.231
3	2.908	1.809
4	2.173	1.496
5	1.811	1.244
6	1.448	0.996
7	1.086	0.747
8	0.724	0.498
9	0.362	0.249
10	0.000	0.000

HIGH FLOW ESTIMATION SUMMARY DETAILS

No High flows when natural high flows are < 35% of total flows
Adjusted hydrological variability for high flows is 0.01
Maximum high flows are 250% greater than normal high flows

Table of normal high flow requirements (Mill. m3)

Category	A	A/B	B	B/C	C	C/D	D
Annual	12.847	12.780	12.678	12.538	12.356	12.130	11.855
Oct	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nov	1.112	1.106	1.097	1.085	1.070	1.050	1.026
Dec	2.138	2.127	2.110	2.086	2.056	2.019	1.973
Jan	2.761	2.747	2.725	2.695	2.656	2.607	2.548
Feb	2.405	2.392	2.373	2.347	2.313	2.271	2.219
Mar	2.869	2.854	2.831	2.800	2.760	2.709	2.648
Apr	1.562	1.554	1.542	1.525	1.503	1.475	1.442
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aug	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FINAL RESERVE SUMMARY DETAILS

EWR (low and total Flows) are constrained to be below Present Day Flows

Long term mean flow requirements (Mill. m3 and %MAR)

Category	Low Flows		Total Flows	
	Mill. m3	%MAR	Mill. m3	%MAR
A	75.708	25.7	92.656	31.5
A/B	60.482	20.6	77.488	26.3
B	49.900	17.0	66.830	22.7
B/C	41.285	14.0	58.030	19.7
C	34.460	11.7	50.963	17.3
C/D	27.732	9.4	43.932	14.9
D	24.574	8.3	40.407	13.7

FLOW DURATION and RESERVE ASSURANCE TABLES

Columns are FDC precentage points:

Natural Total flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	16.580	12.180	9.990	8.700	7.680	7.110	6.925	6.180	5.455	4.470
Nov	28.675	20.950	18.925	15.480	14.085	11.670	10.255	7.600	6.375	5.096
Dec	51.755	38.800	28.955	23.540	21.255	18.960	16.515	13.380	9.805	6.336
Jan	97.890	51.460	41.080	32.500	28.810	25.260	20.665	17.940	14.335	8.324
Feb	145.825	73.510	49.005	33.870	29.145	25.010	21.885	19.140	15.805	10.213
Mar	117.815	60.880	46.615	39.990	34.100	25.580	21.045	17.810	16.200	10.877
Apr	58.265	47.750	42.110	34.320	25.135	22.640	18.225	16.240	13.530	9.652
May	30.950	25.360	22.635	21.330	19.145	17.080	15.090	13.060	11.300	7.723
Jun	20.735	18.010	16.380	15.220	14.075	12.970	12.335	10.670	8.885	6.121
Jul	15.470	14.110	12.885	11.940	11.385	10.550	9.635	8.760	7.225	5.254
Aug	12.675	11.570	10.340	9.640	9.300	8.640	7.815	7.340	6.130	4.834
Sep	11.595	10.270	8.790	8.150	7.835	7.330	7.015	6.320	5.345	4.133

Natural Baseflow flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	10.849	10.117	8.921	8.020	7.490	7.044	6.459	6.090	5.373	4.346
Nov	12.046	10.880	10.215	9.319	8.713	7.901	7.225	6.357	5.575	4.519
Dec	16.696	13.064	11.762	10.660	9.958	8.961	8.397	7.737	6.531	5.058
Jan	23.042	17.205	13.456	12.361	11.512	10.846	9.948	9.371	7.675	5.733
Feb	31.565	20.304	15.773	14.031	12.610	11.796	10.912	9.445	8.449	6.614
Mar	32.975	24.013	16.326	14.800	13.173	11.969	11.682	10.680	9.105	6.556
Apr	25.969	21.403	17.234	14.580	13.715	12.316	11.558	10.860	8.925	6.594
May	23.387	19.246	15.815	13.788	12.726	11.702	11.325	10.505	8.487	6.368
Jun	19.359	15.860	14.046	13.261	11.837	11.250	10.420	9.790	7.964	6.115
Jul	15.203	12.900	12.050	11.400	11.014	9.993	9.445	8.650	7.190	5.254
Aug	12.110	11.118	10.315	9.640	9.300	8.640	7.800	7.310	6.130	4.834
Sep	10.910	9.990	8.790	8.150	7.835	7.330	7.015	6.280	5.345	4.055

Category Low Flow Assurance curves (mill. m3)

A Category

	10	20	30	40	50	60	70	80	90	99
Oct	5.927	5.919	5.715	5.083	4.640	4.260	3.728	3.414	3.384	3.384
Nov	6.332	6.231	6.221	5.820	5.384	4.777	4.142	3.632	3.322	3.232
Dec	8.085	7.540	7.484	6.906	6.262	5.587	4.914	4.422	3.985	3.571
Jan	9.750	8.729	8.310	7.703	7.087	6.479	5.644	5.160	4.672	4.400
Feb	9.897	9.060	8.607	7.816	6.922	6.294	5.470	4.809	4.598	2.985
Mar	11.056	10.668	10.018	9.088	7.914	7.120	6.369	5.747	5.455	4.242
Apr	10.304	10.252	10.222	8.889	8.150	7.159	6.165	5.816	5.338	4.306
May	10.096	9.688	9.528	8.571	7.721	6.992	6.239	5.708	5.208	4.028
Jun	8.610	8.303	8.297	7.933	7.152	6.479	5.674	5.221	4.714	4.094
Jul	7.607	7.527	7.520	7.259	6.771	6.116	5.396	4.844	4.328	3.751
Aug	6.523	6.523	6.514	6.228	5.849	5.304	4.570	4.227	3.789	3.370
Sep	5.715	5.632	5.481	5.231	4.857	4.443	3.994	3.577	3.191	2.884

A/B Category

	10	20	30	40	50	60	70	80	90	99
Oct	4.804	4.801	4.636	3.982	3.734	3.492	3.149	2.942	2.837	2.837
Nov	5.110	4.998	4.986	4.719	4.429	3.985	3.508	3.076	2.784	2.695
Dec	6.400	5.875	5.829	5.469	5.073	4.604	4.156	3.786	3.390	3.322
Jan	7.454	6.669	6.316	5.965	5.628	5.244	4.763	4.485	4.049	3.800
Feb	7.023	6.577	6.280	5.874	5.414	5.038	4.608	4.194	4.029	2.985
Mar	7.668	7.484	7.174	6.732	6.173	5.684	5.370	5.078	4.830	4.242
Apr	7.923	7.857	7.791	6.784	6.521	5.849	5.185	5.043	4.650	4.240
May	7.629	7.128	6.949	6.460	6.029	5.599	5.254	5.001	4.569	3.997
Jun	6.716	6.284	6.252	6.051	5.633	5.221	4.788	4.562	4.108	3.525
Jul	6.063	5.860	5.852	5.694	5.420	4.988	4.556	4.183	3.716	3.180
Aug	5.237	5.225	5.211	5.023	4.783	4.394	3.870	3.607	3.209	2.848
Sep	4.641	4.584	4.478	4.304	4.044	3.731	3.391	3.023	2.664	2.376

B Category

	10	20	30	40	50	60	70	80	90	99
Oct	3.974	3.974	3.839	3.260	3.125	2.970	2.668	2.477	2.297	2.289
Nov	4.217	4.117	4.105	3.914	3.710	3.354	2.920	2.525	2.246	2.157
Dec	5.225	4.781	4.732	4.496	4.247	3.902	3.496	3.158	2.795	2.760

Jan	5.967	5.344	5.064	4.865	4.710	4.490	4.062	3.821	3.426	3.199
Feb	5.367	5.114	4.928	4.732	4.526	4.340	3.962	3.591	3.460	2.985
Mar	5.770	5.695	5.570	5.390	5.164	4.909	4.650	4.409	4.205	3.997
Apr	6.340	6.302	6.263	5.502	5.464	4.994	4.476	4.284	3.962	3.738
May	6.066	5.612	5.451	5.212	5.038	4.825	4.533	4.308	3.930	3.439
Jun	5.438	5.059	4.993	4.906	4.708	4.482	4.101	3.915	3.503	2.957
Jul	4.968	4.757	4.750	4.666	4.536	4.253	3.867	3.531	3.105	2.608
Aug	4.322	4.300	4.285	4.158	4.007	3.713	3.237	2.994	2.630	2.326
Sep	3.842	3.799	3.720	3.588	3.392	3.130	2.816	2.473	2.137	1.867

B/C Category

Oct	3.296	3.295	3.180	2.706	2.589	2.451	2.188	2.011	1.803	1.742
Nov	3.503	3.414	3.402	3.233	3.049	2.730	2.334	1.973	1.707	1.620
Dec	4.343	3.971	3.929	3.726	3.509	3.205	2.838	2.530	2.200	2.172
Jan	4.963	4.444	4.212	4.045	3.920	3.739	3.362	3.158	2.802	2.597
Feb	4.472	4.261	4.111	3.952	3.788	3.644	3.317	2.988	2.890	2.648
Mar	4.811	4.752	4.653	4.512	4.334	4.133	3.930	3.741	3.580	3.465
Apr	5.274	5.242	5.210	4.586	4.534	4.144	3.768	3.524	3.274	3.171
May	5.047	4.672	4.548	4.351	4.218	4.053	3.813	3.615	3.292	2.818
Jun	4.522	4.206	4.156	4.089	3.929	3.747	3.416	3.268	2.897	2.388
Jul	4.129	3.950	3.945	3.873	3.764	3.522	3.179	2.879	2.494	2.037
Aug	3.591	3.565	3.552	3.437	3.300	3.037	2.606	2.380	2.051	1.804
Sep	3.192	3.152	3.079	2.958	2.778	2.536	2.243	1.923	1.610	1.358

C Category

Oct	2.637	2.635	2.546	2.276	2.162	2.025	1.779	1.598	1.344	1.210
Nov	2.812	2.756	2.753	2.600	2.434	2.133	1.759	1.429	1.176	1.094
Dec	3.540	3.293	3.273	3.089	2.891	2.601	2.242	1.948	1.636	1.615
Jan	4.163	3.744	3.600	3.456	3.362	3.200	2.803	2.606	2.251	2.045
Feb	4.006	3.764	3.672	3.509	3.345	3.211	2.850	2.502	2.413	2.227
Mar	4.402	4.339	4.233	4.082	3.891	3.677	3.459	3.256	3.084	2.961
Apr	4.501	4.470	4.439	3.994	3.827	3.482	3.289	2.883	2.722	2.658
May	4.276	4.084	4.059	3.851	3.736	3.577	3.318	3.083	2.759	2.258
Jun	3.731	3.597	3.597	3.562	3.421	3.248	2.894	2.754	2.377	1.866
Jul	3.348	3.302	3.300	3.253	3.178	2.949	2.602	2.308	1.934	1.493
Aug	2.885	2.885	2.881	2.784	2.669	2.424	2.006	1.798	1.495	1.303
Sep	2.550	2.513	2.445	2.333	2.166	1.942	1.671	1.375	1.085	0.852

C/D Category

Oct	1.974	1.973	1.913	1.848	1.737	1.601	1.370	1.185	0.883	0.675
Nov	2.120	2.107	2.105	1.967	1.818	1.536	1.182	0.882	0.642	0.565
Dec	2.739	2.629	2.620	2.454	2.275	1.999	1.645	1.364	1.070	1.055
Jan	3.367	3.048	2.991	2.870	2.807	2.663	2.245	2.054	1.699	1.490
Feb	3.549	3.274	3.245	3.072	2.909	2.783	2.386	2.017	1.934	1.742
Mar	4.005	3.937	3.823	3.661	3.456	3.225	2.991	2.773	2.589	2.456
Apr	3.745	3.717	3.681	3.409	3.128	2.905	2.812	2.241	2.193	2.143
May	3.593	3.589	3.578	3.357	3.261	3.106	2.825	2.551	2.226	1.697
Jun	3.057	3.055	3.052	3.042	2.918	2.753	2.375	2.241	1.855	1.342
Jul	2.662	2.662	2.662	2.637	2.595	2.378	2.025	1.736	1.372	0.948
Aug	2.213	2.213	2.211	2.132	2.037	1.812	1.405	1.215	0.937	0.804
Sep	1.907	1.873	1.810	1.707	1.554	1.347	1.097	0.825	0.558	0.344

D Category

Oct	1.559	1.559	1.559	1.559	1.477	1.372	1.181	1.029	0.729	0.527
Nov	1.533	1.533	1.533	1.423	1.329	1.098	0.802	0.590	0.419	0.410
Dec	2.110	2.110	2.107	1.983	1.858	1.629	1.315	1.102	0.927	0.926
Jan	2.719	2.598	2.597	2.566	2.565	2.477	2.043	1.905	1.576	1.396
Feb	3.410	3.154	3.148	2.962	2.824	2.739	2.298	1.914	1.875	1.689
Mar	4.005	3.937	3.823	3.661	3.456	3.225	2.991	2.773	2.589	2.456
Apr	3.402	3.387	3.234	3.231	2.894	2.887	2.780	2.153	2.149	2.115
May	3.448	3.448	3.445	3.213	3.180	3.064	2.776	2.488	2.177	1.615
Jun	2.823	2.823	2.823	2.823	2.746	2.627	2.230	2.148	1.766	1.245
Jul	2.272	2.272	2.272	2.272	2.271	2.106	1.773	1.531	1.210	0.810
Aug	1.620	1.620	1.620	1.587	1.563	1.402	1.035	0.932	0.729	0.691
Sep	1.270	1.247	1.203	1.132	1.024	0.881	0.707	0.518	0.332	0.182

Category Total Flow Assurance curves (mill. m3)

A Category

Oct	5.927	5.919	5.715	5.083	4.640	4.260	3.728	3.414	3.384	3.384
Nov	9.081	8.907	8.799	8.247	6.532	5.819	4.974	4.119	3.338	3.232
Dec	13.370	12.685	12.440	11.571	8.470	7.591	6.514	5.358	4.014	3.571
Jan	16.576	15.374	14.711	13.727	9.939	9.068	7.710	6.367	4.710	4.400
Feb	15.842	14.848	14.182	13.064	9.406	8.549	7.270	5.862	4.631	2.985
Mar	18.149	17.573	16.670	15.348	10.878	9.810	6.725	6.280	5.495	4.242
Apr	14.165	14.012	13.844	12.298	9.764	8.623	7.334	6.499	5.360	4.306
May	10.096	9.688	9.528	8.571	7.721	6.992	6.239	5.708	5.208	4.028
Jun	8.610	8.303	8.297	7.933	7.152	6.479	5.674	5.221	4.714	4.094
Jul	7.607	7.527	7.520	7.259	6.771	6.116	5.396	4.844	4.328	3.751
Aug	6.523	6.523	6.514	6.228	5.849	5.304	4.570	4.227	3.789	3.370
Sep	5.715	5.632	5.481	5.231	4.857	4.443	3.994	3.577	3.191	2.884

A/B Category										
Oct	4.804	4.801	4.636	3.982	3.734	3.492	3.149	2.942	2.837	2.837
Nov	7.845	7.660	7.551	7.132	5.572	5.022	4.336	3.560	2.799	2.695
Dec	11.657	10.993	10.760	10.109	7.269	6.598	5.747	4.717	3.419	3.322
Jan	14.244	13.279	12.683	11.958	8.465	7.819	6.818	5.687	4.087	3.800
Feb	12.937	12.335	11.826	11.094	7.885	7.281	6.398	5.241	4.062	2.985
Mar	14.724	14.352	13.791	12.959	9.121	8.360	6.725	6.280	4.870	4.242
Apr	11.765	11.597	11.394	10.175	8.126	7.306	6.347	5.723	4.671	4.240
May	7.629	7.128	6.949	6.460	6.029	5.599	5.254	5.001	4.569	3.997
Jun	6.716	6.284	6.252	6.051	5.633	5.221	4.788	4.562	4.108	3.525
Jul	6.063	5.860	5.852	5.694	5.420	4.988	4.556	4.183	3.716	3.180
Aug	5.237	5.225	5.211	5.023	4.783	4.394	3.870	3.607	3.209	2.848
Sep	4.641	4.584	4.478	4.304	4.044	3.731	3.391	3.023	2.664	2.376
B Category										
Oct	3.974	3.974	3.839	3.260	3.125	2.970	2.668	2.477	2.297	2.289
Nov	6.929	6.758	6.649	6.308	4.844	4.383	3.741	3.005	2.261	2.157
Dec	10.440	9.859	9.623	9.099	6.426	5.880	5.075	4.081	2.824	2.760
Jan	12.702	11.901	11.381	10.809	7.524	7.044	6.101	5.013	3.463	3.199
Feb	11.234	10.826	10.430	9.910	6.978	6.565	5.738	4.629	3.492	2.985
Mar	12.769	12.509	12.134	11.568	8.088	7.563	6.725	5.648	4.244	3.997
Apr	10.151	10.012	9.838	8.865	7.057	6.439	5.630	4.958	3.983	3.738
May	6.066	5.612	5.451	5.212	5.038	4.825	4.533	4.308	3.930	3.439
Jun	5.438	5.059	4.993	4.906	4.708	4.482	4.101	3.915	3.503	2.957
Jul	4.968	4.757	4.750	4.666	4.536	4.253	3.867	3.531	3.105	2.608
Aug	4.322	4.300	4.285	4.158	4.007	3.713	3.237	2.994	2.630	2.326
Sep	3.842	3.799	3.720	3.588	3.392	3.130	2.816	2.473	2.137	1.867
B/C Category										
Oct	3.296	3.295	3.180	2.706	2.589	2.451	2.188	2.011	1.803	1.742
Nov	6.186	6.025	5.918	5.600	4.170	3.747	3.146	2.448	1.722	1.620
Dec	9.501	8.993	8.766	8.278	5.664	5.161	4.399	3.443	2.228	2.172
Jan	11.624	10.928	10.460	9.924	6.703	6.266	5.378	4.337	2.840	2.597
Feb	10.274	9.910	9.553	9.073	6.212	5.844	5.073	4.015	2.923	2.648
Mar	11.733	11.490	11.145	10.621	7.226	6.758	6.024	4.966	3.619	3.465
Apr	9.043	8.911	8.744	7.912	6.109	5.573	4.909	4.191	3.295	3.171
May	5.047	4.672	4.548	4.351	4.218	4.053	3.813	3.615	3.292	2.818
Jun	4.522	4.206	4.156	4.089	3.929	3.747	3.416	3.268	2.897	2.388
Jul	4.129	3.950	3.945	3.873	3.764	3.522	3.179	2.879	2.494	2.037
Aug	3.591	3.565	3.552	3.437	3.300	3.037	2.606	2.380	2.051	1.804
Sep	3.192	3.152	3.079	2.958	2.778	2.536	2.243	1.923	1.610	1.358
C Category										
Oct	2.637	2.635	2.546	2.276	2.162	2.025	1.779	1.598	1.344	1.210
Nov	5.456	5.330	5.233	4.933	3.538	3.136	2.559	1.896	1.190	1.094
Dec	8.623	8.242	8.040	7.575	5.015	4.529	3.780	2.847	1.664	1.615
Jan	10.728	10.135	9.756	9.250	6.105	5.689	4.790	3.768	2.288	2.045
Feb	9.724	9.331	9.035	8.556	5.735	5.380	4.581	3.514	2.444	2.227
Mar	11.224	10.980	10.631	10.103	6.742	6.264	5.523	4.464	3.122	2.961
Apr	8.216	8.086	7.922	7.272	5.379	4.890	4.413	3.540	2.743	2.658
May	4.276	4.084	4.059	3.851	3.736	3.577	3.318	3.083	2.759	2.258
Jun	3.731	3.597	3.597	3.562	3.421	3.248	2.894	2.754	2.377	1.866
Jul	3.348	3.302	3.300	3.253	3.178	2.949	2.602	2.308	1.934	1.493
Aug	2.885	2.885	2.881	2.784	2.669	2.424	2.006	1.798	1.495	1.303
Sep	2.550	2.513	2.445	2.333	2.166	1.942	1.671	1.375	1.085	0.852
C/D Category										
Oct	1.974	1.973	1.913	1.848	1.737	1.601	1.370	1.185	0.883	0.675
Nov	4.716	4.634	4.539	4.258	2.903	2.520	1.968	1.341	0.656	0.565
Dec	7.729	7.487	7.300	6.858	4.360	3.891	3.155	2.247	1.098	1.055
Jan	9.811	9.322	9.035	8.558	5.500	5.107	4.195	3.194	1.735	1.490
Feb	9.163	8.739	8.509	8.027	5.254	4.911	4.085	3.010	1.965	1.742
Mar	10.701	10.456	10.104	9.571	6.254	5.765	5.017	3.958	2.626	2.456
Apr	7.392	7.267	7.100	6.627	4.651	4.288	3.916	2.887	2.213	2.143
May	3.593	3.589	3.578	3.357	3.261	3.106	2.825	2.551	2.226	1.697
Jun	3.057	3.055	3.052	3.042	2.918	2.753	2.375	2.241	1.855	1.342
Jul	2.662	2.662	2.662	2.637	2.595	2.378	2.025	1.736	1.372	0.948
Aug	2.213	2.213	2.211	2.132	2.037	1.812	1.405	1.215	0.937	0.804
Sep	1.907	1.873	1.810	1.707	1.554	1.347	1.097	0.825	0.558	0.344
D Category										
Oct	1.559	1.559	1.559	1.559	1.477	1.372	1.181	1.029	0.729	0.527
Nov	4.070	4.003	3.912	3.662	2.389	2.060	1.569	1.039	0.433	0.410
Dec	6.987	6.858	6.681	6.287	3.896	3.479	2.791	1.965	0.954	0.926
Jan	9.017	8.729	8.504	8.125	5.197	4.865	3.950	3.020	1.611	1.396
Feb	8.896	8.495	8.293	7.804	5.116	4.819	3.958	2.885	1.906	1.689
Mar	10.550	10.308	9.961	9.437	6.191	5.707	4.971	3.932	2.625	2.456
Apr	6.965	6.856	6.576	6.376	4.383	4.239	3.859	2.783	2.169	2.115
May	3.448	3.448	3.445	3.213	3.180	3.064	2.776	2.488	2.177	1.615

Jun	2.823	2.823	2.823	2.823	2.746	2.627	2.230	2.148	1.766	1.245
Jul	2.272	2.272	2.272	2.272	2.271	2.106	1.773	1.531	1.210	0.810
Aug	1.620	1.620	1.620	1.587	1.563	1.402	1.035	0.932	0.729	0.691
Sep	1.270	1.247	1.203	1.132	1.024	0.881	0.707	0.518	0.332	0.182

11 APPENDIX B: BIOPHYSICAL NODES PER IUA

11.1 X1 - KOMATI

IUA	Biophysical node
X1-1	X11A-01354
X1-1	X11A-01358
X1-1	X11A-01295
X1-1	X11A-01300
X1-1	X11A-01248
X1-1	X11B-01370
X1-1	X11B-01361
X1-1	X11B-01272
X1-1	X11C-01147
X1-2	X11D_01129
X1-2	X11D-01137
X1-2	X11E-01237
X1-2	X11F-01133
X1-2	X11G-01188
X1-2	X11G-01143
X1-3	X11D-01219
X1-3	X11D-01196
X1-3	X11E-01157
X1-3	**EWR K1**
X1-3	X11G-01177
X1-3	X11H-01140a
X1-3	X11F-01163
X1-4	**EWR G1**
X1-4	X11K-01165,
X1-4	X11K-01199,
X1-4	X11K-01179,
X1-4	X11K-01194
X1-5	X11K-01227,
X1-5	X12G-01200;
X1-5	X12H-01296,
X1-5	**EWR K2**
X1-5	X12K-01316
X1-6	X12A-01305,
X1-6	X12B01246,
X1-6	X12C-01242,
X1-6	X12C-01271,
X1-6	X12D-01235,
X1-6	**EWR T1**
X1-6	X12H-01338,
X1-6	X12H-01340
X1-6	X12H-01318,
X1-6	X12J-01202,
X1-6	X12K-01333,
X1-6	X12J-01332
X1-7	X14A-01173
X1-7	X14B-01166
X1-8	X14F-01085
X1-8	**EWR L1**
X1-8	X14G-01128
X1-9	X13J-01221,
X1-9	X13J-01214,
X1-9	X13J-01205,
X1-9	X13J-01210,
X1-9	X13J-01149,
X1-9	X13J-01141,
X1-9	**EWR K3A**
X1-10	X13K-01114,

IUA	Biophysical node
X1-10	X13K-01136,
X1-10	X13K-01068,
X1-10	X13K-01038,
X1-10	X13L-01000,
X1-10	X13L-01027,
X1-10	X13L-00995

11.2 X2 - CROCODILE

IUA	Biophysical node
X2-1	X21B-00898
X2-1	X21B-00929
X2-1	X21B-00925
X2-1	**EWR C1**
X2-1	X21A-01008
X2-1	**EWR C2**
X2-1	X21C-00859
X2-2	X21D-00938
X2-2	X21E-00947
X2-2	**EWR C3**
X2-2	X21D-00957
X2-2	X21E-00897
X2-3	X21F-01046
X2-3	X21F-01100
X2-3	X21F-01096
X2-3	X21F-01092
X2-3	X21F-01081
X2-3	X21F-01091
X2-3	**EWR E1**
X2-4	X21G-01090
X2-4	X21G-01073
X2-4	X21G-01016
X2-4	X21J-01013
X2-4	X21H-01060
X2-4	X21K-01007
X2-5	**EWR E2**
X2-5	X21K-00997
X2-6	X22B-00987
X2-6	X22B-00888
X2-6	X22C-00946
X2-6	X22J-00993
X2-7	X22A-00824
X2-7	X22A-00887
X2-7	X22A-00875
X2-7	X22A-00919
X2-7	X22A-00920
X2-7	X22A-00917
X2-7	X22A-00913
X2-7	X22C-00990
X2-8	X22D-00843
X2-8	X22D-00846
X2-8	X22F-00842
X2-8	X22E-00849
X2-8	X22E-00833
X2-8	X22F-00886
X2-8	X22F-00977
X2-8	X22C-01004
X2-8	X22H-00836
X2-9	X22J-00958
X2-9	X22K-00981
X2-9	X22K-01042

IUA	Biophysical node
X2-9	X22K-01043
X2-9	X22K-01029
X2-9	**EWR C4**
X2-10	X23B-01052
X2-10	X23C-01098
X2-10	**EWR C7**
X2-10	X23E-01154
X2-10	X23F-01120
X2-11	X24C-01033
X2-11	**EWR C5**
X2-11	X24E-00982
X2-11	X24F-00953
X2-11	X24H-00880
X2-11	**EWR C6**
X2-12	X24A-00826
X2-12	X24A-00860
X2-12	X24A-00881
X2-12	X24B-00903
X2-12	X24B-00928
X2-12	X24C-00969
X2-12	X24C-00978
X2-13	X24E-00973
X2-13	X24E-00922
X2-13	X24G-00902
X2-13	X24G-00876
X2-13	X24G-00844
X2-13	X24G-00823
X2-13	X24G-00820
X2-13	X24G-00904
X2-13	X24H-00882

11.3 X3 - SABIE/SAND

IUA	Biophysical node
X3-1	X31A-00741
X3-1	X31A-00778
X3-1	X31A-00783
X3-1	X31A-00786
X3-1	X31A-00794
X3-1	X31A-00796
X3-1	X31A-00799
X3-1	X31A-00803
X3-2	X31B-00756
X3-2	**EWR S1**
X3-2	X31B-00792
X3-2	**EWR S4**
X3-2	**EWR S2**
X3-2	X31D-00772
X3-2	X31E-00647a
X3-2	X31F-00695
X3-3	**EWR S5**
X3-3	**EWR S3**
X3-3	X31K-00750
X3-3	X31K-00752
X3-3	X31K-00758
X3-3	X31M-00681
X3-3	X31M-00739
X3-3	X31M-00747
X3-3	X31E-00647b
X3-4	X31D-00773
X3-4	X31H-00819

IUA	Biophysical node
X3-4	*X31J-00774*
X3-4	*X31J-00835*
X3-4	*X31K-00713*
X3-4	*X31L-00657*
X3-4	*X31M-00673*
X3-4	*X31L-00664*
X3-4	*X31L-00678*
X3-5	*X33A-00731*
X3-5	*X33A-00737*
X3-5	*X33B-00784*
X3-5	*X33B-00804*
X3-5	*X33B-00829*
X3-5	*X33D-00811*
X3-5	*X33D-00861*
X3-6	*X31K-00771*
X3-6	*X31M-00763*
X3-6	*X33A-00661*
X3-6	*X33A-00806*
X3-6	*X33B-00694*
X3-6	*X33B-00834*
X3-6	*X33C-00701*
X3-6	*X33D-00864*
X3-6	*X33D-00894*
X3-6	*X33D-00908*
X3-6	*X33D-00911*
X3-7	*X32D-00605*
X3-7	*X32E-00629*
X3-7	*X32E-00639*
X3-7	**EWR S6**
X3-7	*X32F-00628*
X3-8	**EWR S7**
X3-8	*X32B-00551*
X3-8	*X32C-00558*
X3-8	*X32C-00564*
X3-8	*X32C-00606*
X3-8	*X32G-00549*
X3-8	*X32G-00565*
X3-9	*X32H-00560*
X3-9	*X32H-00578*
X3-9	**EWR S8**
X3-9	*X32J-00651*
X3-9	*X32J-00730*

11.4 X4

IUA	Biophysical node
X4	*X40A-00437*
X4	*X40A-00454*
X4	*X40A-00479*
X4	*X40A-00492*
X4	*X40A-00433*
X4	*X40A-00420*
X4	*X40A-00426*
X4	*X40A-00475*
X4	*X40A-00459*
X4	*X40A-00486*
X4	*X40A-00469*
X4	*X40B-00534*
X4	*X40B-00537*
X4	*X40B-00532*
X4	*X40B-00497*

IUA	Biophysical node
X4	*X40B-00531*
X4	*X40B-00530*
X4	*X40B-00511*
X4	*X40C-00592*
X4	*X40C-00513*
X4	*X40D-00663*
X4	*X40D-00594*
X4	*X40D-00598*
X4	*X40D-00660*