# Determination of Water Resource Classes and Associated Resource Quality Objectives in the Inkomati Water Management Area

***Information Document: November 2014***

water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

INKOMATI
CATCHMENT MANAGEMENT AGENCY

**PURPOSES OF THIS BACKGROUND INFORMATION DOCUMENT ARE TO:**

- Provide progress to date on the Water Resources Classification Process undertaken in the Inkomati Catchment.
- Provide the consequences of operational scenarios in terms of economics, ecosystem services, ecology and water quality.
- Present draft management classes.
- Present draft RQOs

Stakeholders are invited to participate in the process by contributing information at meetings and workshops, or by corresponding with the public participation office or the technical team at the addresses provided below.


**Public participation office:**
Anelle Lötter
Jones and Wagener (Pty) Ltd
P O Box 1434, Rivonia, 2128
Tel: 012 667 4860
Fax: 012 667-6129
Email: anelle@jaws.co.za

**Technical enquiries:**
Delana Louw, Rivers for Africa
Post Box 1684, Derdepark, 0035
Tel: (012) 346 3496
Cell: 082 4611289
Fax: (012) 346 9956
Email: iwre@icon.co.za


## 1. BACKGROUND AND PROGRESS MADE THUS FAR

The Department of Water and Sanitation initiated a study in April 2013 on the classification and determination of the Resource Quality Objective (RQOs) for the significant water resources in the catchments of the Inkomati. The objective of the study is to set the water resource classes (commonly known as Management Classes (MCs)) and determine the RQOs in the catchments of the Inkomati.

The study follows a step-wise process whereby a class and associated RQOs of a water resource are defined by taking into account the social, economic and ecological landscape in a catchment in order to assess the costs and benefits associated with utilisation versus protection of a water resource. As such, the process is not carried out in isolation, but is integrated within the overall planning for water resource protection, development and use. A key component of classification is integrating economic and social goals into the determination of the management class. Therefore the economic, social and ecological implications of choosing appropriate MCs need to be established and communicated to all interested and affected parties during the Classification Process.

To determine the class and RQOs of a water resource, both the Water Resource Classification System (WRCS) and the Procedures to Develop and Implement RQOs each lay out a set of procedures grouped together into seven steps. When the steps are applied to a specific catchment will result in the determination of a class and RQOs which aim to achieve a balance between protection of a water resource and use thereof to meet social and economic goals. For the purpose of this study, the classification steps have been integrated with the RQOs determination steps (Table 1).

According to the integrated steps for determining MCs and RQOs (Table 1) steps 1 to 4 are completed. Currently the study team is in the process of setting the MCs and associated RQOs (define the numerical limits and goals) as well as evaluating management options (scenarios) with stakeholders (Step 5 and 6). Scenarios are water resource management options available for a particular water resource that satisfy protection and use and further development and includes the water quality, quantity and distribution requirements to support ecosystem functioning.

The purpose of the 3$^{rd}$and final Project Steering Committee (PSC) meeting is to provide feedback on the work that was done since the 2$^{nd}$ PSC meeting. This includes the evaluation of operational scenarios that have been chosen in the 2$^{nd}$ PSC meeting, proposed MCs and catchment configuration, proposed RQOs and numerical limits.


**DWS Study Managers**

| | | | |
|---|---|---|---|
| **Ms Shane Naidoo** | **Director: Water Resources Classification** | **Tel: 012 336 6707** | **NaidooShane@dwa.gov.za** |
| **Ms Mohlapa Sekoele** | **Project Coordinator** | **Tel: 012 336 8329** | **SekoeleM@dwa.gov.za** |

**http://www.dwa.gov.za/rdm/WRCS/default.aspx**

## 2. DELINEATION OF INTEGRATED UNITS OF ANALYSIS (IUAS)

As part of Step 1, 34 IUAs have been identified for the Inkomati WMA (Figure 5). These have been based on the socio-economics of the areas, water uses and users, envisaged level of protection required and significance of the resource. An IUA is a broad scale homogenous unit (or catchment area) that contains several biophysical nodes and can be managed as an entity. These nodes define at a detail scale specific attributes which together describe the catchment configuration of the IUA. Scenarios are assessed within the IUA and relevant implications in terms of the Management Classes (MCs) are provided for each IUA.The 34 IUAs were proposed, reviewed and accepted by representative stakeholder organisations and the PSC members.

**Table 1: The Integrated steps for determining different classes and RQOs**

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

## 3. IDENTIFICATION AND EVALUATION OF OPERATIONAL SCENARIOS WITHIN THE INTEGRATED WATER RESOURCE MANAGEMENT PROCESS

The overarching aim of the scenario evaluation process is to find the appropriate balance between the level of environmental protection and the use of the water resource to sustain socio-economic activities. Scenarios are water resource management options available for a particular water resource that satisfy protection and use and further development and includes the water quality, quantity and distribution requirements to support ecosystem functioning. Once the preferred scenario has been selected the MC is defined by the level of environmental protection embedded in that scenario.

There are three main elements (variables) to consider in this balance, namely the ecology, ecosystem services and the economic benefits obtained from the use of a portion of the water resource. The scenario evaluation process therefore estimates the consequences that a set of plausible scenarios will have on these elements by quantifying selected metrics to compare the scenarios on relative bases with one another.

The sequential activities carried out to evaluate the scenarios are presented in Figure 1, starting with the vision setting and describing the scenarios to be analysed.

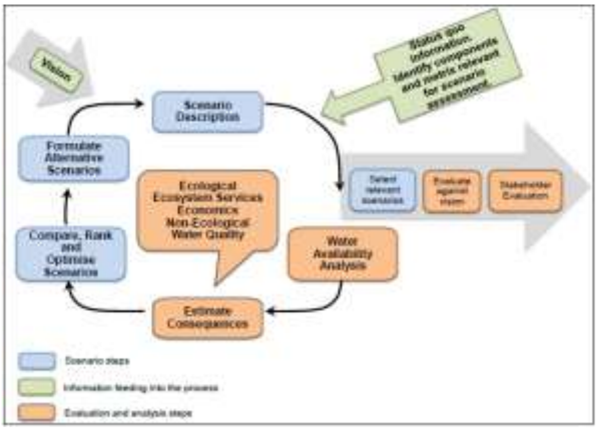



**Figure 1: Schematic representation of scenario analysis process**

The status quo information was applied to identify the components requiring evaluation and defining the relevant parameters to be quantified. Water availability analyses were carried out for the scenarios, which feeds into the activity to determine the consequences on the Ecology, Ecosystem Services, Economy and Non-Ecological Water Quality. The scenarios were ranked, first, for the individual variables and secondly an overall integrated ranking was derived based on multi-criteria analysis methods.

The results of the initial set of scenarios were interpreted to identify possible alternative release rules to improve the integrated scores with the objective to find and recommend an optimised scenario.

Several scenarios were identified for discussion and consideration by the stakeholders as described below. The scenario details are contained in a separate report and summarised in this background document. The full list of scenarios analysed are shown in Appendix A.

### SCENARIO DESCRIPTION

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

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

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

- **Komati catchment:**
  - Water Conservation & Water Demand Management.
  - Construction of the Silingane Dam
- **Crocodile catchment**
  - Water Conservation & Water Demand Management.
  - Construction of the Mountain View Dam
  - Construction of the Boschjeskop Dam
- **Sabie catchment**
  - Water Conservation & Water Demand Management.
- **Sand Catchment**
  - Construction of the New Forest Dam

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

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

### Ecological State

Integrated into the future water demand and development scenarios are options related to the ecological water requirements (EWR). Broadly these consist of

- No EWR
- Maintaining the Present Ecological State
- Implementing the Recommended Ecological State

The full list of scenarios considered is attached as Appendix A.

## 4. ECONOMIC CONSEQUENCES OF SCENARIOS

In the evaluation of the different users it was identified that the following sectors in the project area could be affected by a change in the water allocation; namely, irrigation, urban and domestic household use, and industry.The different identified scenarios investigated provide different water volumes allocated to the different economic sectors. In some of the scenarios if implemented, irrigation could be impacted very negatively, in others the current status could be maintained and even provide improved results.

The overall evaluation is that some of the scenarios will, from an economic point of view, be very beneficial to the region while others will not be. The final integration with the environmental and ecosystem services sectors must still take place, but it should be possible to select a scenario which will be good to the environment without causing too much of a negative economic impact.

In Figure 2 below, the ranking of the different scenarios are presented in terms of their impact on Gross Domestic Product (GDP), with 0% as the baseline, for each of the river systems.

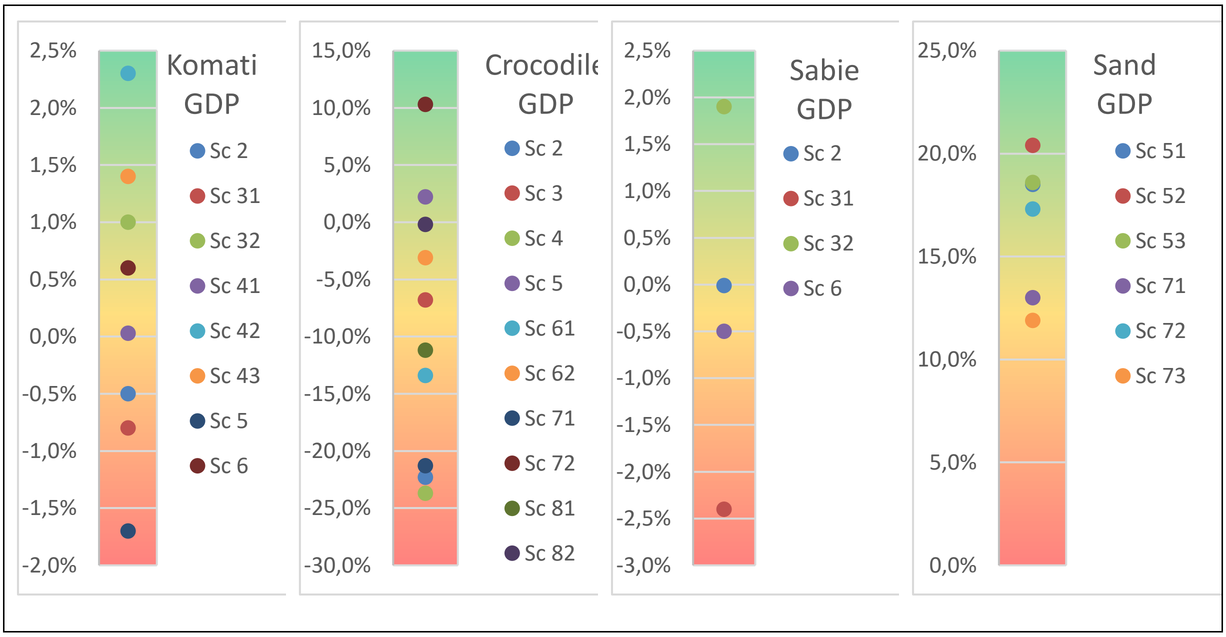



**Figure 2: Impact of scenarios on GDP**

The ranking of the different scenarios for each of the river systems are presented (Figure 3) in terms of their impact on Employment (Labour), with 0% as the baseline.

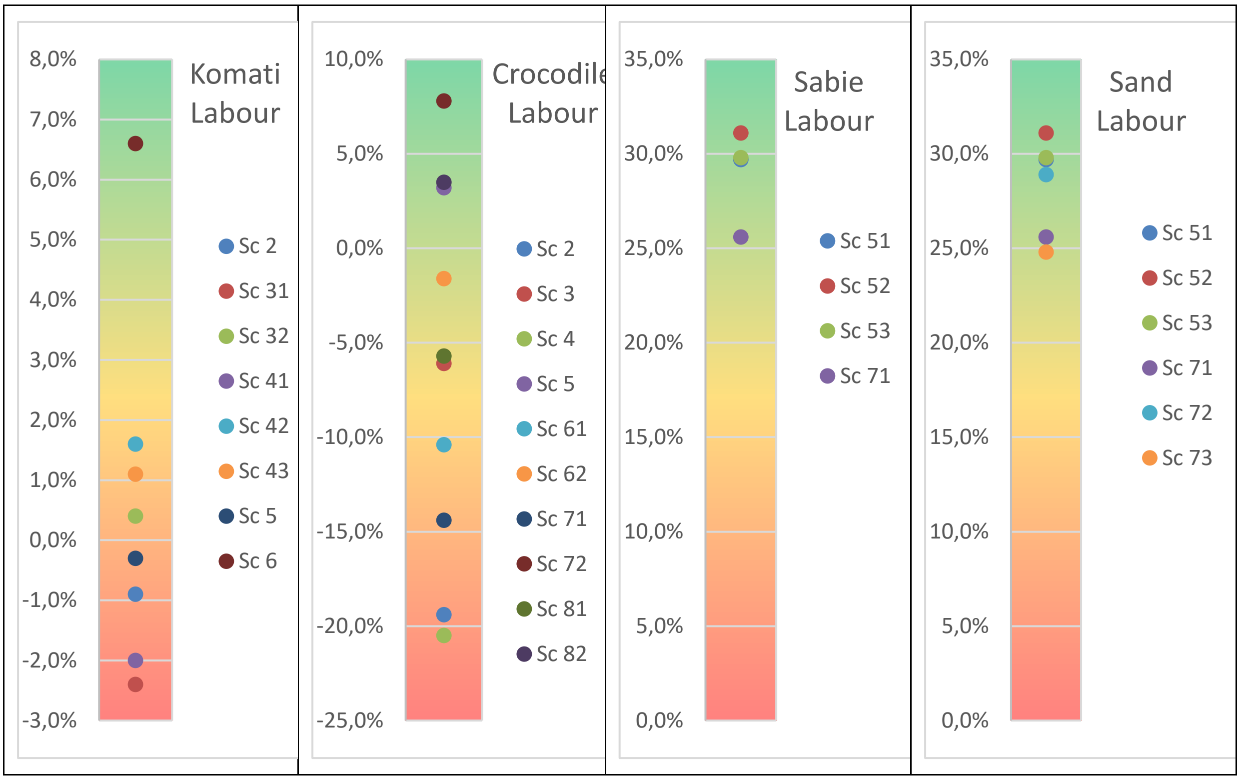



**Figure 3: Impact of scenarios on employment (labour)**

**Komati River System**: Most of the scenarios will not have a great impact on the current status quo with GDP impact ranging from -1.6% to 2.3% change. The impact on employment ranges from -2.2% to 6% change. Most of these changes are a result of changes to the domestic water allocation and irrigation schemes.

**Crocodile River System**: This system will be severely affected by the scenarios with changes in GDP ranging from -23.7% to 10.3%. The impact on employment shows a similar situation with changes ranging from -20.5% to 7.8%. The biggest impact is a result of changes in the allocation for irrigation and the subsequent impact on the industry sector.

**Sabie River System**: The scenarios for this river system will not impact the GDP significantly with changes ranging from -2.4% to 1.9% while employment changes range from -4.2% to 1.7%.

**Sand River System**: All the scenarios in the sand will have a positive impact on GDP and Employment. GDP changes range from 11.9% to 20.4%, while employment changes are between 24.8% and 31.1%. This is mainly due to the increased water available for the urban and domestic service sectors.

In the final evaluation process, taking into consideration the very high unemployment in the project area, the employment rating should carry more weight than the GDP rating.

## 5. ECOSYSTEM SERVICES CONSEQUENCES OF SCENARIOS

Natural habitats and ecosystems provide a range of environmental goods and services that contribute enormously – and are even essential – to human well-being. River systems and their associated use values are of particular importance. For operational purposes this study follows the approach defined in the 2005 Millennium Ecosystem Assessment and classifies ecosystem services along functional lines using categories of provisioning, regulating, cultural, and supporting services.

An analysis of the ecological water requirements (EWRs) sites 3, 5, 6, and 8 (the full list of EWR sites is attached as Appendix B) was undertaken for the Sabie and Sand River systems. Here scenarios (Sc) S1, S4, S51 and S53 were evaluated. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. Each site was evaluated under the impact against a base value of 1, representing the status quo. Anticipated change was evaluated against the base value with a negative impact represented as a score lower than 1 and an overall positive score represented as greater than 1. The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites. Here the perceived vulnerability of households dependent on the provisioning aspect of Ecosystem Services played a major role. For the Sabie River system Sc S1, and S32 were deemed to be largely negative with respect to impact on

Ecosystems Services. For the Sand River system most of the scenarios were either neutral in impact or marginally positive. For the Sabie and Sand systems the results are as represented in Figure 4 below.

For the Crocodile River system EWRs 3, 4, 5, 6 and 7 were examined. Sc C1, C5, and C72 were deemed to be marginally negative. The remaining scenarios were either neutral or marginally positive. The ranking of the scenarios was then integrated and presented as an overall score for the Crocodile, see Figure 4 below.

For the Komati River system the water resource class and the set of ecological categories (ECs) for the biophysical nodes are not sensitive to the range of scenarios that were evaluated and analysed. This was examined with respect to the Ecosystems services and it was concluded that same applied. In this regard all scenarios returned a value of 1 for ecosystem services.

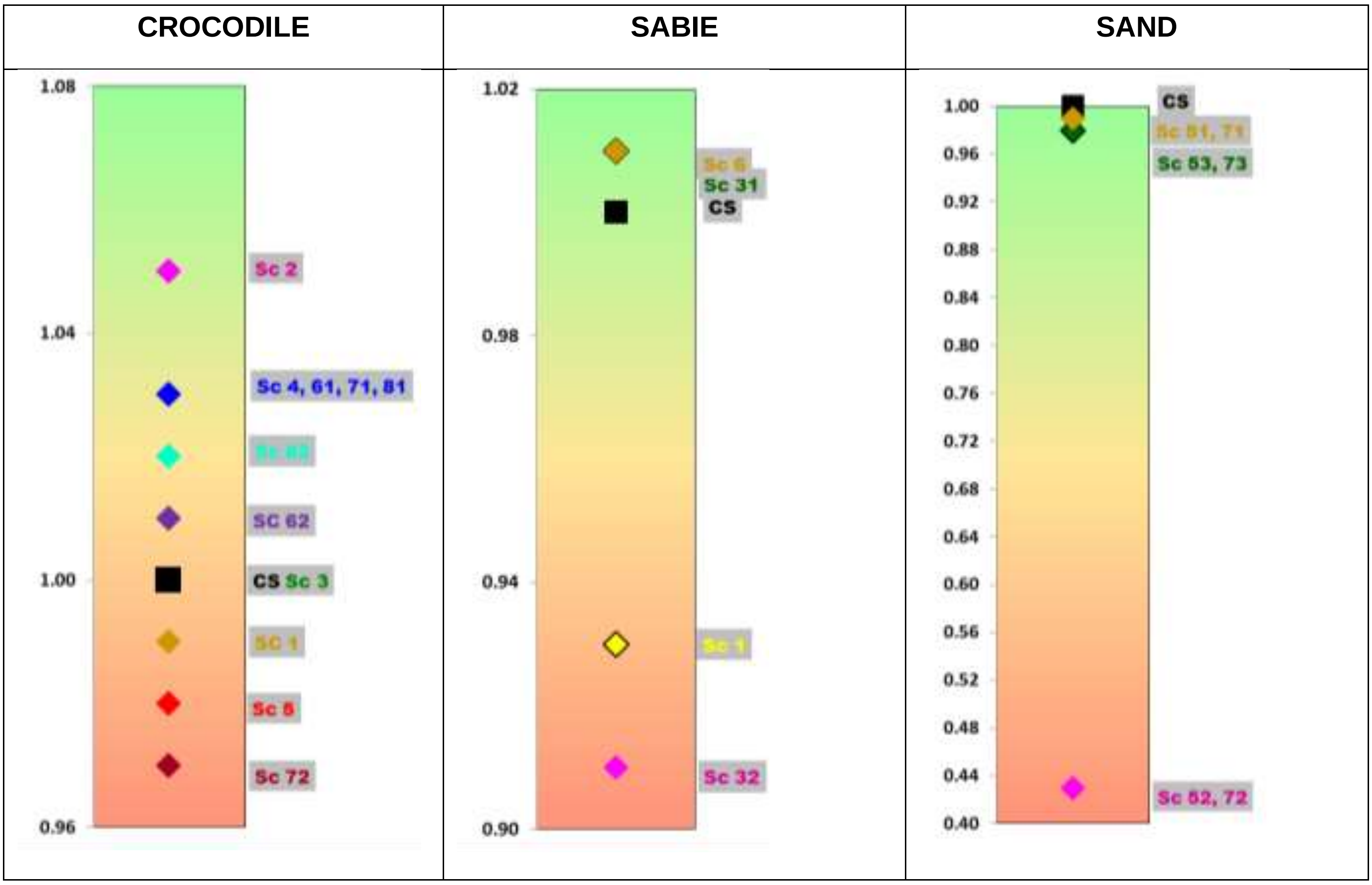



**Figure 4: Graphical representation of consequences of scenarios on Ecosystem Services for the Crocodile, Sabie and Sand River systems**

## 6. ECOLOGICAL CONSEQUENCES OF SCENARIOS

The ecological consequences (rivers) of the scenarios are evaluated at the key biophysical nodes (EWR sites) by determining the impact on the Ecological Category. The process to determine the ecological consequences consists of analysing the scenario's flow regime and determining how the biophysical components (drivers: geomorphology and physico-chemical variables; responses: fish, riparian vegetation and macro-invertebrates) will respond to these changes. A range of models are then applied and the predicted Ecological Category for each component determined. An EcoStatus (overall Ecological Category) can also then be determined.

Once this information is available for each scenario at each EWR site, then the scenarios must be ranked from better to worse considering the change in ecological state at the EWR site. The ranking illustrates the degree to which a scenario meets the Recommended Ecological Category (REC) (or one can describe it as the degree to which the ecological objectives which is represented by the REC are met). The scoring of one to zero is defined as follows:

- 1: REC is met for all components*
- 0: REC is not met at any component and each component would be evaluated individually as zero.

*Components: Drivers (physico-chemical, geomorphology) and responses (fish, macro-invertebrates, and riparian vegetation).

This process is undertaken for each EWR site and a combined ranking must then be provided for the system as a whole. This process is based on a weight for each EWR site that considers its ecological importance. An overall ranking is then supplied and the results are shown below for the Crocodile, Sabie and Sand River Systems.

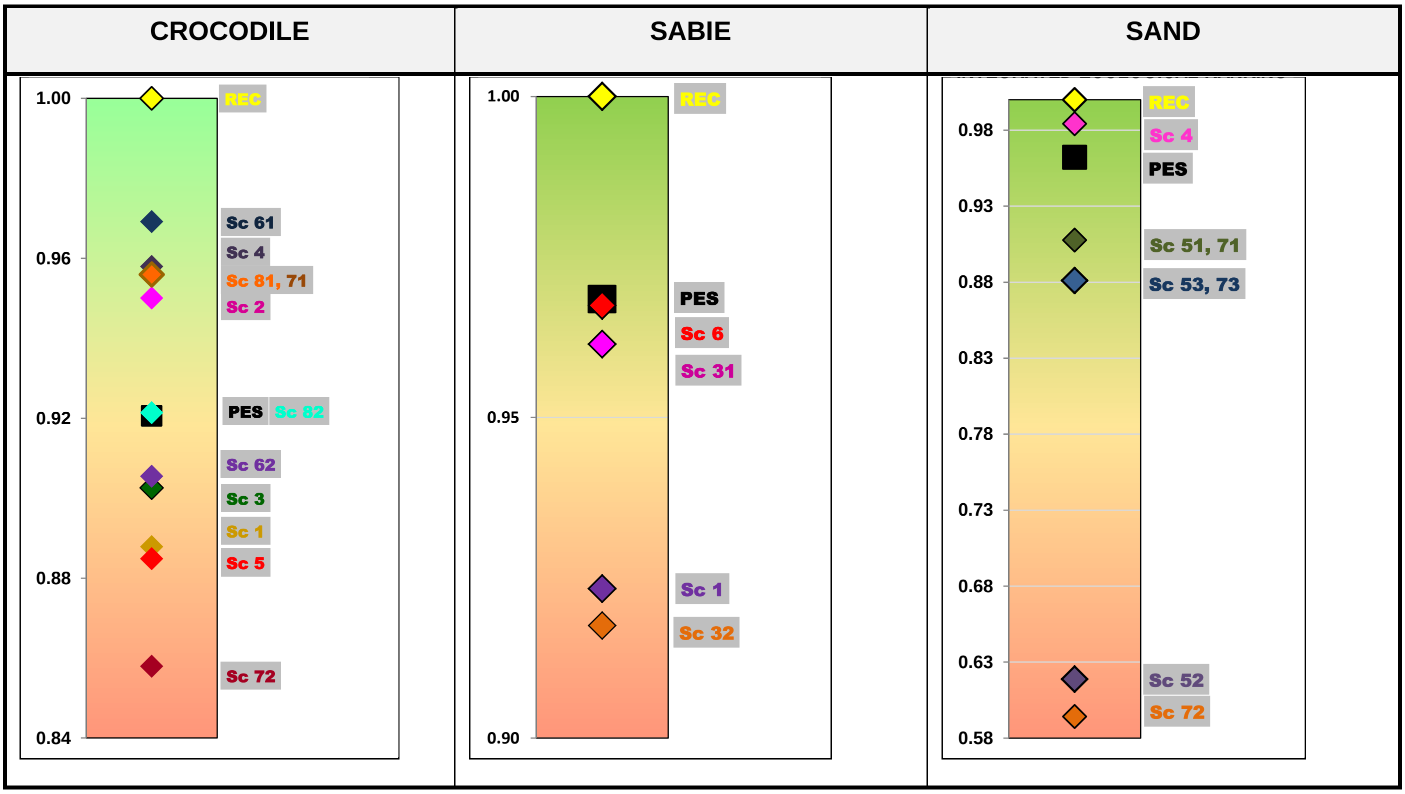



**Figure 5: Graphical representation of ecological consequences of scenarios for the Crocodile, Sabie and Sand River systems**

This ranking shows that none of the scenarios meet the REC for the system.

**Komati River System:** The scenarios are only relevant for EWR K3 (Komati River at Tonga Rapids) and EWR L1 (Lomati River downstream of Driekoppies Dam). There is no impact of the scenarios at K3. The Lomati River at EWR L1 is largely impacted on by the unseasonal releases for irrigation from Driekoppies Dam. The scenario results illustrate that Sc K2, K31 and K41 are similar to the present day flows (i.e. maintain the PES) whereas the other scenarios are in a worse state due to the impacts on riparian vegetation which in turn impacts on the instream components. This results in a change from a C to a C/D EcoStatus.

**Crocodile River System:**The scenarios only impact on EWR 3, 4, 5 and 6 in the Crocodile River and EWR 7 in the Kaap River. The worst case scenarios are Sc C72 and C5 which both includes new dam options but with no EWR releases. Scenario C1 which represents the current operating rule also has the potential to degrade the river although it will still maintain the EcoStatus of a C at EWR 6. The best options are those options that include the REC. It is however known that these have serious potential economic consequences. Scenario C3 (with no new dams) and Scenario C82 (that includes new dams) are potentially the best compromise options to explore further.

**Sabie River System:** The scenarios only impact on EWR 3 (Sabie River) and EWR 5 (Marite River). At all the other EWR sites, the status quo is therefore maintained. Scenario S31 and S6 are the best options as they are the closest to meeting the ecological objectives. If one however considers that the Sabie River has always been seen as the flagship river in the KNP as well as one of the few rivers left in South Africa in excellent condition, then the ranking order of the Sabie River should (from an ecological view point) override the integrated ranking. As Sc S6 is the only scenario that maintains the PES (and REC) in the Sabie River, this scenario is the ecological recommendation.

**Sand River System:** The scenarios largely impact on EWR 6 (Mutlumuvi River) and EWR 8 (Sand River). Due to the lower confidence at EWR 7 (Thulandziteka (Sand) River) and as it is situated upstream of the impact of the New Forest Dam, this site was not considered during the scenario evaluation. Scenario S52 and S72 are not viable options as a section of the Mutlumuvi River will change to a seasonal system. Scenario S4, although the best option, was recognised not to be a realistic option as the return flows associated with this scenario are too high. Scenario S51 and S53 also include these return flows. The remaining scenarios are Sc S71 and S73. Scenario S71 includes a full EWR release which will have a major impact on the yield. To further optimise, it is recommended that Sc S73 be further investigated.

## 7. WATER QUALITY (USER) CONSEQUENCES OF SCENARIOS

This short paragraph describes how user water quality (i.e. UserSpecs for uses such as irrigation and stock watering, industrial, domestic, recreation) were incorporated into an evaluation of the consequences of scenarios on a stretch of river. The following steps were followed:

- Identify the RU or nodes of interest (nested within IUAs) which may potentially be impacted by the scenarios;
- Gather background information on water users in the catchment and previously set objectives for water quality (where available);
- Use land use information and the Water Quality Status Quo task conducted for the study to identify which users are located where, and where the water quality hotspot areas are found;
- Link users to the RUs or nodes of interest which may potentially be impacted by the scenarios;
- Identify the user groups water quality requirements and drivers of water quality;
- Utilize the ecological information from the Reserve study to describe aquatic ecosystem requirements;
- Identify primary users and driving water quality variables;
- Test this information with the Technical Task Group and update as required;
- Provide an impact rating of selected scenarios on water quality at identified sites for the driving user(s). Weight sites to achieve ranks relative to each other and rank the rank the scenarios in terms of water quality impact, if required.

To summarize, user water quality state per scenario and per relevant RU and IUA were scored using the driving water quality variables linked to the primary water quality user(s). Note that although the aquatic ecosystem is the resource base rather than a "user", it is grouped and evaluated with other users for purposes of this step of the Classification process.

## 8. INTEGRATION OF CONSEQUENCES AND LINKS TO WATER RESOURCE CLASSES

The determination of the overall grading of the scenarios (from best to worst) were undertaken by integrating the consequences of the four variables, ecology, ecosystem services, economy and employment by applying multi-criteria analysis techniques. This method is ideal for comparing scenarios where the outcomes of the drivers are quantified in dissimilar numeric values. In this analysis the consequences for the economy is expressed in rand, employment in terms of number of people, while the ecology health is rated relative to the Recommended Ecological Category scenario and the ecosystem services relative to the present conditions. The scenario scores for the four variables are visually presented together in Figures 6-9 and at the bottom of each bar the relative weight applied to each variable indicates the relative importance of each variable. At the one side of "the balance" is the ecology and as indicated it is assigned a weight of 0.5 or 50%. The remaining three variables represent the "other side of the balance" with their combined weights adding up to 0.5 of 50%. These weights are used to "weigh" the variable ratings in deriving the overall score for each scenario. (Further details will be provided at the meeting). The integrated ranking following the normalised method is also provided in the figures.

**Komati River system Recommended Scenario:**

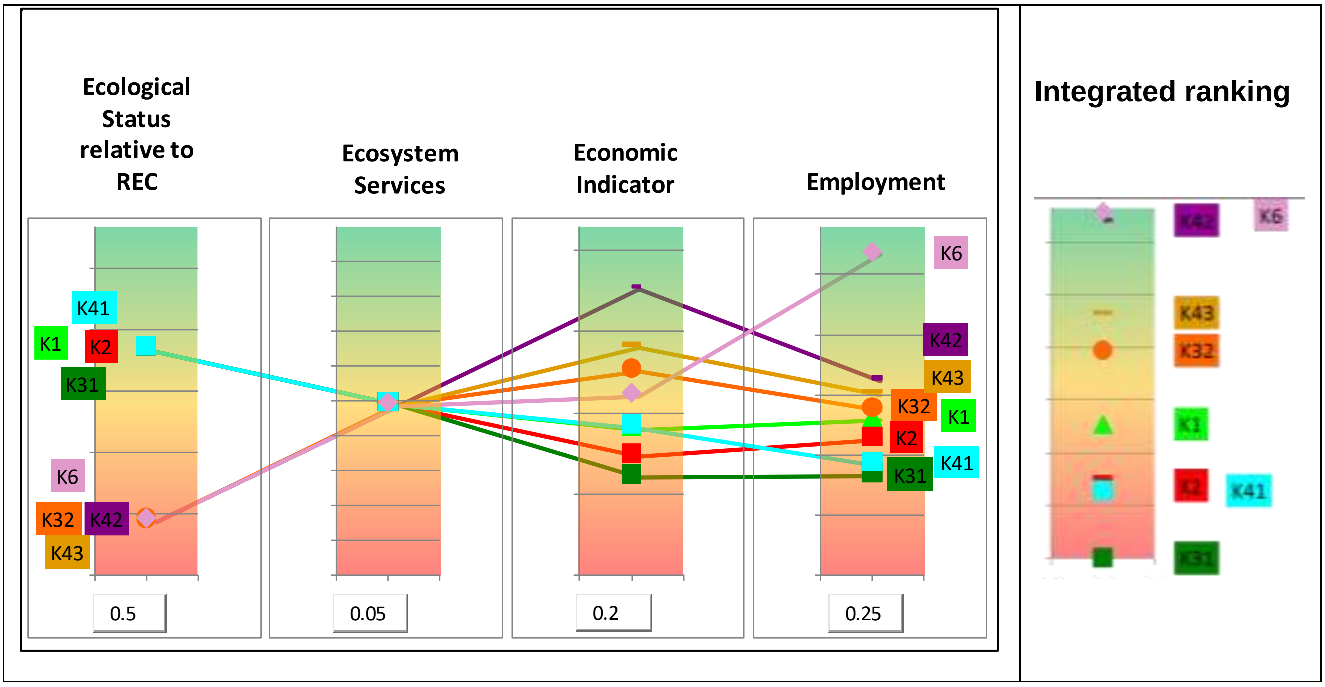



**Figure 6: Graphical results of overall ranking from the multi-criteria analysis (normalised method) for the Komati River system**

Scenarios K42 and K6 rank the highest among the scenarios with both having similar scores. Sc K6 has the highest employment score while Sc 42 the highest economic score. The selection of either scenario for the purpose of classification would result in the same Water Resource Class and set of Ecological Categories for the biophysical nodes in the system. It can therefore be concluded that for the Komati River system the Water Resource Class and the set of ECs for the biophysical nodes is not sensitive to the range of scenarios that were evaluated and analysed.

**Crocodile River system recommended scenario**

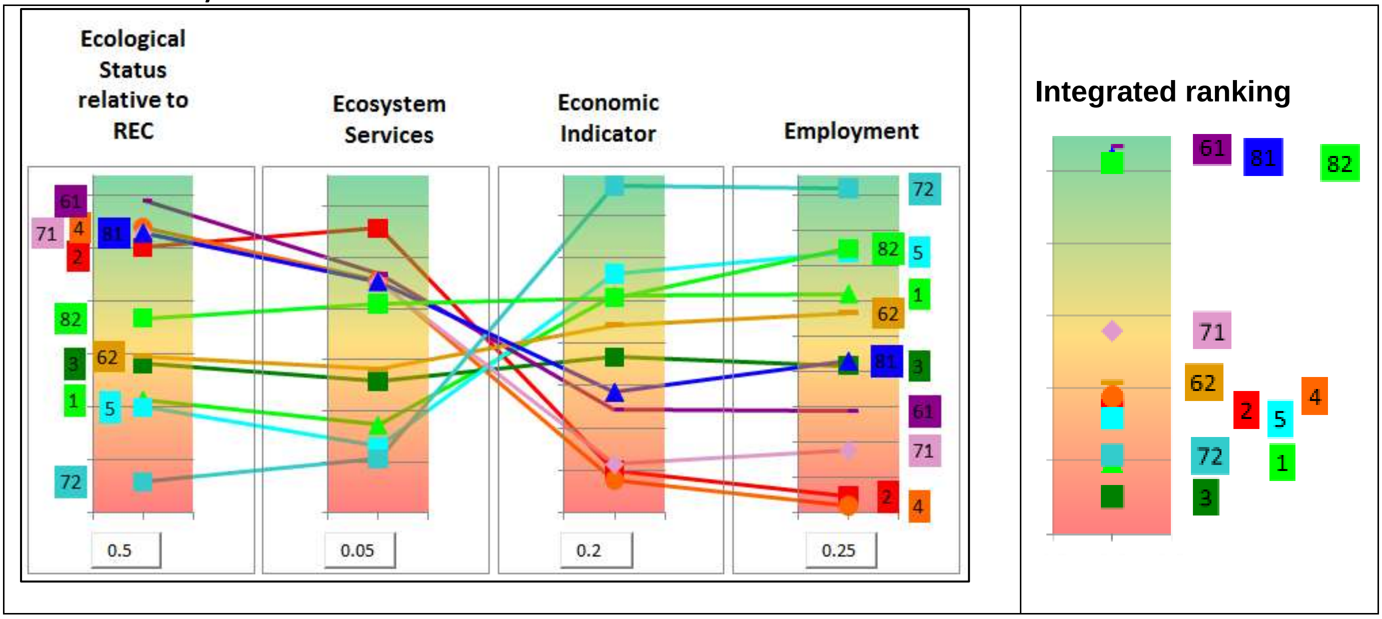



**Figure 7:Graphical results of overall ranking from the multi-criteria analysis (normalised method) for the Crocodile River system**

The scenario scores indicated that there is a large advantage in the socio-economic variable scores for Sc C82 compared to Sc C61, while the ecology is maintained at a level slightly above the Present Ecological State (as represented by Scenario 1). This implies Sc C82 is an improvement for both the ecology and socio-economics compared to current conditions (Sc C1) while Sc C61 only improves the ecology. A further aspect to consider is that the ecological score for Sc C61 is the highest for all the scenarios and as such represents an "extreme" option and not a balanced outcome.

It is proposed that Sc C82 be selected as the preferred scenario for the long term future.Scenario C82 incorporates both the future development options (Mountain View and Boschjeskop dams), which have the risk that it will be a long time before both dams are developed. Sc C62 (includes only Mountain View Dam) is therefore proposed as the scenario to be aimed at over the medium term future since Mountain View Dam has a higher probability of being developed. Over the short term the selection is between Sc C1 and Sc C3. Scenario C3 includes additional water for Mozambique, makes releases towards improving the current ecological conditions as well as allows for growth in domestic water supply and is therefore proposed for the preferred scenarios for the short term. All three the proposed scenarios (Sc C3, C62 and C82) are where the "PES" releases are the target EWR and allow progressive improvements in both the ecological health as well as the socio-economic conditions in future.

**Sabie River system recommended scenario**

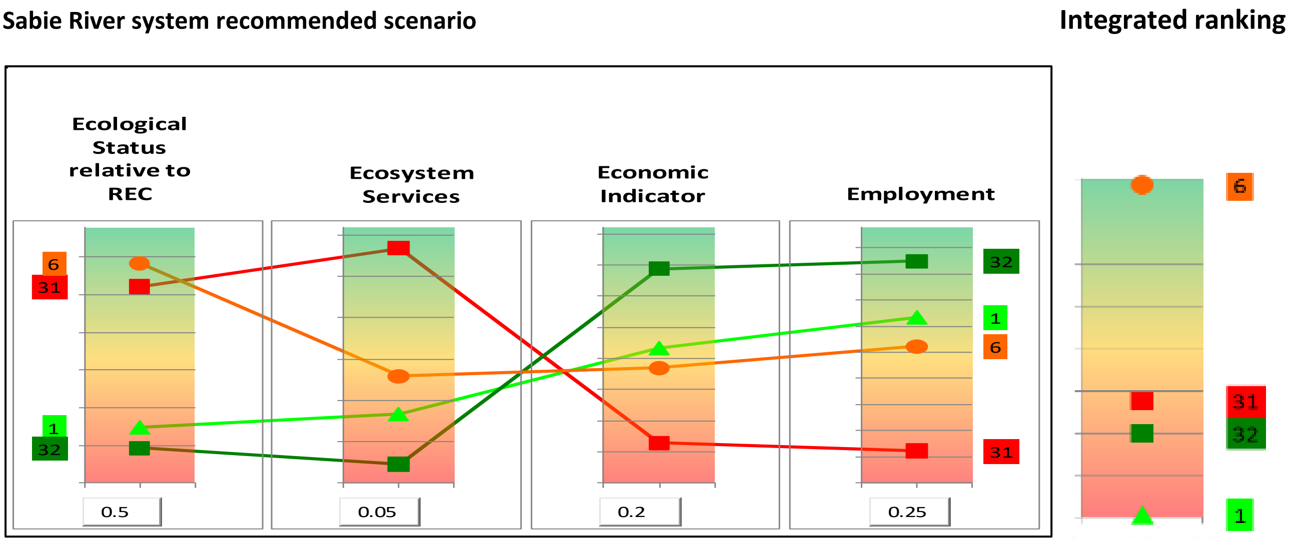



**Figure 8: Graphical results of overall ranking from the multi-criteria analysis (normalised method) for the Sand River system**

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

Scenario S6 in the Sabie implies that additional water for growth in water use in the urban domestic sector need to be sourced and the proposed New Forest Dam (see description of Sc S71) in the Sand River system serve as a solution to make more water available.

**Sand River system recommended scenario**

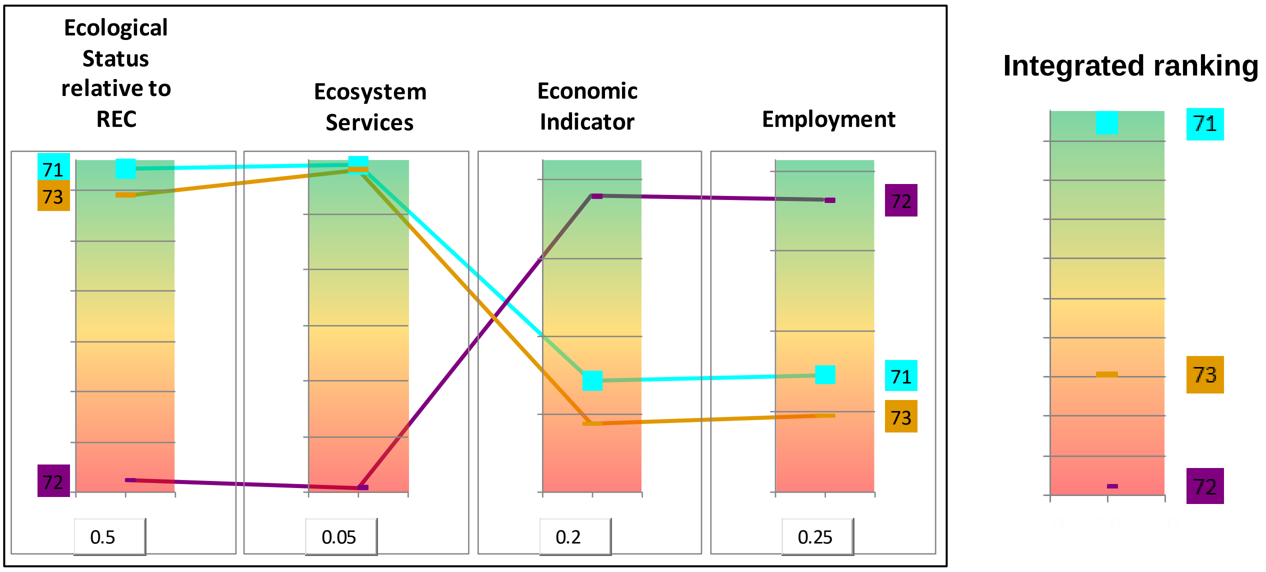



**Figure 9: Graphical results of overall ranking from the multi-criteria analysis (normalised method) for the Sand River system**

Based on the results of a sensitivity analysis, it was concluded that Sc S71 is recommended as the preferred scenario for deriving the Water Resource Classes. This scenario includes the New Forest Dam to be constructed and a portion of the EWR to be released.

## RECOMMENDED WATER RESOURCE CLASSES AND ECOLOGICAL CATEGORIES

Based on the above recommendations the following Water Resource Classes are derived and recommended.

**Komati River system**

| IUA | Scenarios and Water Resource Class | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PES | REC | K1 | K2 | K31 | K32 | K41 | K42 | K43 | K6 |
| X1-1 | III | III | III | III | III | III | III | III | III | III |
| X1-2 | II | II | II | II | II | II | II | II | II | II |
| X1-3 | II | II | II | II | II | II | II | II | II | II |
| X1-4 | III | III | III | III | III | III | III | III | III | III |
| X1-5 | II | I | II | II | II | II | II | II | II | II |
| X1-6 | II | I | I | I | I | I | I | I | I | I |
| X1-7 | II | I | II | II | II | II | II | II | II | II |
| X1-8 | III | II | III | III | III | III | III | III | III | III |
| X1-9 | III | III | III | III | III | III | III | III | III | III |
| X1-10 | XXX | III | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

Following on from the selection of Sc K42 as the preferred scenario for the Komati River system, the embossed column in Table 8.8 gives the recommended Water Resource Classes. The results for IUA 10 (maps showing IUAs are attached as Appendix C) indicated by "XXX" imply that these scenarios did not comply with the criteria for a Class III. This is due to a large portion of the river reach length in EC D, D/E or E (mostly due to inundation and the significant number of weirs) and therefore not complying with the criteria set in Table 8.1.

**Crocodile River system**

| IUA | Scenarios and Water Resource Class | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PES | REC | C1 | C2 | C3 | C4 | C5 | C61 | C62 | C71 | C72 | C81 | C82 |
| X2-1 | II | II | II | II | II | II | II | II | II | II | II | II | II |
| X2-2 | II | II | II | II | II | II | II | II | II | II | II | II | II |
| X2-3 | I | I | I | I | I | I | I | I | I | I | I | I | I |
| X2-4 | II | II | II | II | II | II | II | II | II | II | II | II | II |
| X2-5 | I | I | I | I | I | I | I | I | I | I | I | I | I |
| X2-6 | II | I | II | II | II | II | II | II | II | II | II | II | II |
| X2-7 | II | I | I | I | I | I | I | I | I | I | I | I | I |
| X2-8 | XXX | II | II | II | II | II | II | II | II | II | II | II | II |
| X2-9 | II | I | II | II | II | II | II | II | II | II | II | II | II |
| X2-10 | II | II | II | II | II | II | II | II | II | II | III | II | II |
| X2-11 | II | I | II | I | II | I | III | I | II | I | III | I | II |
| X2-12 | II | II | II | II | II | II | II | II | II | II | II | II | II |
| X2-13 | I | I | I | I | I | I | I | I | I | I | I | I | I |

Following on from the selection of Sc C3, C62 and C82 as the preferred scenarios for the Crocodile River system, the embossed columns in the table gives the recommended Water Resource Classes, note that the Water Resource Classes are the same for all three scenarios. The result for IUA 8, indicated by "XXX" for the PES implies the under the current situation, the WRC does not comply with the criteria for a Class III.

**Sabie River system**

| IUA | Scenarios and Water Resource Class | | | | | |
|---|---|---|---|---|---|---|
| | PES | REC | S1 | S31 | S32 | S6 |
| X3-1 | II | I | I | I | I | I |
| X3-2 | II | I | I | I | I | I |
| X3-3 | I | I | II | I | II | I |
| X3-4 | III | III | III | III | III | III |
| X3-5 | I | I | II | I | II | I |
| X3-6 | I | I | I | I | I | I |

Following on from the selection of Sc S6 as the preferred scenario for the Sabie River system, the embossed column in the table gives the recommended Water Resource Classes. The WRC for X3-1 and X3-2 is as for the REC. Improvements that are required are non flow-related and not associated with the scenario.

It must be noted that as Sc 6 consists largely of the current situation of the dam with no new proposed infrastructure; Sc 6 will be relevant for the short, medium and long term.

**Sand River system**

| IUA | Scenarios and Water Resource Class | | | | |
|---|---|---|---|---|---|
| | Status quo | REC | S71 | S72 | S73 |
| X3-7 | III | III | III | XXX | III |
| X3-8 | II | II | II | II | II |
| X3-9 | I | I | I | I | I |

Following on from the selection of Sc S71 as the preferred scenario for the Sand River system, the embossed column in the table gives the recommended Water Resource Classes. The result for IUA X3-7, indicated by "XXX" for S72 implies the scenarios did not comply with the criteria for a Class III. This is due to no releases made for the ecology from the proposed New Forest Dam in those scenarios, resulting in EC of "F" for EWR 6.

It must be noted that as S71 includes a new dam (the New Forest Dam) that may only be constructed in the far future, the current state in the short term will be recommended and S72 in the long term if New Forest Dam is constructed.

## 9. RESOURCE QUALITY OBJECTIVES

RQOs capture the **Management Class** of the Classification System and the **ecological needs determined in the Reserve** into **measurable management goals** that give direction to resource managers as to how the resource needs to be managed. Resource Quality Objectives provide **numerical and/or descriptive statements** about the **biological, chemical and physical attributes that characterise a resource for the level of protection defined by its Class**. The NWRS therefore stipulates that "*Resource Quality Objectives might describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota*".

The links between Scenarios, Water Resource Classes and Resource Quality Objectives are illustrated in the figure below:


Different level (in terms of detail) RQOs are set for river reaches or Resource Units which are represented by biophysical nodes. During this study the aspects that feed into the determination of RQOs have already been undertaken eg:

- Identification of priority Resource Units (rivers and wetland).
- Determination of EWRs (flow component of RQOs).
- Determination of Ecological categories
- Determination of water quality hotspots that provides indication of the priority areas for user specifications.

More recently, the biological indicators and driving variables for water quality has been identified, and the narrative RQOs determined for rivers, wetland and groundwater. The RQOs will be provided and further discussed at the PSC meeting.

## 10. WHY SHOULD YOU REMAIN INVOLVED IN THE STUDY?

It is important to understand that this study will eventually impact on you as a water user, as it will determine the management measures in order to sustainably manage the Inkomati Water Management Area catering for all water users including the aquatic ecosystem. Since this is your catchment, it is important that you become involved in the stakeholder engagement process and technical process.

Stakeholders are invited to participate in the process by contributing information at meetings, workshops or on requests by the study team, by communicating with a PSC member or by corresponding with the public participation office with queries and comments.

Previous information documents on this study are available on the DWA website. Should you wish to review these documents and completed study reports, you are welcome to access them on the DWA website:
**http://www.dwa.gov.za/rdm/WRCS/default.aspx**

# Appendix A: Scenarios Analysed

## Komati (X1) scenarios

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

1 Interim IncoMaputo Agreement

## Crocodile (X2) scenarios

| Scenario | Scenario Variables | | | | | | |
|---|---|---|---|---|---|---|---|
| | Update water demands with revised PES EWR | Updated water demands | Domestic growth | IIMA[2] Flows | Mountain View Dam (Kaap) | Boschjeskop Dam (Nels) | EWR |
| C1 | Yes | No | No | No | No | No | No |
| C2 | No | Yes | No | No | No | No | REC |
| C3 | No | Yes | Yes | Yes | No | No | PES |
| C4 | No | Yes | Yes | Yes | No | No | REC |
| C5 | No | Yes | Yes | Yes | Yes | No | No |
| C61 | No | Yes | Yes | Yes | Yes | No | REC |
| C62 | No | Yes | Yes | Yes | Yes | No | PES |
| C71 | No | Yes | Yes | Yes | No | Yes | REC |
| C72 | No | Yes | Yes | Yes | No | Yes | No |
| C81 | No | Yes | Yes | Yes | Yes | Yes | REC |
| C82 | No | Yes | Yes | Yes | Yes | Yes | PES |

1 Water Conservation/Water Demand Management

2 Interim IncoMaputo Agreement

## Sabie sub-catchment scenarios

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

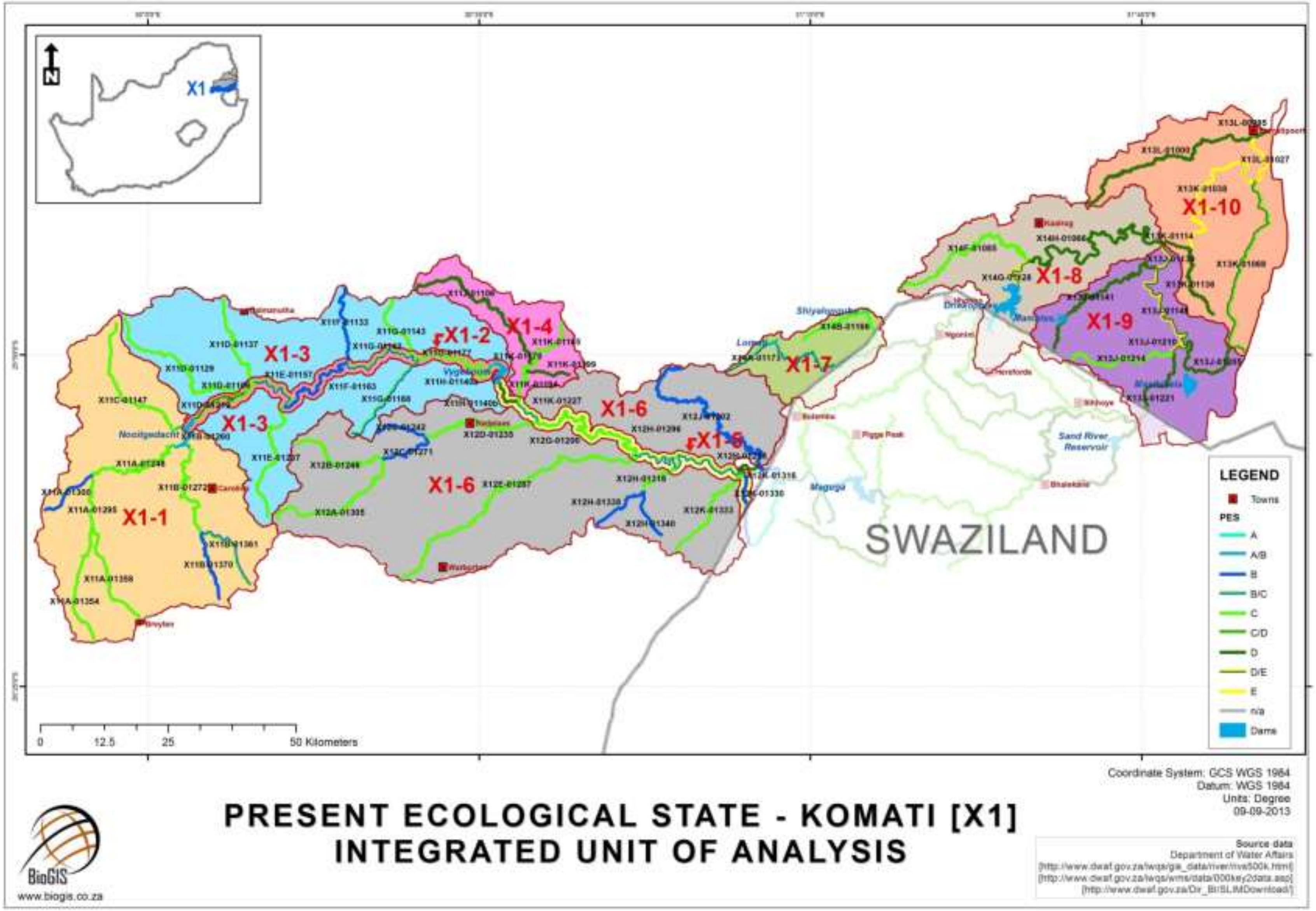
**Sand sub-catchment scenarios**

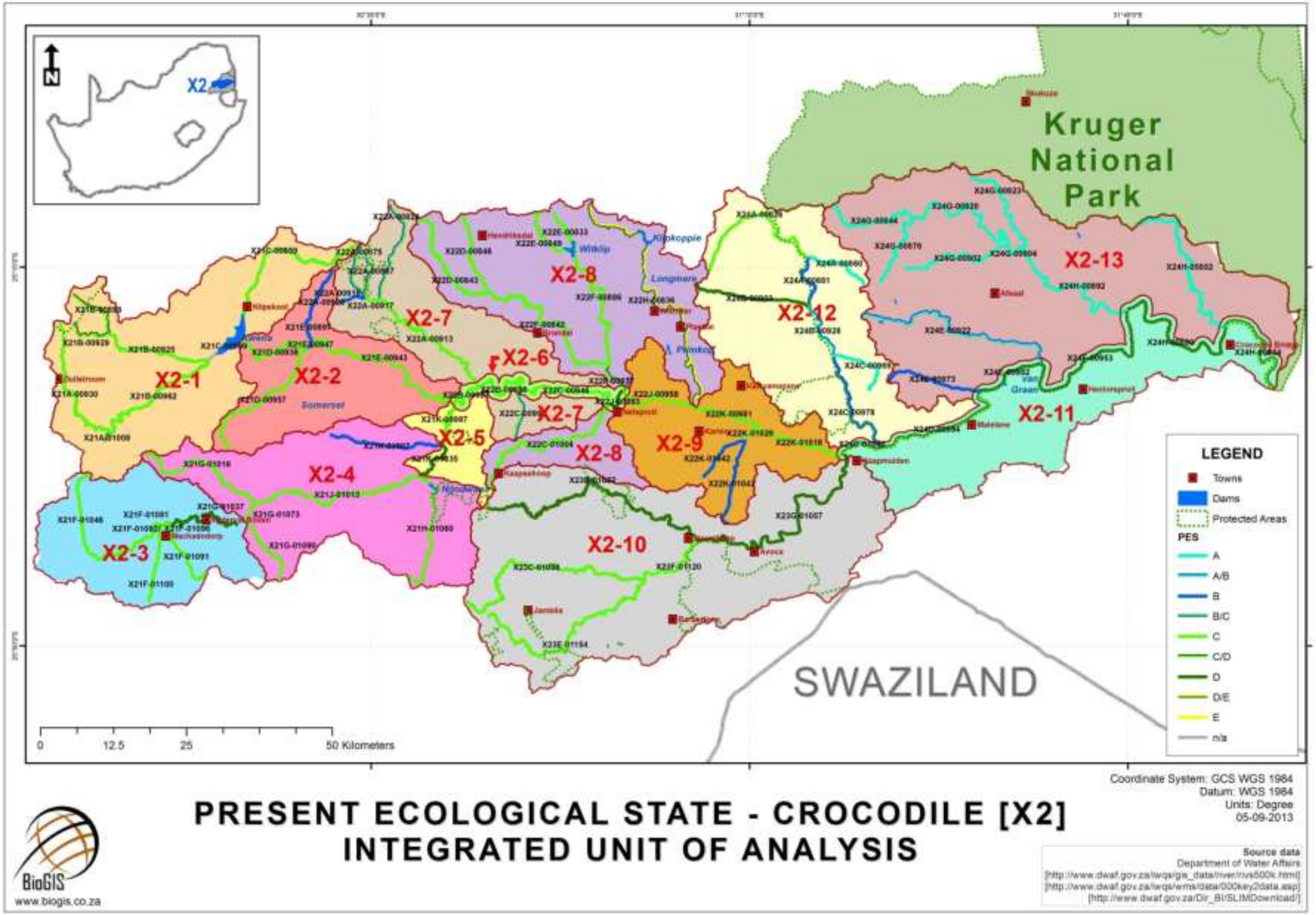
| Scenario | SCENARIO VARIABLES | | | | |
|---|---|---|---|---|---|
| | Update water demands | Growth in water demands | Reinstate Sand Forestry | New Forest Dam (Mutlumuvi River) | EWR |
| S1 | Yes | No, with no return flows | No | No | No |
| S4 | Yes | Yes, with 50% return flows | Yes | No | No |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

## Appendix B: Details of the EWR sites

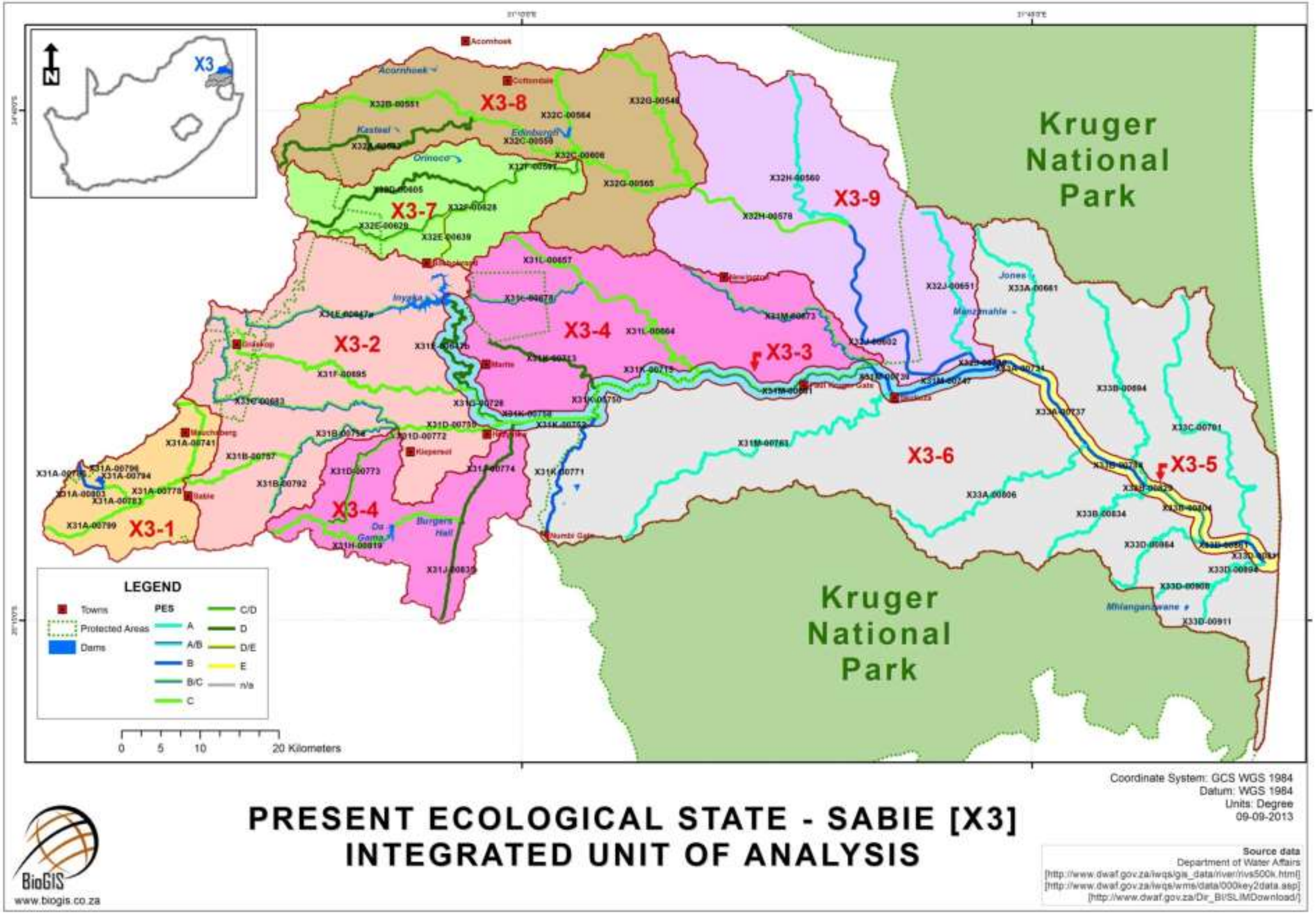
| EWR Site number | EWR Site name | River | Co-ordinates | | Management Resource Unit |
|---|---|---|---|---|---|
| | | | Latitude | Longitude | |
| **Sabie-Sand Catchment (X3)** | | | | | |
| EWR 1 | Upper Sabie | Sabie | 25 04.424 | 30 50.924 | Sabie A |
| EWR 2 | Aan de Vliet | Sabie | 25 01.675 | 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 | Goedehoop | 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 |
| 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 |

**Appendix C: Maps showing Integrated Units of Analysis (IUA)**






**PRESENT ECOLOGICAL STATE - CROCODILE [X2] INTEGRATED UNIT OF ANALYSIS**


X3
N
Kruger National Park
Kruger National Park
X3-1
X3-2
X3-3
X3-4
X3-4
X3-5
X3-6
X3-7
X3-8
X3-9
LEGEND
Towns
Protected Areas
Dams
PES
A
A/B
B
B/C
C
C/D
D
D/E
E
n/a
0 5 10 20 Kilometers
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
09-09-2013
PRESENT ECOLOGICAL STATE - SABIE [X3]
INTEGRATED UNIT OF ANALYSIS
Source data
Department of Water Affairs
[http://www.dwaf.gov.za/iwqs/gis_data/river/rivs500k.html]
[http://www.dwaf.gov.za/iwqs/wms/data/000key2data.asp]
[http://www.dwaf.gov.za/Dir_BI/SLIMDownload/]
BioGIS
www.biogis.co.za