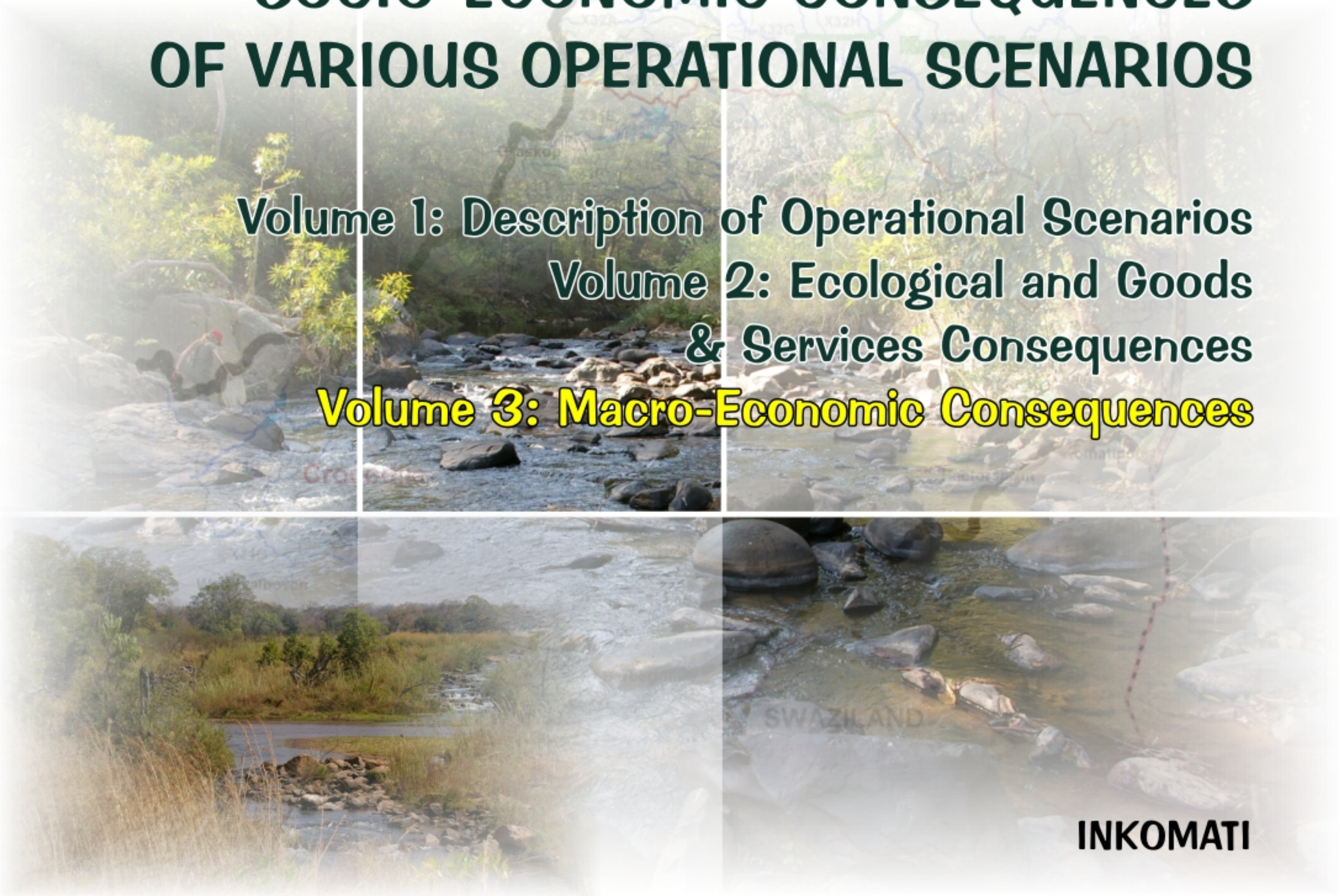
Comprehensive Reserve Determination Study for Selected Water Resources (Rivers, Groundwater and Wetlands) in the INKOMATI WATER MANAGEMENT AREA, MPUMALANGA

PROJECT NO: WP 9133

ECOLOGICAL, GOODS & SERVICES AND SOCIO-ECONOMIC CONSEQUENCES OF VARIOUS OPERATIONAL SCENARIOS



Volume 1: Description of Operational Scenarios
Volume 2: Ecological and Goods & Services Consequences
Volume 3: Macro-Economic Consequences

INKOMATI

MARCH 2010 **REPORT NO.: 26/8/3/10/12/011**

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

RfA55_2010

COMPREHENSIVE RESERVE DETERMINATION STUDY FOR SELECTED WATER RESOURCES (RIVERS, GROUNDWATER AND WETLANDS) IN THE INKOMATI WATER MANAGEMENT AREA. MPUMALANGA

SABIE AND CROCODILE RIVER SYSTEMS : OPERATIONAL SCENARIOS AND CONSEQUENCES REPORT: VOLUMES 1 – 3

Approved for Rivers for Africa by:

....	....
Delana Louw	**Adhishri Singh**
Technical Project Manager	**Administrative Project Manager**

Approved for the Chief Directorate: Resource Directed Measures by:

....

Barbara Weston
Study Manager

PREFACE

BACKGROUND

The CD:RDM identified the Inkomati Water Management Area (WMA) as requiring a comprehensive Reserve assessment in light of the initiation of the Compulsory Licensing Process in the WMA and the proposed Montrose and Mountain View Dams. These studies require higher levels of confidence in the Reserve determination results as is currently available in certain of the catchments, such as the Sabie-Sand and Crocodile River catchments. This will assist the DWAF to make informed decisions regarding the authorisation of future water use and the magnitude of the impacts of the present and proposed developments.

The Reserve studies that were previously conducted for the Crocodile and Sabie-Sand river catchments consist of:

- An Intermediate Ecological Reserve study was undertaken during 2002 (Godfrey, 2002) for the Crocodile System. This study will update and refine the Intermediate Ecological Reserve study. The same study sites will be used, but more updated methodologies applied where necessary.
- An Intermediate Ecological Reserve was undertaken during 1996 (Tharme, 1997) for the Sabie-Sand system. Many of the methods now in place were not available at that stage and to complicate matters further, the large floods of 2001 (biggest floods on record) resulted in most of the physical site specific data not being applicable. Where applicable, the same study sites were used, but resurveyed and all historical information was also used within this updated study.

STUDY AREA AND STUDY SITES

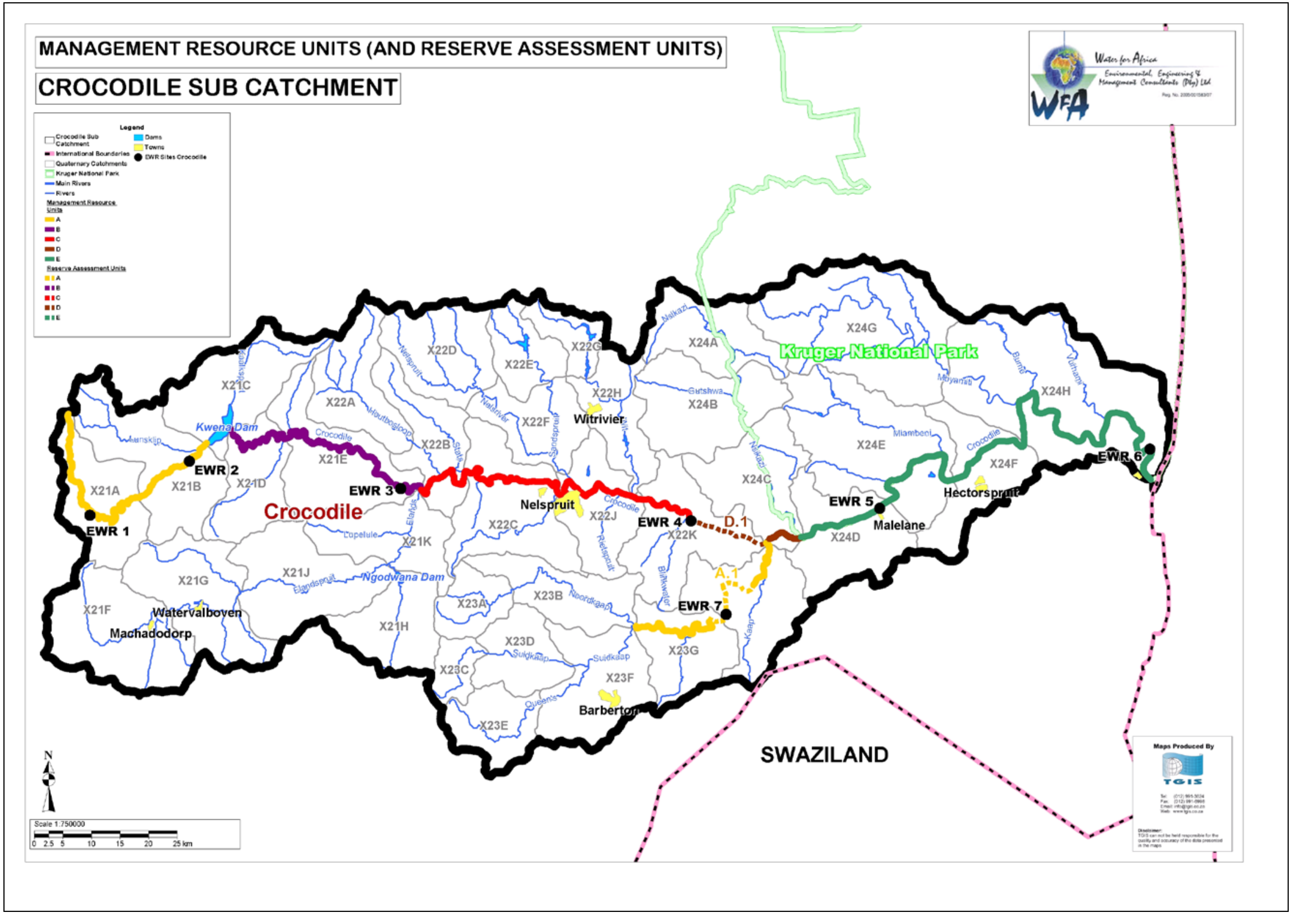
The Inkomati WMA is largely located within the Mpumalanga Province. It can be considered to consist of three largely independent catchments, the Komati, Crocodile (East) and Sabie–Sand River catchments. All these rivers drain the WMA and confluence to form the Incomati River in Mozambique which flows into the Indian Ocean.

The Reserve requirements for the Komati River system (the remaining major river system in WMA 5) was determined and approved in 2003, the results of which are at a high confidence and are still relevant for use and implementation by the DWA. As such it was deemed unnecessary to include this system in the study area. The focus of this study therefore is only on the Crocodile (X2) and Sabie-Sand (X3) catchments. The locality and characteristics of the EWR sites in the Sabie-Sand and Crocodile River catchments are provided in the table below and following two figures. Information on site selection and the Management Resource Units (MRUs) in which they fall are provided in RDM Report 26/8/3/10/12/006 (DWAF, 2008).

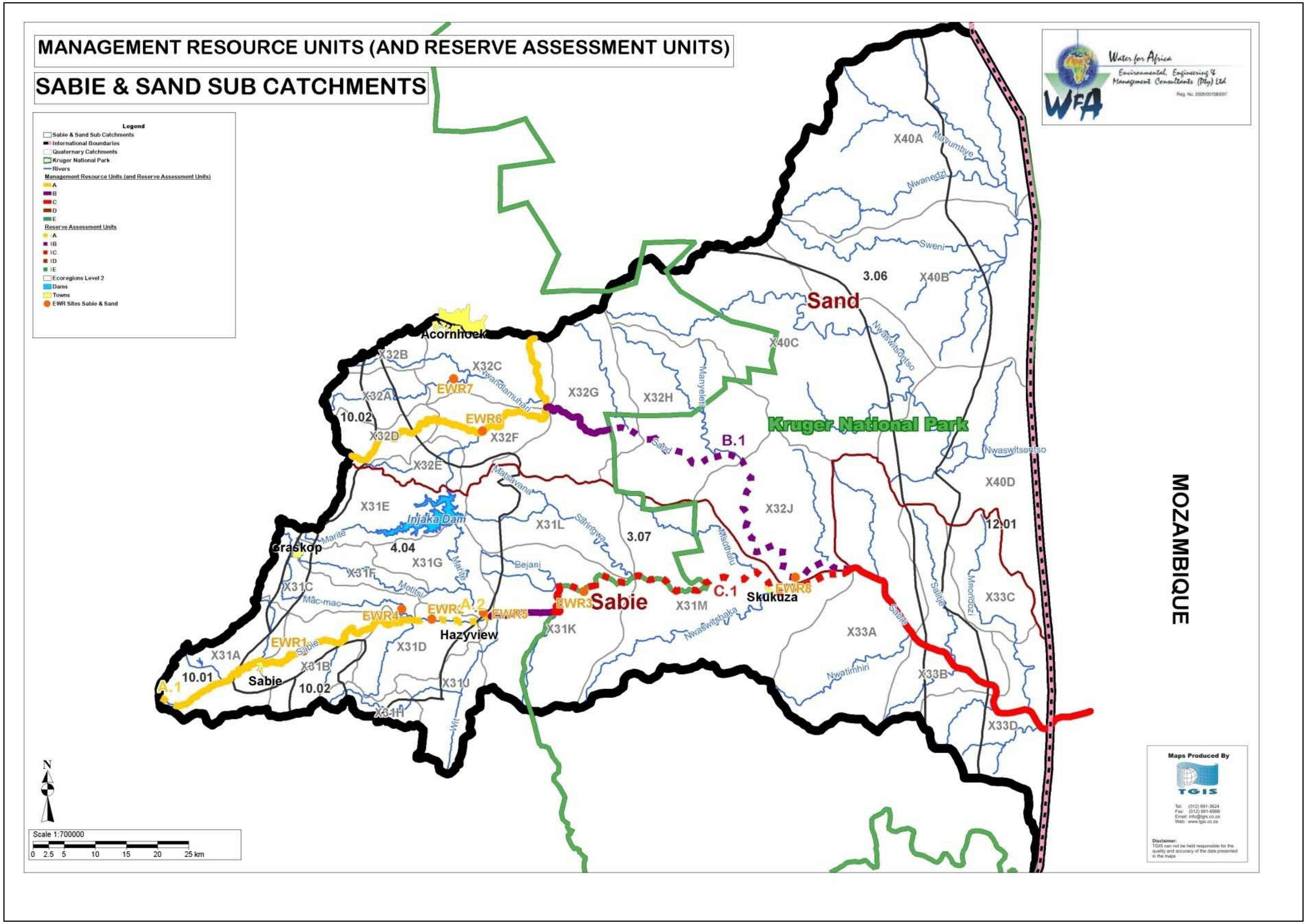
Locality of EWR sites for the Inkomati River System

EWR site no	EWR site name	River	Coordinates		EcoRegion[1] (Level 2)	Geomorphic Zone	Quat[2]
			Latitude	Longitude			
CROCODILE SYSTEM							
EWR 1	Valeyspruit	Crocodile River	S25 29.647	E30 08.656	9.02	Upper Foothills	X21A
EWR 2	Goedehoop	Crocodile River	S25 24.555	E30 18.955	9.04	Upper Foothills	X21B
EWR 3	Poplar Creek	Crocodile River	S25 27.127	E30 40.865	10.02	Lower Foothills	X21E
EWR 4	KaNyamazane	Crocodile River	S25 30.146	E31 10.919	4.04	Lower Foothills	X22K
EWR 5	Malelane	Crocodile River	S25 28.972	E31 30.464	3.07	Lower Foothills	X24D
EWR 6	Nkongoma	Crocodile River	S25 23.430	E31 58.467	12.01	Lower Foothills	X24H
EWR 7	Honeybird	Kaap River	S25 38.968	E31 14.572	4.04	Upper Foothills	X23H
SABIE SYSTEM							
EWR 1	Upper Sabie	Sabie River	S25 04.424	E30 50.924	4.04	Upper Foothills	X31B
EWR 2	Aan de Vliet	Sabie River	S25 01.675	E31 03.099	4.04	Lower Foothills	X31D
EWR 3	Kidney	Sabie River	S24 59.256	E31 17.572	3.07	Lower Foothills	X31K
EWR 4	MacMac	Mac Mac River	S25 00.800	E31 00.243	4.04	Upper Foothills	X31C
EWR 5	Marite	Marite River	S25 01.077	E31 07.997	4.04	Upper Foothills	X31G
EWR 6	Mutlumuvi	Mutlumuvi River	S24 45.352	E31 07.923	3.07	Upper Foothills	X32F
EWR 7	Tlulandziteka	Tlulandziteka River	S24 40.829	E31 05.188	3.07	Lower Foothills	X32C
EWR 8	Sand	Sand River	S24 58.045	E31 37.641	3.07	Lower Foothills	X32J

1 Refer to Kleynhans *et al*. (2007) for EcoRegion description.
2 Quaternary catchment



Crocodile River catchment and locality of EWR sites



Sabie-Sand River catchment and locality of EWR sites

THIS REPORT

This report consists of three separate standalone volumes which each provide a summary of the methods followed and the results. To ensure that a logical process could be followed in any one of the reports, this combined executive summary was provided in each report. This provides the context of all the work undertaken for Step 5 of the Ecological Reserve study.

The report consists of three volumes as follows:

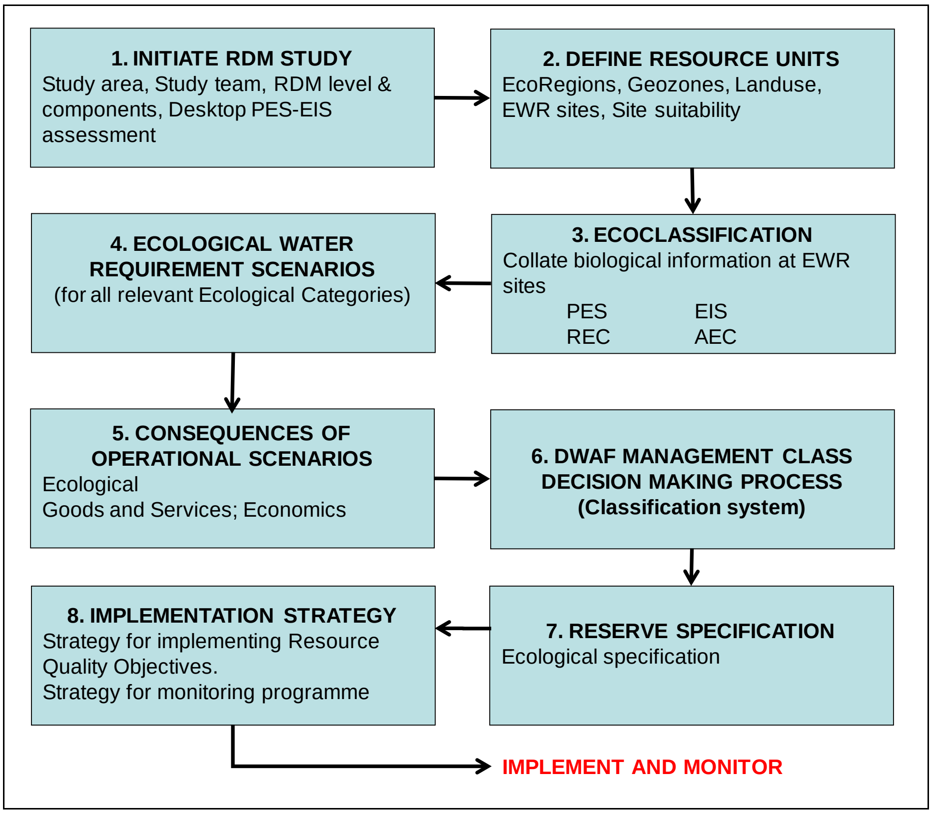
- Volume one: Description of the operational scenarios.
- Volume two: Ecological and G&S consequences of the operational scenarios.
- Volume three: Macro Economic consequences of the operational scenarios.

EVALUATION OF OPERATIONAL SCENARIOS

During this part of an Ecological Reserve study, aspects other than ecology are also considered for the evaluation of various operational flow scenarios and/or future development scenarios. The purpose of this is to provide the decision-maker with sufficient information to make informed decisions regarding the implications of the flow scenario and the Ecological Category which will be signed off as the Ecological Reserve. This will in future form part of the Classification System.

Operational scenarios are any flow scenario other than the present which could be implemented in future.

The Comprehensive Ecological Reserve Methodology was followed within the 8 - step Ecological Reserve process (refer to figure below). This section summarizes step 5 of the Ecological Reserve process that was followed during this study.



The 8-step Ecological Reserve procedure (adapted from DWAF, 1999)

Step 5 refers to the ecological consequences of operational scenarios. However, as part and parcel of the Ecological Reserve approach, this step has been extended since the early 2000s to include the Goods and Services (G&S) and macro economic consequences. In the absence of a Classification system, this was specifically to provide DWA with a greater understanding of the consequences of decisions to either protect or use the water resources in the Crocodile, Sabie and Sand River catchments.

The objective of this Reserve step is therefore to provide sufficient information to the decision maker regarding the operational scenarios and the consequences of these in terms of:

- Ecology
- Goods and Services (G&S)
- Socio Economics

This should then allow for informed decision-making regarding which Ecological Category and Reserve should be signed off.

INFORMATION REQUIRED PRIOR TO THIS STEP

Reserve Step 3: EcoClassification

EcoClassification determines the Present Ecological State (PES) and identifies the changes (from natural) that have taken place resulting in the PES. A Recommended Ecological Category (REC) based on the Ecological Importance and Sensitivity (EIS) is also identified as well as the issues that will have to be addressed to achieve this REC (if different from the PES).

A suite of models is used to determine the EcoClassification. This process has to be in place and finalised prior to step 5. Ecological consequences are described in terms of changes in Ecological Category from the PES, and a good understanding of the PES is therefore required. The models are used in a predictive fashion to estimate what the resulting EC will be for each operational scenario.

Reserve Step 4: EWR scenarios

The term EWR scenario refers to flow regimes set for a range of ECs. The resulting flow regimes, serve as a baseline against which to measure the consequences on the PES of the flow regimes associated with the various operational flow scenarios.

This information is also used during the design of the operational scenario phase to assess the implications of the Reserve and can guide the design of the operational scenarios.

Goods and Services

The consequences of operational scenarios on the G&S must be assessed. It is therefore required to identify the relevant G&S as well as to estimate a value of the G&S. This serves as the baseline and changes based on the different operational scenarios are measured against this. The focus is on G&S that will change due to changes in flow and the associated responses of the other physical drivers and biota.

Socio Economics

The economic impact of the proposed operational scenarios is measured against the deviation from the current economic activities. This entails that a detailed analysis of the current activities of water use are performed and expressed in terms of Gross Domestic Product (GDP), Employment and impact on households and specifically on Low Income Households. The parameters are expressed in terms of direct, indirect and induced impacts.

If a specific scenario is by implication causing a curtailment in the volume of available water the impact of the lower volume is calculated and expressed. The curtailment of a specific activity takes place against a number of assumptions. It is assumed that domestic and industrial water will be provided within an active Water Conservation and Demand Management program. This does not apply for irrigation water and is it mostly the irrigation activities that are curtailed.

In the case of a volume curtailment it is accepted that the area is reduced. When decreasing "Assurance of Supply" the long term average production yield is lowered. In the case of curtailment, the low value crops are reduced first, followed by the higher value crops. In the final instance the macro economic impacts of the different scenarios are presented to assist in the final decision making process.

STEP 5: DETERMINING CONSEQUENCES TO OPERATIONAL SCENARIOS

Identifying and determining operational scenarios

The operational scenarios mostly focus on different flow scenarios. There are two types of operational flow scenarios:

a) Changes in the present operation in terms of flow.

b) Future development scenarios (which will result in different operational flow scenarios).

The Reserve team is dependent on the client supplying the operational scenarios. Usually, the Reserve team and the managing client body, in this case DWA and specifically the Project Management Team, will facilitate the process. Various meetings were held to present findings, discuss preliminary results, and to agree on a final range of the most likely and realistic scenarios to be provided for assessing consequences.

Part and parcel of this process is yield modelling. The flow time series at various points in the catchment were provided through a water resources systems model in terms of natural and present day flows. A monthly time step was used in all these simulations. Prior to identifying the operational scenarios, the EWR scenarios for different ECs was run through the yield model to identify whether the EWR scenarios could be met and, if not, how much could be met and where (in terms of seasons etc.) the problems lie.

This information can then provide guidance for identifying operational scenarios. Three hypothetical examples of the rationale and type for different scenarios are provided:

- If it is identified that the Reserve can mostly be met except during the dry season in very dry years, the EWR drought flows can be decreased by an estimated percentage and this will serve as one of the scenarios. The EWR specialists will then assess what the implications are of the decreased flows in terms of EC.
- Another example could be that a new irrigation development is being planned and an existing dam has to supply the water for this irrigation development. The yield modelling process will include this future irrigation development and then assess the resulting flows at each EWR site. The EWR specialist will again assess the consequences on EC.
- Future development scenarios could consist of a new dam and transfer scheme. These kinds of scenarios are complicated as each future development scenario consists of its own range of scenarios, which is dependent on how the system will be operated.

Once all the scenarios are identified, the output from the yield model is provided in the required format for consequences assessment. Volume 1 in this report series documents the operational scenarios that were modelled and the consequence of these scenarios on system yield.

Assessing consequences of operational scenarios

a) Ecological consequences

Detail is provided in Volume 2 regarding this process. In summary, the flow regime at each EWR site and for each scenario is provided as a flow duration table. This information is used either in this format, or converted to ecological stress. Where necessary, the response of the fluvial geomorphology, physico-chemical variables and biota, is modelled to assess the EC for each operational flow scenario.

b) Goods and Services

Detail is provided in Volume 2 regarding this process. In summary, the ecological specialists evaluate whether the identified Goods and Services will change in terms of order of magnitude for each operational scenario.

c) Socio-economics

Detail is provided in Volume 3 regarding this process. The economic baseline of irrigation agriculture water use was established per allocation zone and the value of water was expressed in terms of the contribution to Gross Domestic Production (GDP), Employment and Low Income Households. The changed due to each operational scenario as well as the EWR scenarios are determined.

ACRONYMS AND ABBREVIATIONS

AEC	Alternative Ecological Category
CD: RDM	Chief Directorate: Resource Directed Measures
CD:RDM	Chief Directorate: Resource Directed Measures
COMBUD	Computer Based Budgets
D:RQS	Directorate: Resource Quality Services
DWA	Department of Water Affairs (Name change 2009)
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
EZ	Economic Zone
FDI	Flow dependent macroinvertebrate
FFHA	Fish Flow Habitat Assessment
FRAI	Fish Response Assessment Index
FROC	Fish Frequency of Occurrence
FV	Future value
GDP	Gross Domestic Product
G&S	Goods and Services
GAI	Geomorphology Assessment Index
HFSR	Habitat Flow Stressor Response
LSR	Large semi-rheophilic fish
MAR	Mean Annual Runoff
MCM	Million Cubic Metres
MCM/annum	Million Cubic Metres per annum
MIRAI	Macroinvertebrate Assessment Index
MRU	Management Resource Unit
MVI	Marginal vegetation macroinvertebrate
PAI	Physico-chemical Assessment Index
PD	Present Day
PDH	Present Day Hydrology
PES	Present Ecological State
Quat	Quaternary catchment
REC	Recommended Ecological Category
SAM	Social Accounting Matrix
Sc	Scenario
SR	Small rheophilic fish
VEGRAI	Riparian Vegetation Response Assessment Index
WIM	Water Impact Model
WMA	Water Management Area

Department of Water Affairs

Chief Directorate: Resource Directed Measures

COMPREHENSIVE RESERVE DETERMINATION STUDY FOR SELECTED WATER RESOURCES (RIVERS, GROUNDWATER AND WETLANDS) IN THE INKOMATI WATER MANAGEMENT AREA, MPUMALANGA

CROCODILE RIVER AND SABIE-SAND SYSTEM: OPERATION SCENARIOS AND CONSEQUENCES REPORT

VOLUME 3:
MACRO ECONOMIC CONSEQUENCES

MARCH 2010

AUTHOR: Conningarth Economists

PREPARED BY: Rivers for Africa
PO Box 1684
Derdepark
Pretoria
0053

DWA Project No: WP 9133
Report No: 26/8/3/10/12/011

Reports as part of this project:

Report no	Report title
26/8/3/10/12/001	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Inception report
26/8/3/10/12/002	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Desktop EcoClassification report
26/8/3/10/12/003	Newsletters
26/8/3/10/12/004	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Basic Human Needs Reserve report
26/8/3/10/12/005	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Groundwater report
26/8/3/10/12/006	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Resource Unit report
26/8/3/10/12/007	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Desktop Estimation report
26/8/3/10/12/008	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Wetland report
26/8/3/10/12/009	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: EcoClassification report
26/8/3/10/12/010	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: EWR scenario report
26/8/3/10/12/011	**Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Operation Scenarios and Consequences report. Operation Scenarios and Consequences report**
26/8/3/10/12/012	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: EcoSpecs report
26/8/3/10/12/013	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Socio Economic Present State Evaluation Report
26/8/3/10/12/014	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Training audit and report
26/8/3/10/12/015	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Main report
26/8/3/10/12/016	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Electronic information and data

Bold indicates this report which consists of Volume 3 of a 3 part series of reports used to describe the operational scenarios that were evaluated and their ecological goods and services and macro-economic consequences.

THIS REPORT IS TO BE REFERENCED AS FOLLOWS:

Department of Water Affairs, South Africa. 2010. Comprehensive Reserve Determination Study for Selected Water Resources (Rivers, Groundwater and Wetlands) in the Inkomati Water Management Area, Mpumalanga. Crocodile River and Sabie-sand system: Operation Scenarios and Consequences Report. Volume 3: Macro Economic Consequences. Authored by Conningarth Economists for Water for Africa, edited by Louw, MD and Koekemoer, S. RDM Report no 26/8/3/10/12/011.

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Authors of the report:
William Mullins

Contributors to the process:
Toriso Tlou
Stephan Mallory

Trainee:
Riekie Cloete

EXECUTIVE SUMMARY

VOLUME 1: THE DESIGN OF OPERATIONAL SCENARIOS

CROCODILE SUB-SYSTEM GROUP 1: EWR DEMANDS EXCLUDED

Scenarios C1 to C6*: A combination of operating rules, restrictions, and/or curtailments applied*: The scenarios related mainly to the option to either introduce curtailments to water users (by means of compulsory licensing) or to introduce harsher restrictions than assumed in the Base Scenario. While a wide range of possible options have been modelled, the river flow is very similar for many of the scenarios. Under Sc C3 and Sc C6 the water saved by the restrictions of irrigation resulted in increased yield of Kwena Dam and two additional scenarios, Sc C3.1 and C6.1 were modelled and the ecological consequences were determined. Under these scenarios the increased yield was released down the river to determine how much of the additional yield would supply the EWRs.

Scenario C7: *New dam at Montrose:* A new dam will be constructed at the Montrose site which is located just downstream of the confluence of the Crocodile and Elands Rivers. In order to keep this analysis uncomplicated, the following assumptions were made:

- The Montrose Dam would replace the Kwena Dam as being the main regulator of flow in the Crocodile River. Kwena Dam would supplement the Montrose Dam by making releases when the storage in Montrose Dam drops to below 10% of its full supply capacity.
- Montrose Dam would not contribute to the ecological flow requirements of the Crocodile River (in this scenario).
- The water abstracted from the Montrose Dam (i.e. yield) was supplied directly from the dam and not released into the Crocodile River to supplement downstream users. No restriction was imposed on the yield i.e. it was the historic firm yield of the dam.
- The Base Scenario restriction rules were applied to existing users in the catchment.

Scenario C8: *New dam at Mountain View:* This scenario consisted of the Mountain View site which is located a few kilometres upstream of the confluence of the Kaap and Crocodile Rivers. The same assumptions as for Montrose Dam were made.

Scenario C9: *New dams at Montrose and Mountain View:* In this scenario it was assumed that new dams would be constructed at the Mountain View and Montrose site.

Scenario C11: *No cross-border flows:* One of the main drivers of the low-flow under current operating conditions is the cross-border flows. As the lower Crocodile River has in the past flowed at very low flows, it was requested that the scenario of not supplying these minimum flows be modelled.

CROCODILE SUB-SYSTEM GROUP 2 SCENARIOS: EWR DEMANDS INCLUDED

The scenarios presented in this section pertain specifically to implementing the EWR for the Recommended Ecological Category (REC) and the Present Ecological State (PES) (basically EWR scenarios). Operating rules which entailed a range of restrictions and curtailments were developed to meet the EWR scenarios.

Scenario C10 and C12: ***Reduced releases from Kwena Dam to meet the PES (Sc C10) and REC (Sc C12) EWR at EWR 3:*** Under the current operation of the Crocodile system water is released out of the Kwena Dam into the Crocodile River to supplement the water supply to irrigators riparian to the river. Due to the large irrigation water demands throughout winter, the flow in the Crocodile River at EWR 3 is often higher than natural during the winter. As summer releases are often not made due to sufficient inflow from tributaries to supply irrigation requirements, the low flows in summer are abnormally low, resulting in a seasonal reversal. In order to assess the economic impact of avoiding this unseasonal flow, this scenario modelled releases into the Crocodile River only to meet the EWR 3 requirements. Although the total supply to the irrigation sector remained relatively high, the irrigators located near the end of the Crocodile River would experience very low assurance of supply. Also, the international requirements would not be met.

Scenario C13: ***Meet the Present Ecological status at EWR 6:*** **The PES would be maintained with PRESENT DAY HYDROLOGY, i.e., the Base Scenario**. A PES EWR scenario was also generated which resulted in a higher requirement than the present day hydrology.

THEREFORE, the PES EWR had to be seen as one scenario in a range of flows that would meet the PES but would result in a higher PES than the present hydrology. The PES EWR was therefore a scenario of a flow regime that would also maintain the PES. This flow scenario would imply a decreased risk of the river degrading from the PES, whereas the risk of degradation associated with the present day flows was higher.

In order to meet the PES EWR scenario (see above), irrigators would need to be curtailed by 25%. Given this curtailment, a restriction rule was developed to meet the PES at EWR 7 located on the Kaap River. Note that the restriction rule applied to irrigators in Zone 2 (Kaap River) was a function of the natural flow at EWR 7 and not the state of storage in the Kwena Dam as assumed in the Group 1 scenarios.

Scenario C14: ***Meet the REC at EWR 6*****:** In order to meet the EWR for the REC, irrigators would need to be curtailed by 50%.

SABIE RIVER SUBSYSTEM

Eight hypothetical scenarios were modelled in the Sabie River catchment. These scenarios entailed increasing the current irrigation requirements in steps up to 30 million m^3/annum. In addition, varying levels of water restriction were imposed on users.

SAND RIVER CATCHMENT

Four abstraction weirs (*viz*. Champagne, Dingleydale, New Forest, Edinburgh) in the Upper Sand exist but are not operating correctly. All the water (i.e.100%) is diverted and only the high flow spills continue downstream. There are also leaks from canals and the weirs that will trickle at places in the river. The Sand scenarios were based on the assumption that these four abstraction weirs would be rehabilitated, thus improving the flow downstream.

Scenarios consisting of combinations of weir improvement, curtailment and restrictions were simulated. The scenarios selected for evaluation are listed below (highlighted).

Scenario	Improvement to downstream flow at abstraction weirs	Curtailments (%)	Restriction Level
Sc 1(Sellick Rule)	**See description below**		
Sc 2	0	0	None
Sc 3	50	0	None
Sc 4	50	0	R5
Sc 5	**50**	**20**	**None**
Sc 6	75	0	None
Sc 7	75	20	None
Sc 8	75	0	R5
Sc 9	**75**	**20**	**R5**

Sellick Rule

In accordance with the Sabie River Catchment Operating Rules (DWAF, 2003), a proportion of the flow in the river is supposed to be allowed to flow past the abstraction points down the river in order to meet the EWR. This proportion varies from one abstraction site to the next depending on its location within the catchment. This rule, referred to here as the Sellick rule (after Charles Sellick) only comes into effect when the river flow drops to a certain level.

SUMMARY OF RESULTS

The results of the various scenarios modelled are summarised in terms of demand, supply and assurance of supply in the tables below.

Results of all Crocodile Group 1 Scenarios (No EWR demand)

Crocodile Scenarios	Description	Zone 1			Zone 2			Additional Yield*#
		Demand*	Supplied*	Assurance of supply (%)	Demand*	Supplied*	Assurance of supply (%)	
C1	C[1]: Zero; R[2] = 35%	400	344	72	77	67	65	
C2	C: 15%; R = 35%	340	315	90	66	62	87	
C3	C: 30%; R = 35%	280	265	97	54	53	96	
C4	C: 15%; R = 0%	340	322	97	66	62	87	
C5	C: 15%; R = 0%	280	266	98	54	53	95	
C6	C: 15%; R = 0%	220	211	98	42	42	98	
C7	Montrose Dam	400	357	76	77	67	65	88
C8	Mountain View Dam	400	338	62	77	67	68	55
C9	Both dams	400	356	86	77	67	65	129
C11	Cross-border = 0;	400	344	74	77	73	84	

* Demand, supply and additional yield units are in million m^3/annum.
# Additional yield is expressed as historic firm yield supplied directly out of the proposed dams.
1 Curtailment 2 Restriction

Results of all Crocodile Group 2 Scenarios (EWRs met)

Crocodile Scenarios	Description	Zone 1			Zone 2		
		Demand*	Supplied*	Assurance of supply (%)	Demand	Supplied	Assurance of supply (%)
C10	Reduce releases from Kwena to meet PES at EWR 3	400	344	74%	77	72	84%
C12	Reduce releases from Kwena to meet REC at EWR 3	400	365	88%	77	72	84%
C13	Meet PES	300	251	70%	58	52	77%
C14	Meet REC	200	173	70%	39	34	75%

*Demand and supply units are in million m^3/annum

Results of all Sabie Scenarios

Sabie Scenarios	Description	Demand*	Supplied*	Assurance of supply (%)
Sabie1	Base	80.3	70.7	62
Sabie5	+25 - No Restriction	105.3	95.7	71
Sabie6	+30 - No Restriction	110.3	100.7	72
Sabie7	+30 - R2 Restriction	110.3	79.8	80
Sabie8	+30 - R5 Restriction	110.3	53.1	89

* Demand and supply units are in MCM/a

Results of all Sand Scenarios

Sand Scenarios	Description	Demand*	Supplied*	Assurance of supply (%)
Sellick	Sellick proportional flow rule	23.6	19.0	78
Sand2	+50 improvement, 20% Curt, R2 Restriction	27.4	21.3	71
Sand3	+75 improvement, 20% Curt, R5 Restriction	17.9	8.1	77

* Demand and supply units are in MCM/a

VOLUME 2: ECOLOGICAL CONSEQUENCES

The purpose of this task is to predict the driver and biota responses to each operational scenario and derive the Ecological Category (EC) for the riverine EWR site and Management Resource Unit (MRU).

All information used during the EcoClassification step (the suite of EcoClassification models set up for different ECs) (DWAF, 2009a) and the Ecological Water Requirement (EWR) scenario step (DWA, 2010) is used as baseline for this assessment.

The following steps were required to determine the ecological consequences of the flow scenarios.

- The operational scenarios (Volume 1) were modelled and a time series was provided for each scenario at each EWR site.
- The time series was converted to a flow duration table and both was provided to the physico chemical and geomorphology specialist.
- These specialists had to provide a conclusion and resulting EC of the operational scenario assessed at the EWR to the biological responses team.
- These specialists completed the Physico-chemical Assessment Index (PAI) and Geomorphology Assessment Index (GAI) models to predict the driver EC.
- The riparian vegetation specialist then assessed the response on the marginal and other riparian zones and supplied this information to the instream biota specialists. This was

done prior to the instream biota assessment as riparian vegetation is a driver in terms of important habitat for the instream biota.

- Where required, the riparian vegetation specialist ran the Vegetation Response Assessment Index (VEGRAI) model to predict the EC for the operational scenario.

Assessment of the economic impacts of the various scenarios essentially identifies the direction of change (either positive or negative), and estimates the magnitude of the change in benefits and costs that may be experienced within the River System. The process adopted was the analysis of potential economic changes based on a valuation of the status quo, that is, the value of the Goods and Services (G&S) currently provided by the water in River systems, identifying the potential change that each of the key G&S may undergo in each of the scenario clusters. And where required the current value of G&S was then multiplied by these factors for each scenario, to provide an indication of the potential future value of the Goods and Services. The change in value was thus measured.

ECOLOGICAL CONSEQUENCES RESULTS

Results are summarised according to whether the scenarios meet the REC or not, and if not, to what degree. Colour coding and symbols should be interpreted as follows:

✓ REC EcoStatus or REC instream IS met.

X REC EcoStatus or REC instream is NOT met.

Light green with black ✓:	Meets REC EcoStatus including all components.
Light green with red ✓:	Meets REC instream, but not riparian vegetation (this is usually because the vegetation REC cannot be met due to non-flow related problems).
Dark Green with black ✓:	Meets the REC EcoStatus, but not all the components.
Turquoise with X:	The scenario is an improvement of the PES but does not meet any of the REC versions as in green above.
Orange with X:	The scenario does not meet REC requirements but meets the PES.
Purple with X:	The scenario results in an EC below the PES, but still above a E EC.
Red with X:	The results are below a E EC.

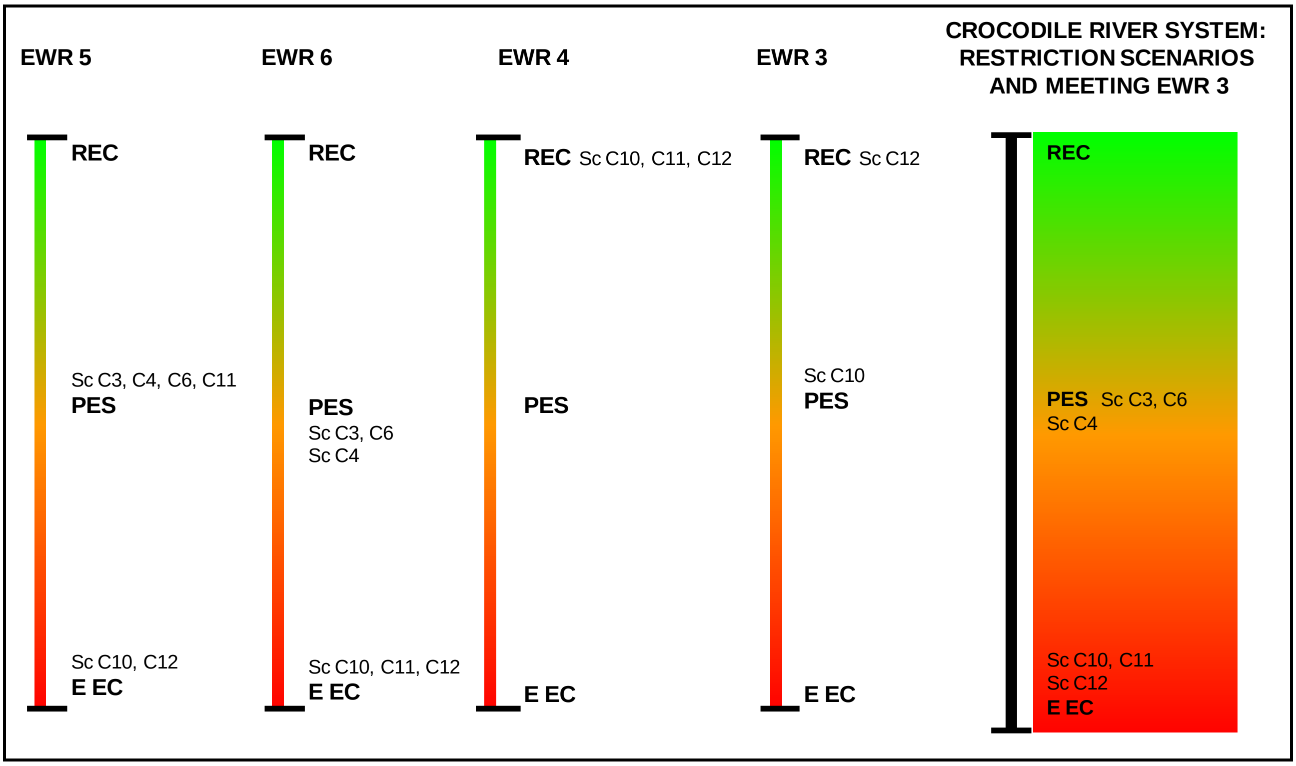
Crocodile Sub-system: Curtailment and restriction irrigation scenarios

An overall assessment was undertaken for the various sub-systems for scenarios of the same type. The table below provides a summary of the results at each EWR site. The overall evaluation usually reflects the results at the site which is least likely to meet the REC. The reasoning is that even if you meet the REC at other EWR sites, the scenario fails within a system context if it does not meet the REC at one of the sites.

EWR SITE	SC 3	SC 4	SC 6	SC 10	SC 11	SC 12
EWR 5	X	X	X	X	X	X
EWR 6	X	X	X	X	X	X
EWR 4				✓	✓	✓
EWR 3				X		✓
OVERALL	X	X	X	X	X	X

The results provided in the table are ranked and illustrated on a scale from good (REC) to 'bad' (an E EC) where in this case the PES has been placed in the middle. This provides an indication of the DEGREE to which the scenarios do not meet the REC and takes into consideration the more detailed assessment on which the summaries are based.

Within a system context none of the scenarios meet the REC at any of the EWR sites. The PES is maintained under Sc C3 and C6. Scenario C4 met the PES EcoStatus; the fish component however deteriorated to an unacceptable level and therefore the overall PES requirement are not met and was ranked below the PES in the figure below. Scenario C10 – C12 resulted in a deterioration of the PES EcoStatus. The overall assessment is provided as the traffic diagram on the right.

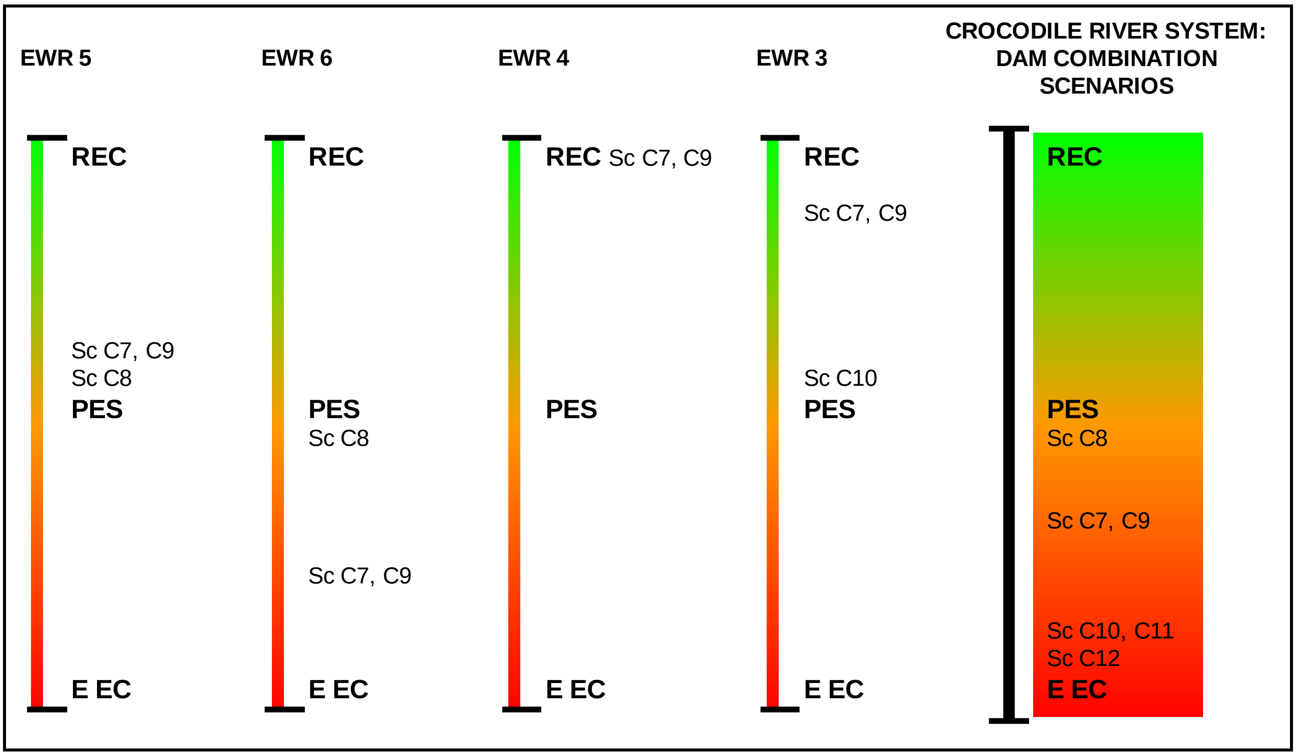


Crocodile Sub-system: Development (new dam) scenarios

These scenarios were not evaluated in detail as each dam and combination will require a whole range of different operating rules for useful comparison. The results are provided below.

EWR SITE	Sc C7	Sc C8	Sc C9
EWR 5	X	X	X
EWR 6	X	X	X
EWR 4	✓		✓
EWR 3	X		X
OVERALL	X	X	X
EWR 7		X	X

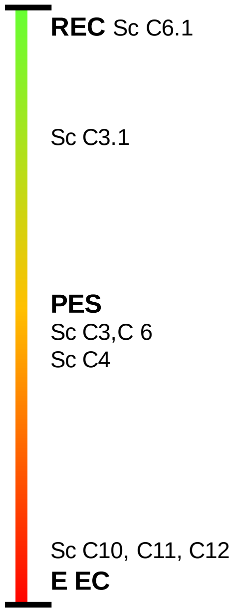
Scenario C7 – C9 did not maintain the PES at EWR 6. Scenario C8 maintains the PES EcoStatus but does not maintain the riparian vegetation and geomorphology PES. Scenario C8 was therefore ranked lower than the PES (figure below) at EWR 6. Looking at EWR 7 in isolation, the scenarios with Mountain View Dam and the no releases downstream of the dam resulted in an unacceptable condition. The overall assessment is provided as the traffic diagram on the right.



Crocodile River: Additional scenarios evaluated at EWR 6

Two optimised scenarios were developed for additional screening, Sc C3.1 and Sc C6.1. Both were evaluated at EWR 6 as the key site. Sc C6.1 achieved the REC and Sc C3.1 improved the PES. The comparison is provided in the figure below.

Driver Components	PES	REC	Sc C3	Sc C4	Sc C6	Sc C10-C12	Sc C3.1	Sc C6.1
HYDROLOGY	D	B						B
WATER QUALITY	C	B	C	D	C	D/E	C	B
GEOMORPHOLOGY	C	C	C	C	C	C	C	C
Response Components	**PES**	**REC**	**Sc C3**	**Sc C4**	**Sc C6**	**Sc C10-C12**	**Sc C3.1**	**Sc C6.1**
FISH	C	B	D	D/E	D	D	B/C	B
MACRO INVERTEBRATES	C	B	C	C	C	D/E	C	B
INSTREAM	C	B	C	D	C	D	B/C	B
RIPARIAN VEGETATION	C	B	B/C	B/C	B	D	B/C	B
ECOSTATUS	C	B	C	C	C	D	B/C	B

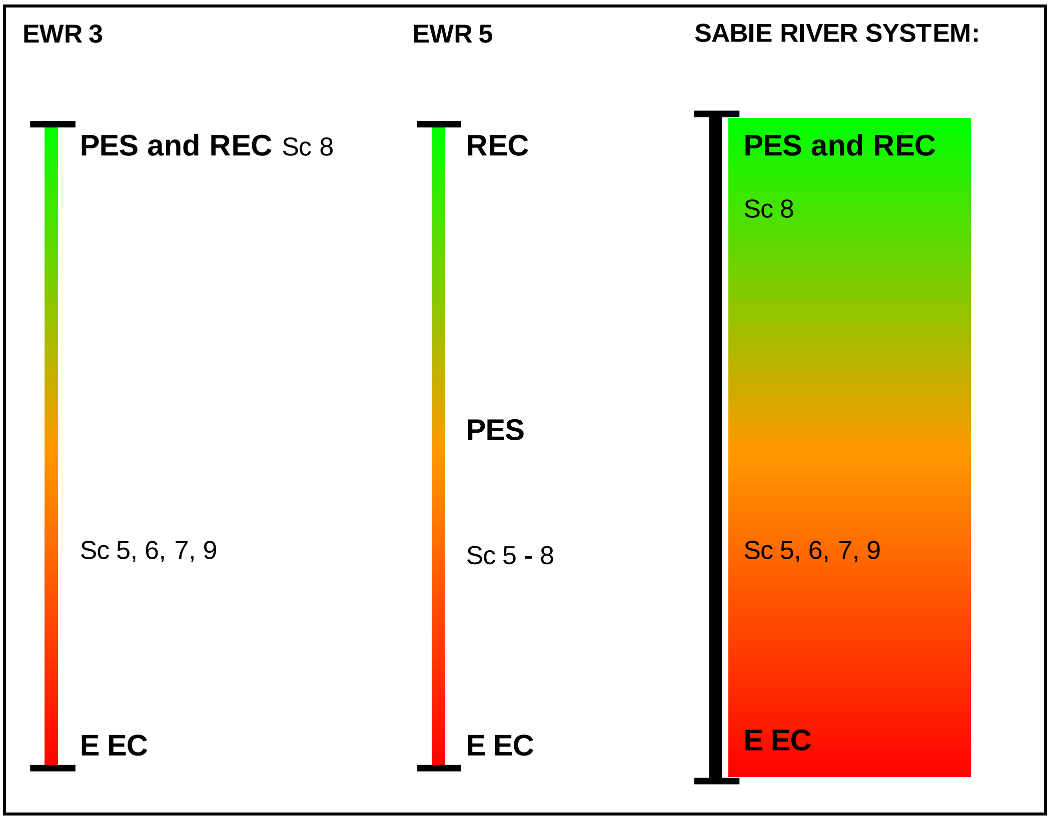


CROCODILE RIVER SYSTEM								
EWR SITE	Sc C3	Sc C4	Sc C6	Sc C10	Sc C11	Sc C12	Sc C3.1	Sc C6.1
EWR 6	X	X	X	X	X	X	X	✓

Ecological consequences of the Sabie Sub-system

The table and figure below provides a summary of the results at each EWR site. Sc 8 achieves the objectives at EWR 3 in KNP but not at Marite (EWR 5). Therefore it is significantly better than the other scenarios which are at both sites lower than the PES.

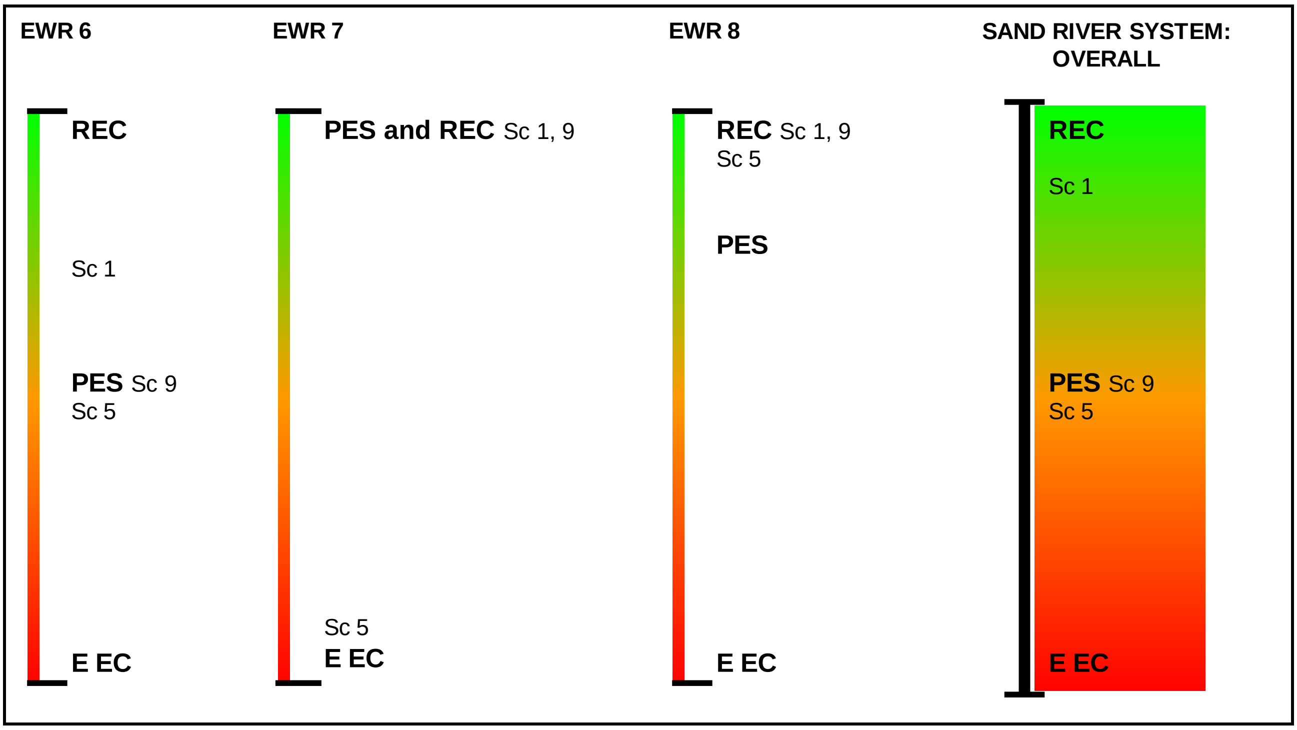
SABIE RIVER SYSTEM				
EWR SITE	Sc 5	Sc 6	Sc 7	Sc 8
EWR 3	X	X	X	✓
EWR 5	X	X	X	X
OVERALL	X	X	X	X



Ecological consequences of Sand sub-system

The table provides a summary of the results at each EWR site. Scenario 1 is an improvement of the PES at EWR 6 and meets the REC at EWR 7 and 8. It is a better scenario than Sc 9 which only meets the PES at EWR 6 and does not improve it as is the case with Sc 1. Scenario 5 is the worst scenario as it does not meet the PES/REC at EWR 7.

SAND RIVER SYSTEM			
	Sc 1	**Sc 5**	**Sc 9**
EWR 6	X	X	X
EWR 7	✓	X	✓
EWR 8	✓	✓	✓
OVERALL	X	X	X



GOODS AND SERVICES SUMMARY OF RESULTS

The following represents a summary of scenarios by economic zone: Those in green are positive and relates to the scenario providing increased resources for the utilization of goods and services; negative (shaded red) relates to a decrease in resources. Those scenarios shaded in yellow are neutral and indicates either (a) no change in resources and will be the same as present or (b) some G&S will be positively affected and some will be negatively affected but overall there is no driving indicator that would suggest either a positive or a negative overall outcome.

Economic Zone	EWR Site	Scenarios							
Crocodile-East sub-catchment									
Upper Crocodile	EWR 1, 2	None							
Elands		None							
Lower Kwena	EWR 3	3	7	10	12				
Middle Crocodile	EWR 4	7	9	10	11	12			
Kaap	EWR 7	8	9						
White River		None							
Lower Crocodile	EWR 5, 6	3	4	6	7	8	9	10	12
Sabie-Sand sub-catchment									
Sabie	EWR 1, 2, 4	None							
Maritsane/Inyaka	EWR 3, 5	5							
Sand	EWR 6 - 8	1	5	9					

RECOMMENDATIONS

Crocodile Sub-system

Of all the scenarios evaluated in the Crocodile River system the optimization scenarios (Sc C3.1 and C6.1) are the best scenarios from an ecological and G&S viewpoint. Scenario C6.1 meets the

REC requirement at EWR 6 (critical site in the Crocodile River system) while Sc C3.1 results in an improvement of the PES at this site.

Due to the socio economic impact of Sc C6.1 it is acknowledged that it is unlikely to be considered. Therefore Sc C3.1 is therefore a better option, although the potential socio-economic consideration can be significant. However; considering the position of the Kruger National Park in the system, and the general High to Very High EIS of the system, it would be irresponsible not to make some attempt to meet Sc C3.1, or investigate further optimization options to determine other scenario options. As Sc C3.1 results in the improvement of the PES, the risk associated with the PES not degrading further will be minimised and, more important, considering the resolution which one is dealing with in terms of ecological and hydrological results, it is even possible that one could reach the B REC (for EWR 6 in the lower Crocodile River). From an ecological and G&S point of view, this would be the recommended scenario.

There are also options to investigate the daily operation of the system which, due to the abstraction regime, results in extreme localised changes in hydrology and impacts negatively on the ecological health of the system. There might be options to recommend a change in the manner of abstraction which could improve the system.

Sabie Sand Sub-system

No operational scenarios were required for evaluation in the Sabie System. Theoretical scenarios that consist of different levels of irrigation restrictions to meet increasing irrigation requirements were investigation. These represent increased flows to various degrees at EWR 5 (Marite) and decreased flows at EWR 3 (Kidney). Scenario 8 is the only scenario that still meets the PES and REC at EWR 3 in the KNP. The Marite REC was not achieved. The present flow regime results in the same situation and it is therefore recommended that the status quo is maintained. If increased flow for irrigation is ever required, Sc 8 would be the recommended option.

The scenarios in the Sand system are all based on improving the irrigation supply structures (small dams, canals, weirs) in the system. Scenario 1, the original Sellick Rule set up to operate the system will be the best scenario as this scenario improves the PES at EWR 6 and meets the REC requirements at EWR 7 and 8. Scenario 1 is therefore recommended from the ecological and G&S viewpoint.

VOLUME 3: ECONOMIC CONSEQUENCES

INTRODUCTION

Changes in water volume have an effect on the economics of a catchment e.g. change in supply to farmers will affect activity per hectare and therefore affect the Gross Domestic product (GDP) and employment opportunities. Assurance also reflects long-term water availability which influences GDP and employment opportunities, but only for the harvesting cost. This implies that if assurance increases, job opportunities will increase during harvesting. Therefore, water volumes were transformed with the use of the WIM model to determine total GDP, total number of employment opportunities and the distribution towards the low income households in Zone 1. All the scenarios were based upon the Base (Current State).

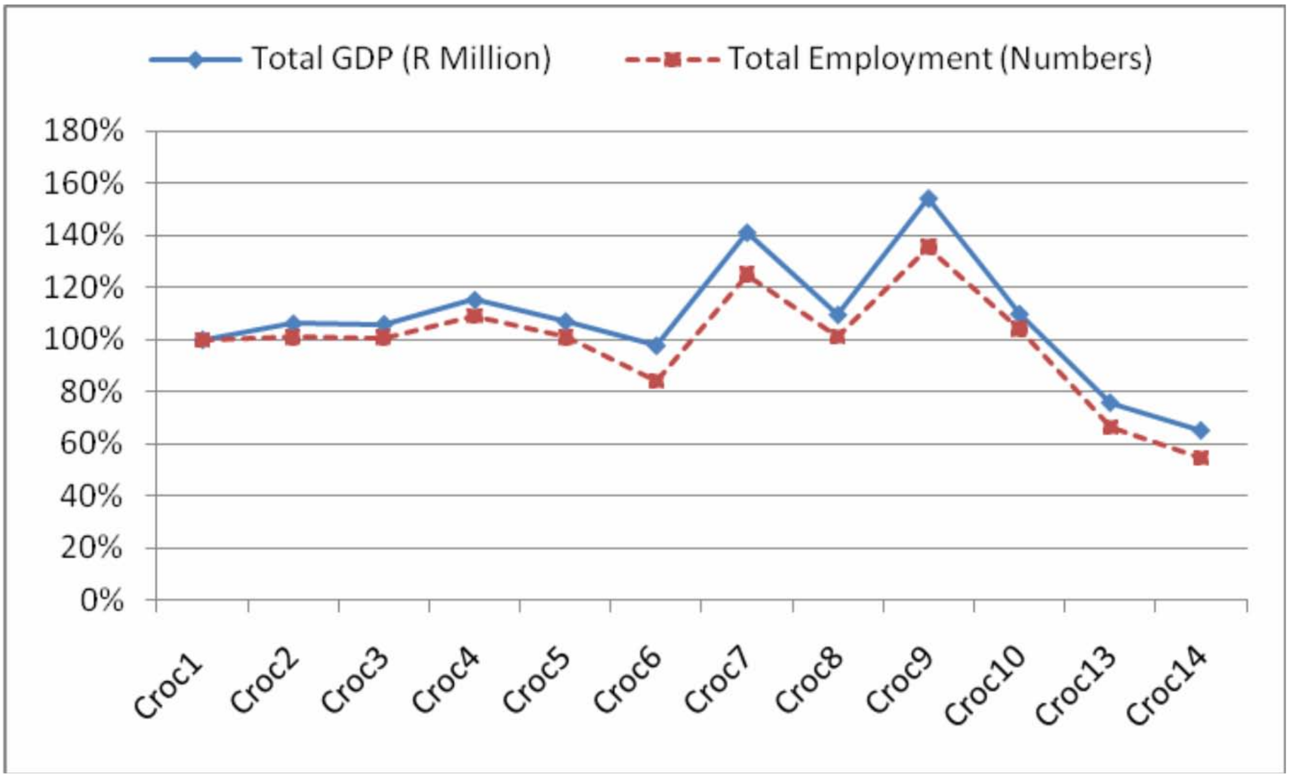
The Sabie scenarios were not further evaluated as all scenarios related to an improved assurance and supply to agriculture.

The Sand system was not further evaluated as all scenarios included the improvement of the current irrigation system and structures which would maintain or improve the current irrigation activities, as well as improve the runoff in the river system.

CROCODILE RIVER CATCHMENT RESULTS

The figure below reflects that Sc C7 and C9 are the best economic impact performers when analysing the scenarios. These economic impacts are expressed in total GDP, total number of employment opportunities as well as the distribution towards Low Income Households. Low income households follow mostly the trend of GDP and are therefore not included in the graph.

When the scenarios involving dams and international flow are excluded, Scenario C4 reflects the best economic performance.

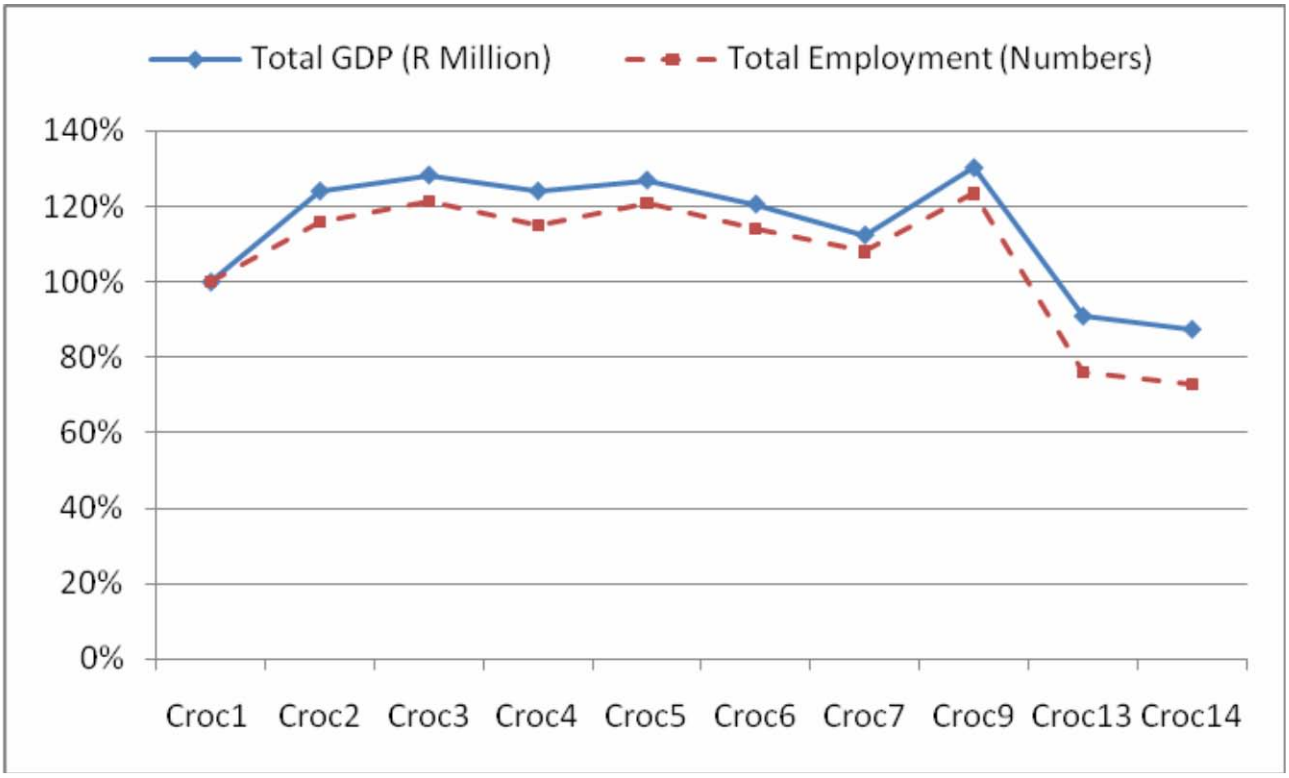


In summary, if the development scenarios (Sc C7 – C9) are excluded from the assessment, Sc C2 to 6 all give a positive deviation compared to Sc 1 (Present Day), with Sc 4 being the best of these scenarios in terms of GDP and total employment. Scenario C9 is the best scenario (most positive GDP impact) and total employment when analysing all the impacts.

It must be noted (refer to Volume 1): The Present Ecological State will be maintained by Sc C1, i.e. the way the system is presently being operated. Scenario C13 (PES), refers to an additional flow scenario which will also maintain the PES and consists of higher flow requirements than present day in certain months. This scenario will include a lower risk of failure of the PES and further degradation of the river to a lower category. The economic consequences associated with this PES EWR scenario must NOT be confused with the consequences of maintaining the river in its present state, as that is being achieved by Sc C1, or the baseline (present operation of the system).

KAAP RIVER CATCHMENT RESULTS

The macro economic impacts of the scenarios on Zone 2 are provided in the figure below. The results reflect that Sc C9 is the best economic impact performer. These economic impacts are expressed in total GDP, total number of employment opportunities as well as the distribution towards Low Income Households. If the development scenarios are excluded, Sc C3 is the most recommended scenario in terms of GDP and employment.



Based on the results all the scenarios have a positive deviation from the GDP, except for Sc C13. Scenario C3 is the best scenario if the development scenarios (Sc C7 – C9) are excluded.

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1 INTRODUCTION

1.1 PURPOSE OF THE REPORT

The analyses of the base (current) state is reflected in the Comprehensive Reserve Determination Study for Selected Water Resources in the Inkomati WMA, where the economic baseline of irrigation agriculture water use was established per allocation zone and the value of water was expressed in terms of the contribution to Gross Domestic Production (GDP), Employment and Low Income Households.

The aim of this study is to measure the incremental deviation from the baseline as described in the Socio Economic Present State Evaluation Report (RDM Report no 26/8/3/10/12/013; DWA, 2010a).

1.2 STUDY AREA

Figure 1-1 below shows the delineation of the Crocodile River catchment into Water Allocation Zones. Zone 1 consists of the whole Crocodile East sub-catchment excluding the Kaap River catchment. The Kaap River, represented in orange in Figure 1-1, has been analysed separately and has been named Zone 2.

The Sabie scenarios were not further evaluated as all scenarios related to an improved assurance and supply to agriculture.

The Sand system was not further evaluated as all scenarios included the improvement of the current irrigation system and structures which would maintain or improve the current irrigation activities, as well as improve the runoff in the river system.

1.3 OUTLINE OF THE REPORT

The consequences of the operational scenarios, RDM Report 26/8/3/10/12/011, consists of a three volume report series which is outlined below:

- Volume one: Description of the Operational Scenarios.
- **Volume two: Ecological and Goods and Services Consequences.**
- Volume three **(this report)**: Macro Economic Consequences.

The report structure of Volume three is provided below.

1.3.1 Chapter 1: Introduction

This chapter.

1.3.2 Chapter 2: Methods and approach

A summary of the scenarios used for the economic modelling is provided.

1.3.3 Chapter 3: Operational scenario results

In this chapter the macro economic impacts of the Crocodile East catchment are discussed.

1.3.4 Chapter 4: Conclusions

The best and worst scenarios are provided in terms of the impact on macro economics.

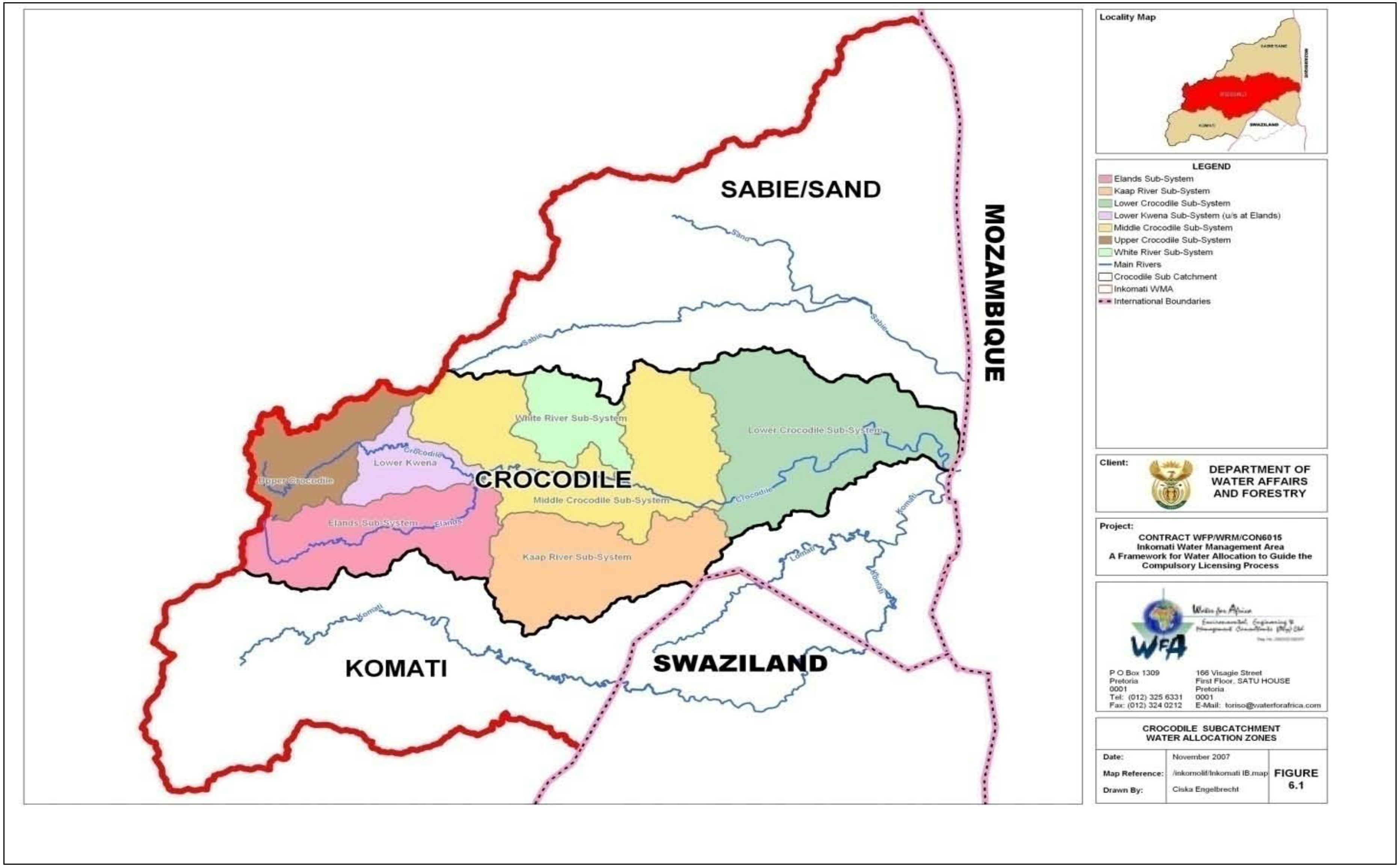

Figure 1–1 Economic Zones of the Crocodile East sub-catchment (Zone 1) and the Kaap Catchment (Zone 2)

2 METHODS AND APPROACH

This chapter includes the methods used to conduct the economic study. This methodology was used to determine the present state and was applied in the interpretation of the scenarios.

2.1 DEFINING THE WATER IMPACT MODEL

2.1.1 Structure of the Water Impact Model (WIM)

The model as is currently constructed is in the form of a dynamic computerised water entitlement model which can be used to identify and quantify the following indicators:

- Economic benefits.
- Maximum possible water reduction.
- Proposed water reduction.
- Capitalised impact.

Despite the fact that farm sizes are far from being definitive, the model includes the ability to analyse three different farm sizes, *viz*., small, medium and commercial. This feature provides a facility for determining whether there are impacts which are specific to different scales of farming operations.

As a first step the macro-economy of the basin was established and then sub-divided into the sub-catchments. Production and employment data were used for the Basin and its sub-catchments where after a macro economic Impact model was constructed for the Basin and the identified sub-catchments. The model is water driven and gives the direct and indirect/induced results for the following activities:

- Agriculture.
- Forestry.
- Industry.
- Households.

Regarding agriculture, the model can accommodate up to ten individual products and for forestry it makes provision for pine, wattle and gum sub-species.

The following direct impacts are estimated by the Water Impact Model:

- Gross Domestic Product (GDP).
- Low Income Households and Total Households.
- Employment Creation.

A group of economic multipliers was then developed to compare different water use activities in terms of Gross Domestic Product (GDP/m^3), employment creation (number/Mm^3) and the low-income households.

2.1.2 Input Structures

The WIM comprises various sub-models which are used in determining the values of the above economic variables. These are described in detail below.

The primary impetus drivers of the WIM are:

- The volume of water allocated to the various water users in each sub-catchment.
- The level of water assurance given to each water user in each sub-catchment.
- Hectares under irrigation.
- Production.
- Economic data in the form of a Social Accounting Matrix (SAM), and
- Economic multipliers.

2.1.3 Multipliers Incorporated into the WIM

By using a Social Accounting Matrix[1] (SAM) applicable to the study area, multipliers have been calculated. The multipliers which were used in this study to determine the economic impacts for the WIM are as follows:

- Economic growth (i.e. the impact on GDP).
- Job creation (i.e. the impact on labour requirements).
- Income distribution (i.e. the impact on low income households).

An example of the agriculture sector multipliers used in this study is as follows:

- **Direct effect**: Refers to effects occurring directly in the agriculture sector.
- **Indirect effects**: Refers to those effects occurring in the different economic sectors that link backward to agriculture due to the supply of intermediate inputs, i.e. fertilisers, seed, etc.
- **Induced effects**: Refers to the chain reaction triggered by the salaries and profits (less retained earnings) that are ploughed back into the economy in the form of private consumption expenditure.

2.1.4 Valuation of Water Use by Irrigated Agriculture

The inputs towards the irrigation sector consist of COMBUD-budgets that were applied to a farm model. The Computer Based Budgets (COMBUD) compiled by the Department of Agriculture was used as base documents to develop the 2007/2008 production budgets. They were updated and adapted for the different production areas in terms of yield, production prices and input costs. The COMBUD budget provided data up to Gross Margin on a hectare basis, after which the fixed costs were subtracted to get Net Farm Income per hectare and in the end the Net Income or Profits per hectare. Figure 2-1 shows the structure of how the Net Farm Income is calculated.

[1] A Social Accounting Matrix (SAM) represents flows of all economic transactions that take place within an economy (regional or national). It is at the core, a matrix representation of the National Accounts for a given country, but can be extended to include non-national accounting flows, and created for whole regions or area. SAMs refer to a single year providing a static picture of the economy (www.wikipedia.org).

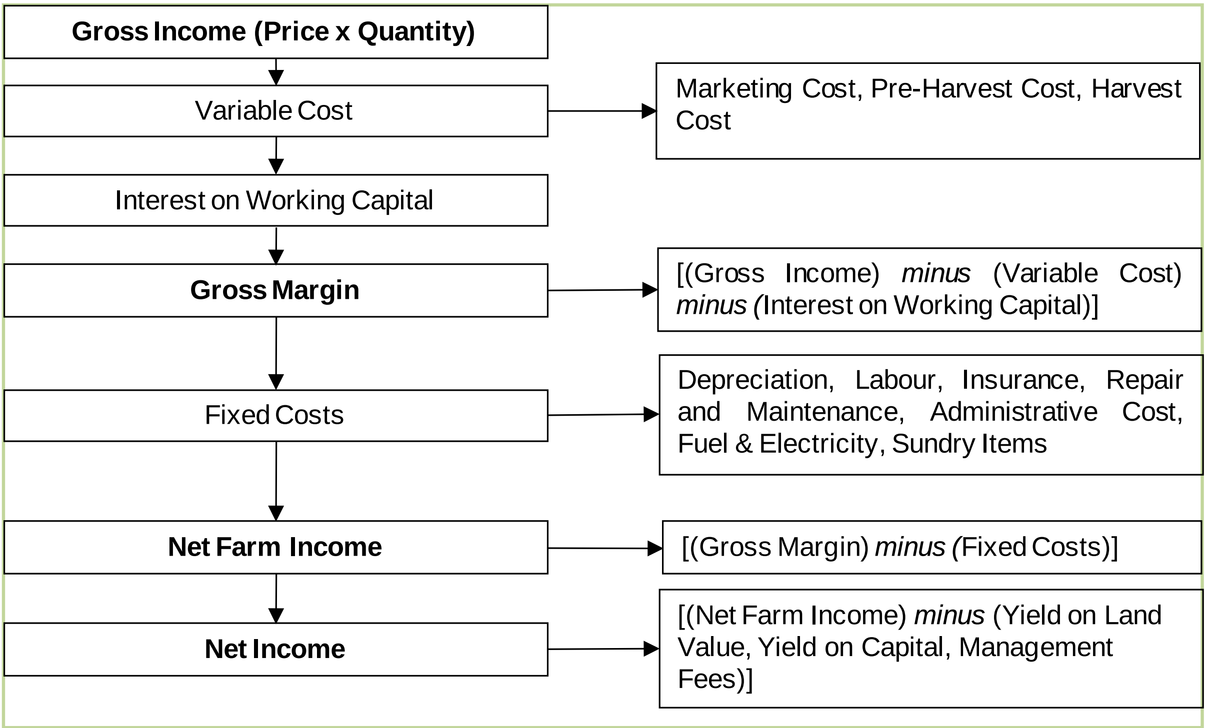

Figure 2–1 Irrigation budget structure

For the use of the macro-economic impacts determination, these costs in the budget are allocated to structures in such a way that it is allocated to the different sectors of the economy. These will be applied to determine the direct, and indirect and induced effects. Production costs included:

- Total costs (Intermediate inputs and labour requirements).
- Agriculture.
- Mining.
- Manufacturing (fuel, fertilizer, pharmaceuticals and other).
- Water.
- Construction.
- Trade and accommodation.
- Transport and communication.
- Financial and business services.
- Community services.
- Salaries and wages (skilled, semi-skilled and unskilled).

2.2 VALUATION OF WATER USE FOR INDUSTRIES

The path followed by the industries; namely mining and power generation, consist of the inputs of turnover and direct employment. The turnover is converted into production. The following step is to determine the costs and divide those with the structure of the economy. Their multipliers, calculated from the SAM, are then used to determine the impact.

2.3 ASSUMPTIONS FOR THE OPERATIONAL SCENARIOS

For purposes of this economic impact analyses the following general assumptions were formulated.

- The impact analysis was only done for irrigation agriculture as no other water user will be affected by the restrictions of water availability.

- It was accepted that the management levels of the irrigators and equipment use is already at very high efficiency levels and no provision was made for improvement in management efficiency or equipment.
- It was assumed that a volume curtailment leads to a reduction in an irrigation area.
- It was further assumed that an improvement in assurance of supply results in increased yields over a period of time.
- In applying the above assumptions the following practical applications were used in the WIM.
- The cultivation of annual crops such as vegetables, wheat and pastures were reduced in accordance with the curtailments applied.
- As sugar cane is more resistant to drought and costs less to replant, the water supply was reduced as curtailments increased.
- Orchards were maintained in all scenarios, only to be affected by area curtailments as a last resort.
- Changes in assurance of supply not only results in a loss of production but also in the quality of produce.
- As the Crocodile River in the present state report consists of 7 Zones and for the purposes of the scenarios combined into one Zone, weighted economic multipliers were applied.

2.4 LIMITATIONS

The application of the above assumptions put in place the following limitations in calculating the impacts of the different scenarios.

- Changes in irrigation management practices were not taken into account.
- Irrigation efficiency levels were maintained at the current levels.
- No sensitivity analysis or cost effective analysis was conducted on input production costs. Sensitivity and cost effective analysis can be used to measure the effectiveness of present production practices.
- Changes in market prices were not taken into account.
- Fiscal impacts of changes in economic activity were not evaluated because the WIM model is a static model and makes no provision for measurement of the fiscal impact.
- The impact of removing old orchard trees and replanting young trees was not evaluated.
- Provincial economic multipliers were used because Mpumalanga provincial Social Accounting Matrix was used.
- Impact on different farming size units was not evaluated.

3 SCENARIO DESCRIPTION

The scenarios for the Crocodile East catchment are described in Volume 1 of this report series.

3.1 SCENARIOS ASSESSED IN ZONE 1: CROCODILE RIVER CATCHMENT

Table 3.1 provides a summary of the scenarios used for economic modelling in Zone 1.

Table 3.1 Summary of scenarios assessed for **Zone 1 -** Crocodile River catchment

Scenarios	Volume (MCM)	Assurance (%)	Curtailment (%)
Sc C1	400.0	68%	N/A
Sc C2	339.6	90%	15%
Sc C3	279.7	97%	30%
Sc C4	339.6	97%	15%
Sc C5	279.7	98%	30%
Sc C6	219.7	98%	45%
Sc C7	478.0	76%	0%
Sc C8	454.5	62%	0%
Sc C9	529.0	86%	0%
Sc C10	399.5	74%	0%
Sc C11	445.5	88%	0%
Sc C13	299.6	70%	25%
Sc C14	199.8	70%	50%
Sc C15	359.6	70%	10%

3.2 SCENARIOS ASSESSED IN ZONE 2: KAAP RIVER CATCHMENT

Table 3.2 provides a summary of the scenarios used for economic modelling in Zone 1.

Table 3.2 Summary of scenarios assessed for **Zone 2 -** Kaap River catchment

Scenarios	Volume (MCM)	Assurance (%)	Curtailment (%)
Sc C1	77.0	65%	N/A
Sc C2	65.5	87%	15%
Sc C3	53.9	96%	30%
Sc C4	65.5	87%	15%
Sc C5	53.9	95%	30%
Sc C6	42.4	98%	45%
Sc C7	77.0	72%	0%
Sc C8	77.0	60%	0%
Sc C9	77.0	82%	0%
Sc C10	77.0	84%	0%
Sc C11	77.0	82%	0%
Sc C13	57.8	77%	25%
Sc C14	38.5	75%	50%
Sc C15	69.3	78%	10%

4 RESULTS

In this chapter the macro economic impacts of the Crocodile East catchment are discussed. Please note that the results of the development scenarios, namely Sc C7, C8 and C9 is not included in the main recommendations. This is because of the multiple permutations that can be used together with the different environmental and engineering variables.

Changes in water volume have an effect on the economics of a catchment e.g. change in supply to farmers will affect activity per hectare and therefore affect the Gross Domestic product (GDP) and employment opportunities. Assurance also reflects long-term water availability which influences GDP and employment opportunities, but only for the harvesting cost. This implies that if assurance increases, job opportunities will increase during harvesting. Therefore, based on the information provided in Table 3.1 and 3.2, water volumes were transformed with the use of the WIM model described in Chapter 2 to determine total GDP, total number of employment opportunities and the distribution towards the low income households in Zone 1. All the scenarios were based upon the Base (Current State).

4.1 ZONE 1 – CROCODILE RIVER CATCHMENT

The macro economic impacts of the scenarios C1 to C14 (excluding Scenario C11) on Zone 1 are provided in Table 4.1.

Table 4.1 Results of different scenarios applied to Zone 1: Crocodile River catchment

Scenarios	Total GDP (R Million)	Total Employment (Numbers)	Low Income Households (R Million)
GROUP 1 (no EWR)			
Sc C1	1 411.97	20 330	391.73
Sc C2	1 499.36	20 508	375.56
Sc C3	1 496.25	20 488	363.29
Sc C4	1 628.15	22 198	396.01
Sc C5	1 510.95	20 518	365.61
Sc C6	1 379.20	17 100	332.95
Sc C7*	1 995.02	25 435	515.55
Sc C8	1 547.51	20 543	444.13
Sc C9	2 181.10	27 558	541.65
Sc C10	1 551.80	21 164	412.32
GROUP 2 (EWR included)			
Sc C13	1 069.19	13 492	298.71
Sc C14	918.17	11 096	253.76

* Yellow refers to scenarios that include the new dam developments.

The results reflect that Sc C7 and C9 are the best economic impact performers when analysing the scenarios. These economic impacts are expressed in total GDP, total number of employment opportunities as well as the distribution towards Low Income Households. Figure 4-1 demonstrates the results of the economic impacts graphically. Low income households follow mostly the trend of GDP and are therefore not included in the graph.

When the scenarios involving dams and international flow are excluded, Sc C4 reflects the best economic performance.

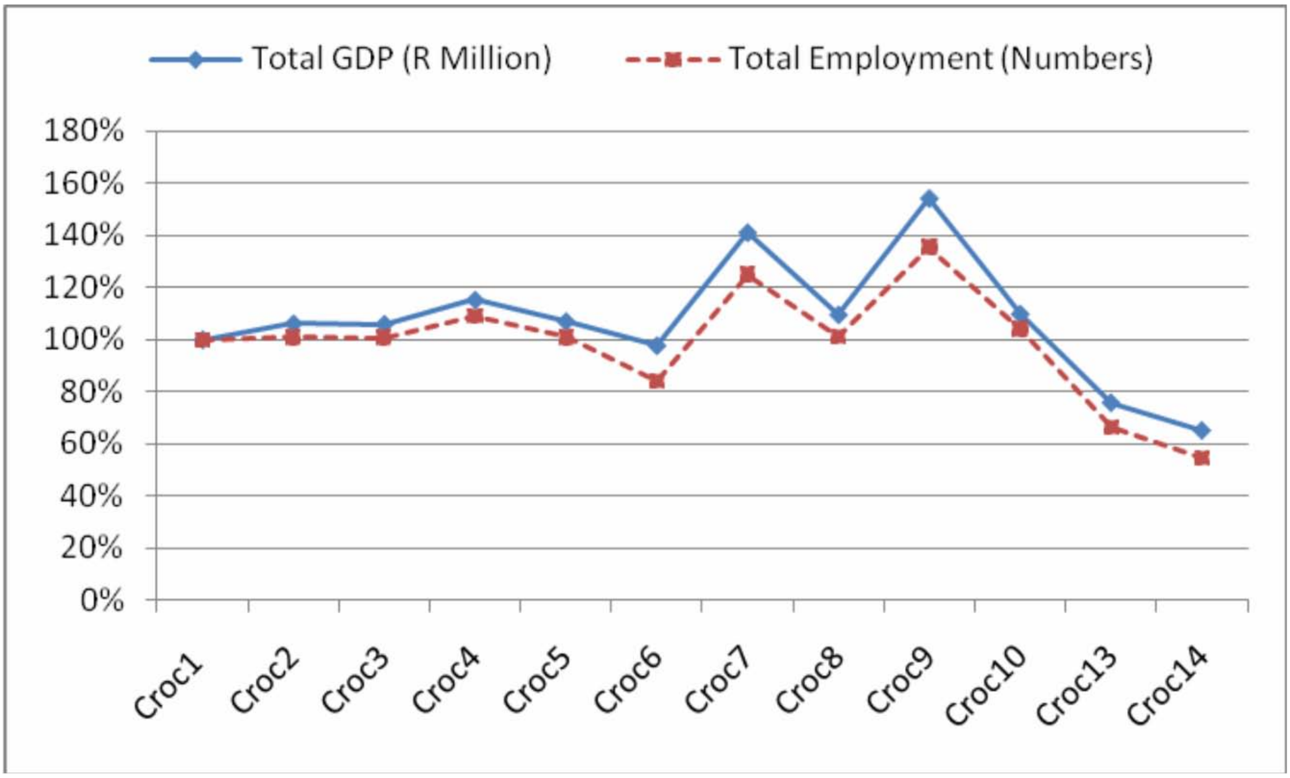

Figure 4–1 **Zone 1: Economic consequences in terms of GDP and Total employment compared to the baseline (Sc C1)**

In summary, if the development scenarios (Sc C7 – C9) are excluded from the assessment, Sc C2 to 6 all give a positive deviation compared to Sc C1 (Present Day), with Sc C4 being the best of these scenarios in terms of GDP and total employment. Sc C9 is the best scenario (most positive GDP impact) and total employment when analysing all the impacts.

The following must be noted (refer to Volume 1):
The Present Ecological State will be maintained by Sc C1, i.e. the way the system is presently being operated. Sc C13 (PES) refers to an additional flow scenario which will also maintain the PES and consists of higher flow requirements than present day in certain months. This scenario will include a lower risk of failure of the PES and further degradation of the river to a lower category. The economic consequences associated with this PES EWR scenario must NOT be confused with the consequences of maintaining the river in its present state, as that is being achieved by Sc C1, or the baseline (present operation of the system).

Scenario C11 includes no international requirements. The value of the international water was determined based on the increased GDP etc. it could result in if used for agriculture. It is not a recommendation and will not be compared further as the results are not compatible with the other results. The evaluation of the value of the water is supplied in Table 4.2.

Table 4.2 Incremental cost of international water supply in terms of GDP and employment

	Total GDP (R Million)	Total Employment (Numbers)	Low Income Households (R Million)
Baseline	1 411.97	20 330	391.73
Scenario 11	2041.56	25 797	500.63
Incremental cost of international supply	629.59	5 467	108.90

It appears as if the international flow requirement costs South Africa R629.6 million in GDP growth and 5 467 in employment opportunities with an accompanying R108.90 million in low income household funds if expressed at 2007 prices.

4.2 ZONE 2 – KAAP RIVER CATCHMENT

The macro economic impacts of the scenarios on Zone 2 are provided in Table 4.3.

Table 4.3 Results of different scenarios applied to Zone 2**: Kaap River catchment**

Scenarios	Total GDP (R Million)	Total Employment (Numbers)	Low Income Households (R Million)
Sc C1	305.46	3 836	82.38
Sc C2	378.91	4 449	88.53
Sc C3	391.79	4 649	87.31
Sc C4	378.91	4 408	88.53
Sc C5	387.77	4 641	86.73
Sc C6	368.42	4 378	80.92
Sc C7*	343.45	4 142	87.79
Sc C9	397.71	4 734	95.53
Sc C13	277.98	2 916	68.76
Sc C14	267.36	2 792	65.33

* Yellow refers to scenarios that include the new dam developments.

For the Kaap River catchment the results reflect that Sc C9 is the best economic impact performer. These economic impacts are expressed in total GDP, total number of employment opportunities as well as the distribution towards Low Income Households. If the development scenarios are excluded, Sc C3 is the most recommended scenario in terms of GDP and employment. This is graphically illustrated in the Figure 4-2 with respect to GDP and employment for all the scenarios assessed. Low income households follow mostly the trend of GDP and are therefore not included in the graph.

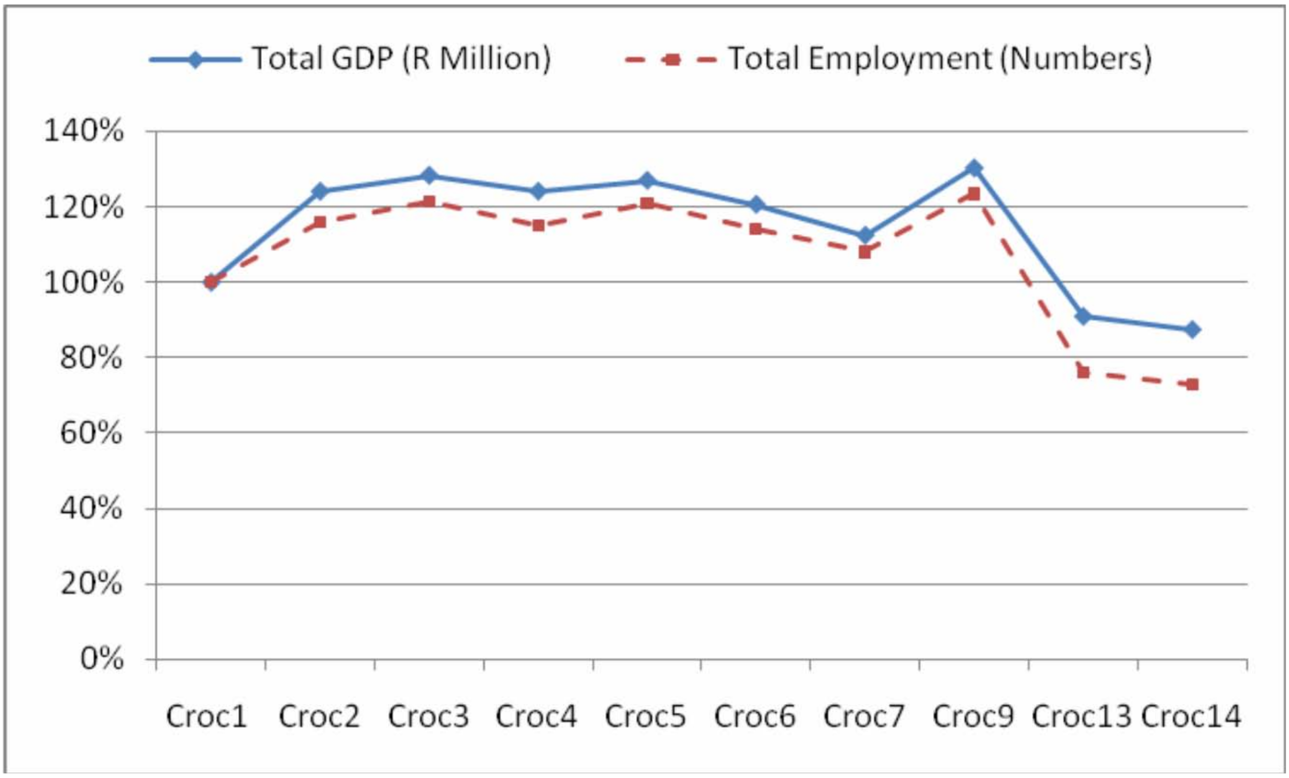

Figure 4–2 **Kaap River Deviation from the Base Scenario: GDP and Employment**

Based on the results presented in Figure 4-5 all the scenarios have a positive deviation from the GDP, except for Sc C13. Scenario C3 is the best scenario if the development scenarios (Sc C7 – C9) are excluded.

5 CONCLUSIONS

5.1 ZONE 1: CROCODILE RIVER CATCHMENT

In terms of macro economic parameters it appears as if in Zone 1, Sc C4 is the most beneficial scenario. The scenarios involving the possible construction of the Montrose (Sc C7) and Mountain View (Sc C8) dams appear to be very beneficial for the economic outcome in the Crocodile catchment. Although the assessment of the economic impacts of Sc C7, C8 and Sc C9 have been conducted with the data made available in Volume 1, it should be noted that these scenarios are hypothetical at this stage. Before any recommendation for the development scenarios can be provided, more in depth analysis needs to be undertaken in terms of dam yields, operating rules and the financial and institutional implications of constructing and maintaining these dams.

The scenario to achieve the REC will be the worst from an economic point of view.

5.2 ZONE 2: KAAP RIVER CATCHMENT

When those scenarios which are influenced by the dams and international flows are excluded in the analysis, Sc C3 is the best economic performer.

The scenario to achieve the REC will be the worst from an economic point of view.