REPORT NO: RDM/WMA11/00/CON/CLA/1314

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

PROJECT NUMBER: WP 10679

VOLUME 7a:

RECOMMENDED WATER RESOURCE CLASSES FOR THE uMKHOMAZI (U1) AND MVOTI (U4) RIVER SYSTEMS

DECEMBER 2014

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

VOLUME 7a: RECOMMENDED WATER RESOURCE CLASSES FOR THE uMKHOMAZI (U1) AND MVOTI (U4) RIVER SYSTEMS

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DOCUMENT INDEX

Index Number	DWA Report Number	Report Title
1	*Report Number: RDM/WMA11/00/CON/CLA/0112*	*Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area:* **Inception Report**
2	*Report Number: RDM/WMA11/00/CON/CLA/0113*	*Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area:* **Status Quo assessment, IUA and Biophysical Node delineation and identification**
3	*Report Number: RDM/WMA11/00/CON/CLA/0213*	*Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area:* **River Resource Units and EWR sites**
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5.3	*Report Number: RDM/WMA11/00/CON/CLA/0314*	*Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area:* **Volume 3: EcoClassification and EWR assessment on the uMkhomazi, uMngeni and Mvoti Rivers**
6	*Report Number: RDM/WMA11/00/CON/CLA/0212*	*Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area:* **BHNR**
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11	*Report Number: RDM/WMA11/00/CON/CLA/0415*	*Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area:* **Main Report**

DEPARTMENT OF WATER AND SANITATION
CHIEF DIRECTORATE: WATER ECOSYSTEMS

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

VOLUME 7a: RECOMMENDED WATER RESOURCE CLASSES FOR THE uMKHOMAZI (U1) AND MVOTI (U4) RIVER SYSTEMS

Approved for RFA by:

……………………………………..	*……………………………………..*
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REPORT SCHEDULE

Version	Date	Comments received on
First draft	*December 2014*	*5 March 2014*
Final	*March 2014*	

EXECUTIVE SUMMARY

INTRODUCTION

*This task is associated with step 4 and 5 of the Water Resource Classification System. In summary, this task forms **part** of Step 4 within the integrated approach adopted for this study, i.e. the identification and evaluation of scenarios within the Integrated Water Resource Management Process. The purpose of this report is to recommended operational scenarios and draft Water Resource Classes for stakeholder evaluation.*

INTEGRATED CONSEQUENCES EVALUATION APPROACH

Considering that the core purpose of the Classification process is to select the Water Resource Class (DWAF, 2007) for a water resource, the scenario evaluation process provides the information needed to assist in arriving at a recommendation that will be consideration by the Minister of the Department of Water Affairs or delegated authority to make the final decision.

The overarching aim of the scenario evaluation process is to find the appropriate balance between the level of environmental protection and the use of the water to sustain socio-economic activities. Once the preferred scenario has been selected the Water Resource Class is defined by the level of environmental protection embedded in that scenario.

There are three main elements (variables) to consider in this balance, namely the Ecology, Ecosystem Services and the Economic benefits obtained from the use of a portion of the water resource. The scenario evaluation process therefore estimates the consequences of a set of plausible scenarios will have on these elements by quantifying selected metrics to compare the scenarios on relative bases with one another. The scenarios were ranked, first, for the individual variables and secondly an overall integrated ranking was derived based on multi-criteria analysis methods.

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

SCENARIO DESCRIPTION

The tables below summarise the scenario definition in the form of a matrix, where each row represents a scenario and the columns indicate each of the variables applicable to each scenario.

Summary of the uMkhomazi (U1) scenarios

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	uMWP-1	Ngwadini OCD
MK1	Yes	No	No	No	No
MK2	Yes	Yes	No	Yes	Yes (no support)
MK21	Yes	Yes	REC tot[1] (EWR 2)	Yes	Yes (no support)
MK22	Yes	Yes	REC low[2] (EWR 2)	Yes	Yes (no support)
MK23	Yes	Yes	REC low+[3] (EWR 2)	Yes	Yes (no support)
MK31	Yes	Yes	REC tot[1] (EWR 3)	Yes	Yes (no support)
MK32	Yes	Yes	REC low[2] (EWR 3)	Yes	Yes (no support)
MK33	Yes	Yes	REC low+[3] (EWR 3)	Yes	Yes (no support)
MK4	Yes	Yes	No	Yes	Yes (with support)

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	uMWP-1	Ngwadini OCD
MK41	*Yes*	*Yes*	*REC tot[1] (EWR 2)*	*Yes*	*Yes (with support)*
MK42	*Yes*	*Yes*	*REC low[2] (EWR 2)*	*Yes*	*Yes (with support)*

1 REC (Total Flows).
2 REC (Low Flows).
3 REC (Total Flows for January, February, March and Low Flows remaining months).

Summary of the Mvoti (U4) scenarios

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	MRDP[1]	Imvutshane Dam
MV1	*Yes*	*No*	*No*	*No*	*No*
MV21	*Yes*	*No*	*REC tot[2]*	*No*	*No*
MV22	*Yes*	*No*	*REC low[3]*	*No*	*No*
MV3	*Yes*	*Yes*	*No*	*Yes*	*Yes*
MV41	*Yes*	*Yes*	*REC tot[2]*	*Yes*	*Yes*
MV42	*Yes*	*Yes*	*REC low[3]*	*Yes*	*Yes*
MV43	*Yes*	*Yes*	*REC low+[4]*	*Yes*	*Yes*

1 Mvoti River Development Project (Isithundu Dam). *2 REC (Total Flows)*
3 REC (Low Flows).
4 REC (Total Flows for January, February, March and Low Flows for remaining months).

ECONOMIC CONSEQUENCES

The economic evaluation of the impact of the different scenarios, as evaluated, is based on the broad assumption that the utilisation of any additional, current or future water allocation is utilised at maximum efficiency.

Any economic evaluation takes place within the specific current situation, not an empty undeveloped river catchment, and it is necessary that the current situation be taken into consideration in the evaluation of any of the operational scenarios.

It was decided to use, in both the baseline as well as the different scenarios, two macro-economic indicators, namely GDP and employment. Although the use of the GDP created is generally accepted as an economic growth indicator, it sometimes does not present the full picture. In the case of irrigation agriculture irrigated sugarcane provides a very large GDP contribution. If the area is highly rural and impoverished then job creation is perhaps more important than GDP creation.

A second factor to consider is the value added process in the production area, as an example, sugarcane mills create a service point in the primary area of production. Many social services start to concentrate around sugarcane mills, such as health clinics, pension pay points and police stations.

The identified operational scenarios involve water provision from the proposed Smithfield Dam in the uMkhomazi and the Imvutshane Dam in the Mvoti River as well as additional re-use volumes from the Darvill works and the EThekwini works. This necessitates an approach that takes into consideration the cost of the infrastructure to provide the additional water as well as the potential benefits that can be derived from the additional available water.

The evaluation of projects is often a difficult task since costs and benefits do not occur only once but appear over time. Furthermore, costs and benefits are often hidden, making them hard to identify, and are also frequently difficult to measure. The same problems occur when the decision maker has to make a choice between numbers of mutually exclusive projects intended to achieve the same goal via a number of different routes. These problems are not limited to capital projects; they also occur when decisions have to be made regarding the merits of current expenditure programmes. The Cost Benefit Analysis (CBA) method provides a logical framework by means of which projects can be evaluated, serving as an aid in the decision making process.

The construction of a CBA in the public sector is approached from the point of view of the total community and not only the shareholders as in the case of a private sector company. It is also necessary that it be highlighted that a CBA does not provide answers about affordability, tariffs and funding.

The results of the different scenarios of each catchment, as it impacts on the different economic sectors, are presented. The results are displayed in the format of the discounted total GDP and employment as calculated.

The total capital cost of the proposed project is entered together with the annual operational and maintenance costs to provide a total annual cost for the future - 40 years.

Mvoti River System

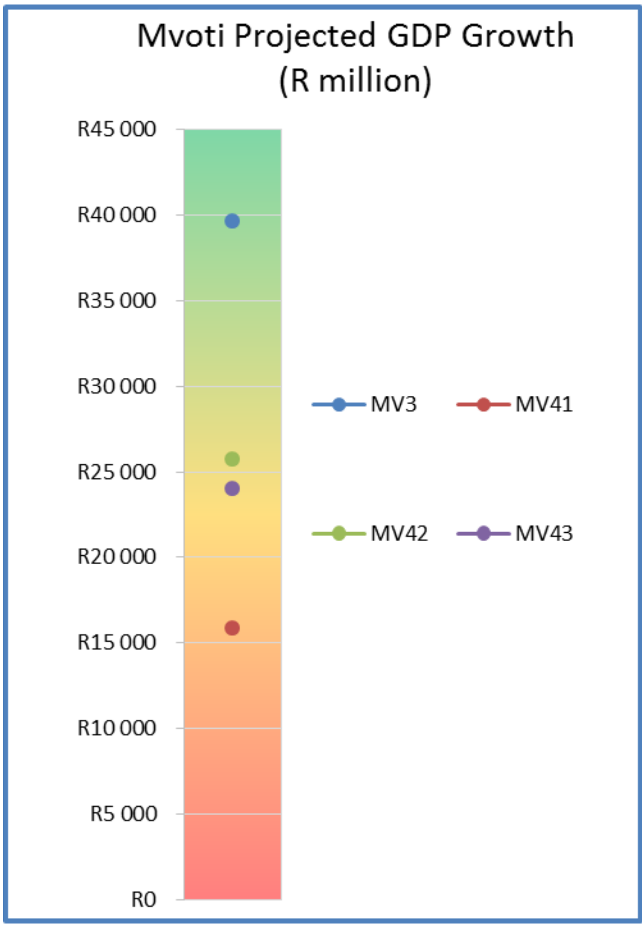
The following table reflects the results of the different operational scenarios in the Mvoti catchment.

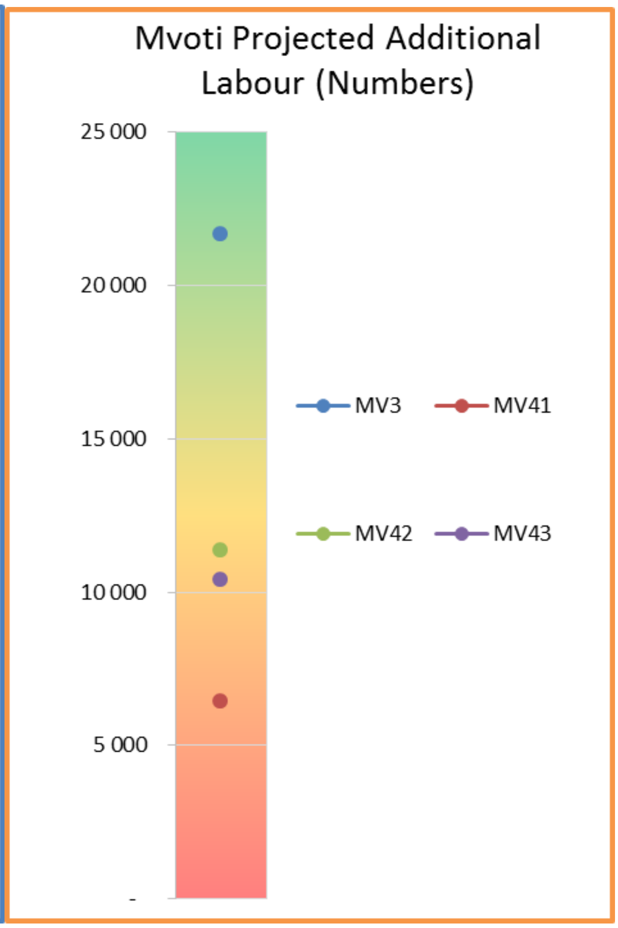
Scenario	Projected GDP growth (R million)	Projected additional labour
MV3	R 39 637.65	21 661
MV41	R 15 808.43	6 427
MV42	R 25 713.48	11 360
MV43	R 23 996.70	10 412

The following table presents the Mvoti results ranked in terms of economic preference.

Position	Projected GDP	Projected Employment
1	MV3	MV3
2	MV42	MV42
3	MV43	MV43
4	MV41	MV41

The following figure presents the Mvoti projected GDP growth and additional labour.





The above table together with the figure indicates that in economic terms Sc MV3 is the most preferable option with Sc MV41 the worst option.

UMkhomazi River System

The table below reflects the results of the different operational scenarios for the Lovu catchment. The results represent not only the possible impact in the uMkhomazi but also the impact of the different volumes that can be transferred.

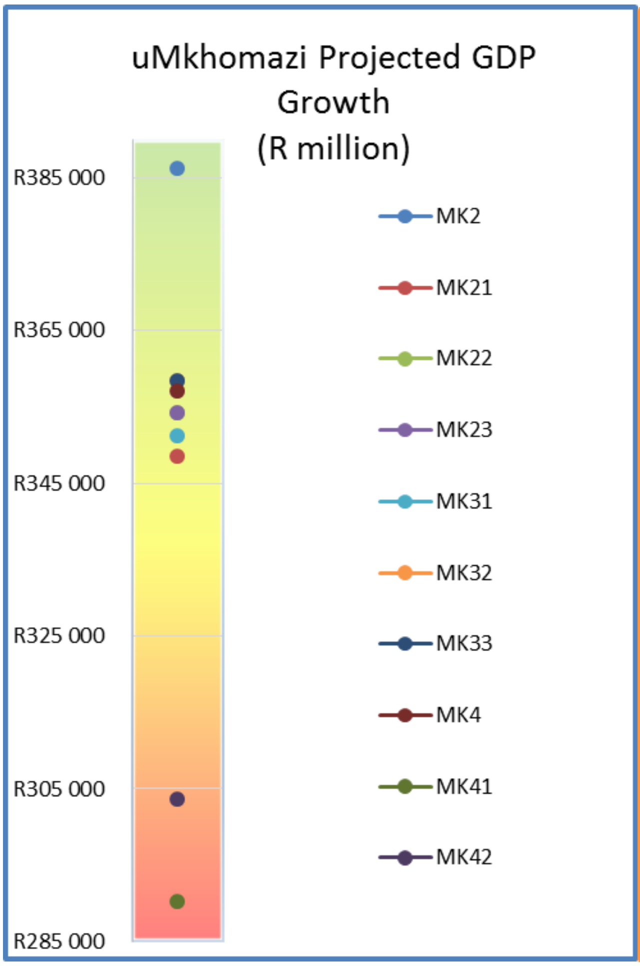
The following table presents the results of the operational scenarios in the uMkhomazi Catchment.

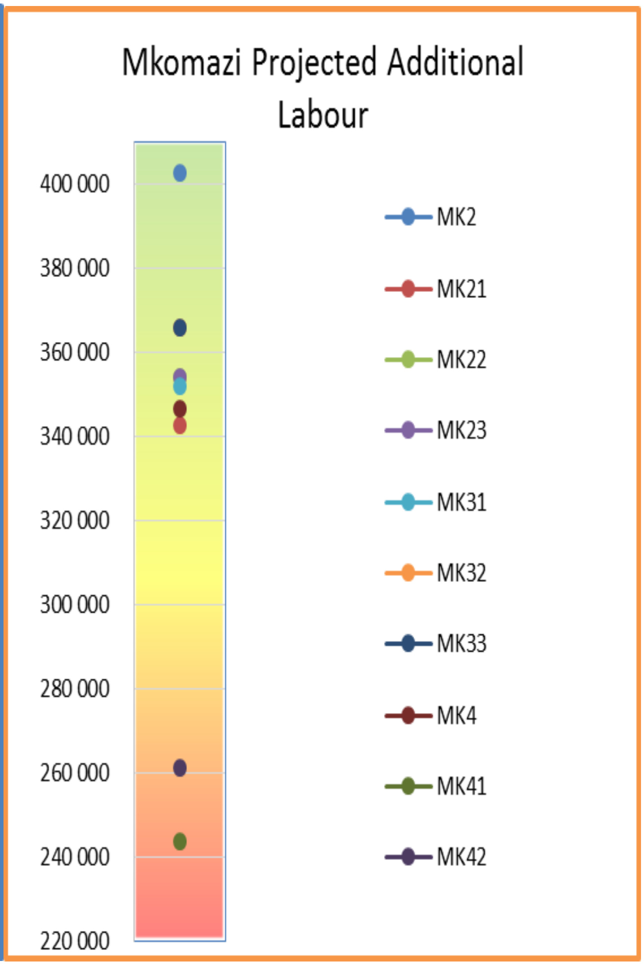
Scenario	Smithfield HFY	Ngwadini HFY	Projected GDP growth (R million)	Projected additional labour
MK2	*196.00*	*11.99*	*R 386 158*	*402 685*
MK21	*142.20*	*8.03*	*R 348 392*	*342 577*
MK22	*150.60*	*8.03*	*R 354 093*	*353 837*
MK23	*150.60*	*8.03*	*R 354 093*	*353 837*
MK31	*150.10*	*5.98*	*R 351 204*	*351 777*
MK32	*161.00*	*6.63*	*R 358 397*	*365 594*
MK33	*161.00*	*6.63*	*R 358 397*	*365 594*
MK4	*142.50*	*54.80*	*R 357 056*	*346 582*
MK41	*84.10*	*54.80*	*R 290 228*	*243 680*
MK42	*92.50*	*54.80*	*R 303 646*	*261 266*

The following table presents the uMkhomazi results ranked in terms of economic preference.

Position	Projected GDP	Projected Employment
1	*MK2*	*MK2*
2	*MK 32 and MK 33*	*MK 32 and MK 33*
3	*MK 4*	*MK22 and MK33*
4	*MK 22 and MK 33*	*MK31*
5	*MK 31*	*MK4*
6	*MK 21*	*MK21*
7	*MK 42*	*MK42*
8	*MK 41*	*MK41*

The following figure presents the uMkhomazi projected GDP growth and additional labour.





All the scenarios provide positive results, but differ in the lower rankings. For both measuring instruments Sc MK2 is the preferable option. Scenario MK41 is economically the least preferred option.

Conclusion

The various operational scenarios all present positive answers and should all make a positive contribution to the economic growth and employment creation in the four catchments. The final preferred option will depend on the interaction between the economic values, the goods and services and the environmental impacts.

ECOLOGICAL CONSEQUENCES

The scenarios were evaluated and, during a specialist meeting, the consequences were determined at each site by ranking the scenarios in terms of how successful they are in meeting the Recommended Ecological Scenario. Based on the site weighting, a system ranking is determined. The results are summarised in the text and figure below.

uMkhomazi River System

The ranking shows that Sc MK2 and MK4 are the lowest in the ranking order at all sites and significantly lower than the other scenarios. This is because Sc MK2 and MK4 include Smithfield Dam with no EWRs. All the rest of the scenarios still maintain the EcoStatus of a C at Mk_I_EWR1 but do not achieve the REC (PES). The major problem at Mk_I_EWR 1 is that the site is close to the dam and therefore only received the water being released from the dam or spills. As the river acts as a conduit to convey water from the dam down the system, the main reasons for not achieving the REC (PES) is the increased (above natural) and unseasonal base flows as well as the decrease in floods.

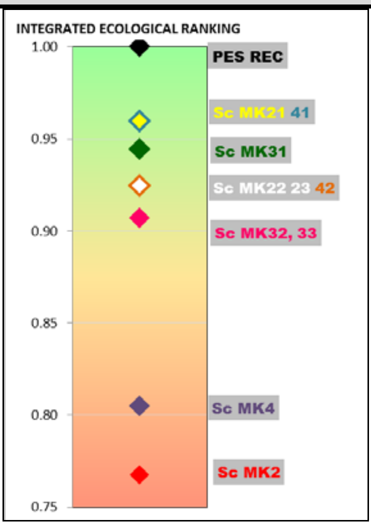
As one moves further downstream of the dam, the impacts become less pronounced. At Mk_I_EWR 2, tributary inflows mitigate some of the impacts of the unseasonal flows and the lack of floods. However the main users are downstream of Mk_I_EWR 2, and therefore the impacts are still felt to some degree. Sc MK 21, MK41 and MK42 still maintain the EcoStatus of a B with Sc MK41 being the better scenario. At Mk_I_EWR3, Sc MK21, MK41 and MK31 maintain the C EcoStatus and are the best scenarios, although it also does not achieve all the ecological objectives.

The integrated ranking shows that Sc MK 21 and MK41 are the best options as they are the closest to meeting the ecological objectives. Both these scenarios include the total EWR flows and the impacts are mostly due to the impacts on the dam itself, such as the barrier effect, impact on larger frequency of floods and largely due to the increased (above natural) base flows.

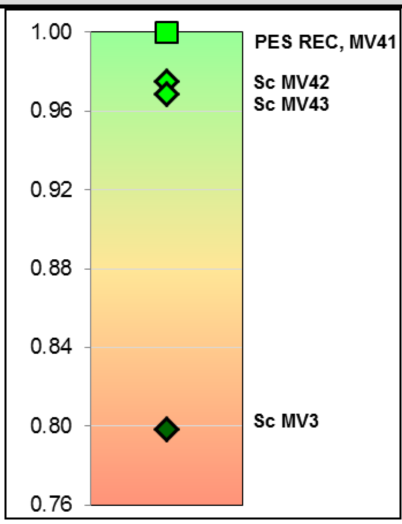
Mvoti River System

Scenario MV41 which includes the dam and releases the full EWR will meet the ecological objectives. Scenario MV42 and MV43 are very similar, still maintain the REC EcoStatus but overall do not comply with all the objectives. Scenario MV3 is the least acceptable as it drops a category overall (D EC) and for most of the components.

uMkhomazi



Mvoti



ECOSYSTEM SERVICES

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 followed 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.

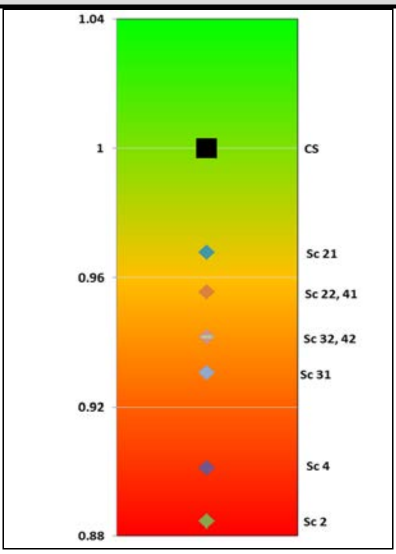
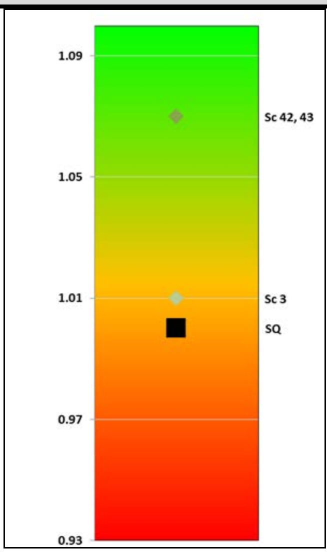
With this in mind an analysis of Mk_I_EWR1, 2 and 3 on the uMkhomazi and Mv_I_EWR2 on the Mvoti was undertaken. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. 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 categories of ecosystem services. Here the perceived vulnerability of households dependent on the provisioning aspect of Ecosystem Services played a major role.

uMkhomazi River System (U1)

For the uMkhomazi, Mk_I_EWR1 was examined with respect to scenarios MK2, MK4, MK21, MK22, MK31, MK32, MK41 and MK42. All scenarios were associated with negative impacts. Scenarios MK2 and MK4 were deemed to be particularly negative. For Mk_I_EWR2 the same scenarios were examined. Again all were negative with Sc MK 2 again being the worst. For Mk_I_EWR3, scenarios MK2, MK21, MK22, MK32 and MK42 were examined. All were marginally negative with the exception of Sc MK 21 which was marginally positive. The integrated results are illustrated below.

Mvoti River System (U4)

At Mv_I_EWR2 scenario MV3, MV42 and MV43 were examined. All were positive. Scenario MV3 is marginally positive while Sc MV42 and MV43 are slightly more positive. The results are presented in the figure below.

<table>
<tr><th>uMkhomazi</th><th>Mvoti</th></tr>
<tr><td>
</td><td>
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DRAFT WATER RESOURCE CLASSES

A range of alternative Water Resource Criteria settings were evaluated by the study team leading to the recommended criteria parameters presented below.

Recommended Water Resource Class criteria table

		% EC representation at units represented by biophysical nodes in an IUA				
		≥ A/B	≥ B	≥C	≥ D	< D
Class 1		0	60	80	95	5
Class 2			0	70	90	10
Class 3	Either			0	80	20
	Or				100	

The resulting Water Resource Classes for the recommended scenario/s (red text below) are provided in the following tables:

uMkhomazi River System: Resulting IUA Water Resource Classes for each scenario

IUA	Scenarios and Water Resource Class												
	PES	REC	MK2	MK21	MK22	MK23	MK31	MK32	MK33	MK4	MK41	MK42	MK21b
U1-1	I	I	I	I	I	I	I	I	I	I	I	I	I
U1-2	II	II	II	II	II	II	II	II	II	II	II	II	II
U1-3	II	I	II	I	II	II	II	II	II	II	I	I	I
U1-4	II	II	III	II	III	III	II	II	II	III	II	III	II
U1-5	II	I	III	II	II	II	III	III	III	III	II	II	III

* Note, these improvements are based on addressing the anthropogenic issues.

Mvoti River System: Resulting IUA Water Resource Classes for each scenario

IUA	Scenarios and Water Resource Class					
	PES	REC	MV3	MV41	MV42	MV43
U4-1	II	II	II	II	II	II
U4-2	II	I	I	I	I	I
U4-3	II	II	III	II	II	II
U4-4	III	II*	III	III	II*	III

* Note, these improvements are based on addressing the anthropogenic issues.

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ACRONYMS AND ABBREVIATIONS

Anth	*Anthropological*
CBA	*Cost Benefit Analysis*
CD: WE	*Chief Directorate: Water Ecosystems*
CS	*Current State*
DWA	*Department of Water Affairs (Change after 2008)*
DWAF	*Department of Water Affairs and Forestry*
DWS	*Department of Water Affairs and Sanitation (Change after May 2014)*
EC	*Ecological Category*
EFY	*Excess Firm Yield*
EHI	*Estuarine Health Index*
EI	*Ecological Importance*
EIS	*Ecological Importance and Sensitivity*
ES	*Ecological Sensitivity*
EWR	*Ecological Water Requirement*
FSC	*Full Supply Capacity*
GDP	*Gross Domestic Product*
HFY	*Historic Firm Yield*
IUA	*Integrated Unit of Analysis*
OCD	*Off Channel Dam*
PES	*Present Ecological State*
REC	*Recommended Ecological State*
RQOs	*Resource Quality Objectives*
Sc	*Scenario*
SQ	*Sub-quaternary (may also be termed a quinary)*
uMWP1	*uMkhomazi Water Project, Phase 1*
UWS	*Ultimate Waste Water Scenario*
WMA	*Water Management Area*
WRCS	*Water Resources Classification System*
WRYM	*Water Resource Yield Model*
WSS	*Water Supply and Sanitation*
WWTW	*Waste Water Treatment Works*

1 INTRODUCTION

1.1 BACKGROUND

There is an urgency to ensure that water resources in the Mvoti to Umzimkulu Water Management Area (WMA) are able to sustain their level of uses and be maintained at their desired states. The determination of the Water Resource Classes of the significant water resources in Mvoti to Umzimkulu WMA will ensure that the desired condition of the water resources, and conversely, the degree to which they can be utilised is maintained and adequately managed within the economic, social and ecological goals of the water users (DWA, 2011). The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2012 for the provision of professional services to undertake the Comprehensive Reserve, classify all significant water resources and determine the Resource Quality Objectives (RQOs) in the Mvoti to Umzimkulu WMA

1.2 STUDY AREA OVERVIEW

The Mvoti to Umzimkulu WMA encompasses a total catchment area of approximately 27,000 km^2 and is situated within Kwazulu-Natal. A small portion of the Mtamvuna River and the upper and lower segments of the Umzimkulu River straddle the Eastern Cape, close to the Mzimvubu and Keiskamma WMA in the south (DWA, 2011).

The WMA extends from the town of Zinkwazi, in the north to Port Edward and on the south along the KwaZulu-Natal coastline and envelopes the inland towns of Underberg and Greytown also incorporating the Drakensberg escarpment. The WMA spans across the primary catchment "U" and incorporates the secondary drainage areas of T40 (Mtamvuna River in Port Shepstone) and T52 (Umzimkulu River). Ninety quaternary catchments constitute the water management area and the major rivers draining this WMA include the Mvoti, uMngeni, uMkhomazi, Umzimkulu and Mtamvuna (DWA, 2011).

Two large river systems, the Umzimkulu and uMkhomazi rise in the Drakensberg. Two medium-sized river systems the uMngeni and Mvoti rise in the Natal Midlands and have been largely modified by human activities, mainly intensive agriculture, forestry and urban settlements. Several smaller river systems (e.g. Mzumbe, Mdloti, Tongaat, Fafa, and Lovu Rivers) are also present within the WMA (DWAF, 2004). Several parallel rivers arise in the escarpment and discharges into the Indian Ocean and the water courses in the study area display a prominent southeasterly flow direction (DWA, 2011). The WMA is very rugged and very steep slopes characterise the river valleys in the inland areas for all rivers and moderate slopes are found but comprise only 3% of the area of the WMA (DWAF, 2004).

This report focusses only on the uMkhomazi (U1) and the Mvoti (U4) River systems.

1.3 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the National Water Classification System, the Reserve and RQOs are supplied in Table 1.1.

Table 1.1 Integrated study steps

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

This task forms ***part*** *of Step 4, i.e. the identification and evaluation of scenarios within the Integrated Water Resource Management Process. This step is closely linked to the next step where the scenarios are tested with stakeholders and the draft Water Resource Classes are determined. Using the results of the status quo assessment (DWA, 2013) (Step 1), the subsequent steps were initiated and the results of Step 4 for the uMkhomazi and the Mvoti systems are documented in this report.*

1.4 TASK D4: IDENTIFICATION AND EVALUATION OF OPERATIONAL SCENARIOS TO IDENTIFY CONSEQUENCES

This task is associated with step 4 and 5 of the Water Resource Classification System (WRCS). In practice, these two steps function as one and are integrated as Task 4 (or step 4 within the integrated approach) (DWA, 2012). The objective of this task was to describe and document the following:

- *Identification of operating scenarios in accordance with the Reconciliation Strategy Study (DWAF, 2008).*
- *River ecological consequences of the operational scenarios (Sc) at the key biophysical nodes (Ecological Water Requirements (EWR) sites) and the estuary by evaluating and determining the impact on the Ecological Category (EC).*
- *Economic consequences of operational scenarios by determining the impact of any water allocation changes.*
- *Assessment of the impacts of the various scenarios on Ecosystem Services of operational scenarios to identify the direction of change (either positive or negative) and estimate the magnitude of the change in benefits and costs that may be experienced within the river system.*
- *Water quality consequences (other than water quality consequences associated with the ecological component).*
- *Integrate the consequences to provide preliminary Water Resource Class for stakeholder evaluation.*

The process described above is illustrated in Figure 1.1 and Figure 1.2. Figure 1.1 illustrates the broad conceptual process from the determination of the Status Quo (Integrated Step 1) through to the determination of Water Resource Classes. Within these steps there are further sub-steps that pertain to integrated step 4 which are described in Figure 1.2.

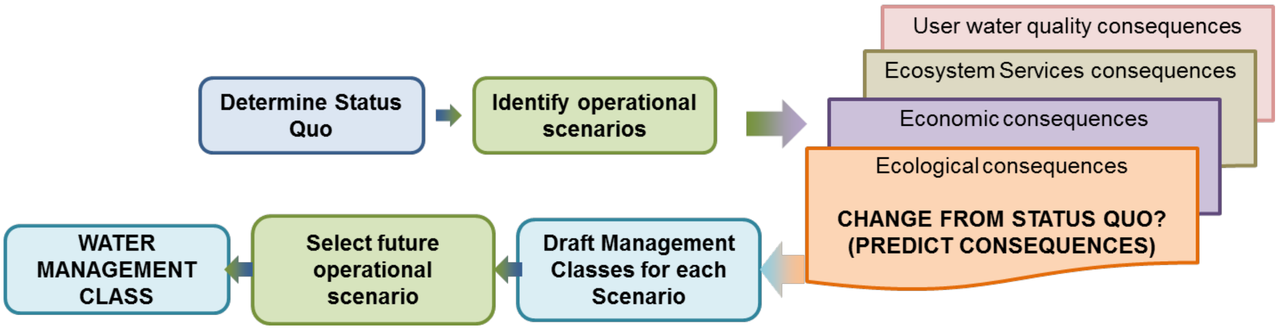


Figure 1.1 The process in Step 4 and 5: Identification of scenarios to the gazetted Water Resource Class

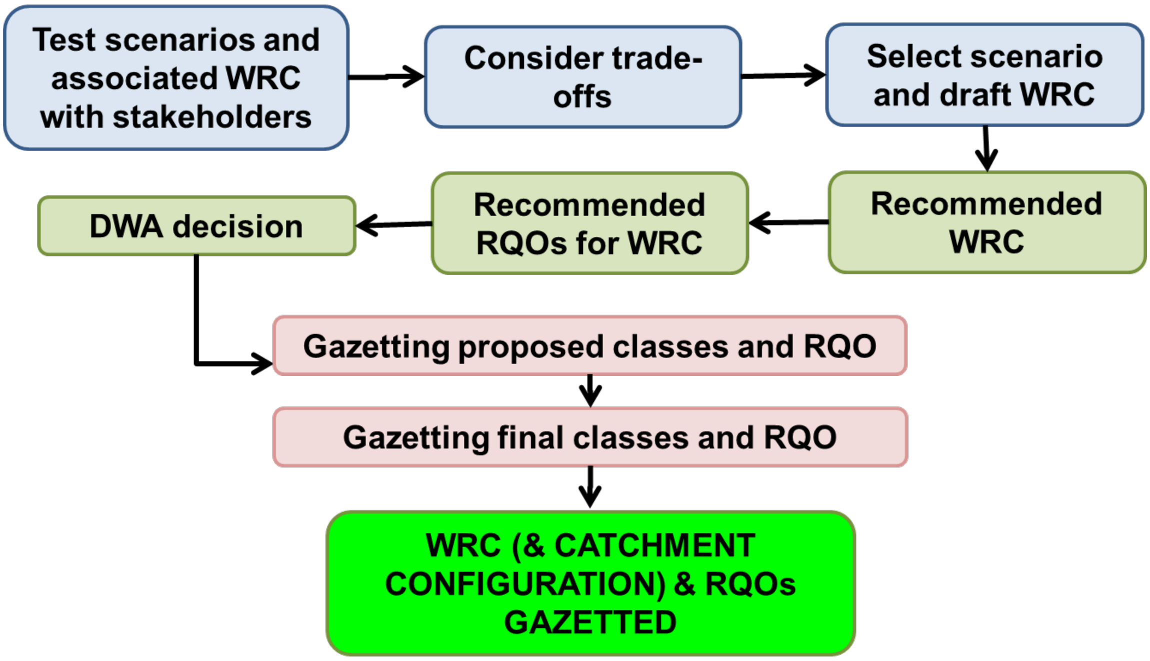


Figure 1.2 Step 5: Illustrates the steps from the testing of scenarios with stakeholders to a final gazetted Water Resource Class and catchment configuration

1.5 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this report is to recommended operational scenarios and preliminary Water Resource Classes for stakeholder evaluation for U1 and U4 catchments.

The report outline is provided below.

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

Chapter 2: Integrated Consequences Evaluation Approach
This chapter provides an overview of the scenario evaluation process. Ecology, Ecosystem Services and the Economic benefits are compared when determining the degree of achieving the appropriate balance between ecological objectives the socio-economic benefits and this chapter provides an expanded description of how the metric for each of the three components were derived.

Chapter 3: Scenario Description

The scenarios considered for evaluation are discussed.

Chapter 4: Economic Consequences
The impact results of different scenarios on the economic sectors are presented in this Chapter.

Chapter 5: Ecological Consequences (Rivers)
The results of the ecological consequences of the various scenarios are presented in this Chapter.

Chapter 6: Ecological Consequences (Estuaries)
The results of the ecological consequences of the various scenarios are presented in this Chapter.

Chapter 7: Ecosystem Services Consequences
The results of impact of the different scenarios on Ecosystem Services are presented in this Chapter.

Chapter 8: Integrated Multi-Criteria Results
The results of the rating, weighting and scoring for the three variables, Economy, Ecology and Ecosystem Services presented in Chapters 4 – 7 were integrated to obtain the overall ranking of the scenarios and described in this chapter.

Chapter 9: Water Resource Classes and Catchment Configuration
The recommended Water Resource Classes among the scenarios are presented. Conclusions and recommendations are provided.

Chapter 10: References

Chapter 11: Appendix A: Example of Rating, Weighting and Scoring
Appendix B provides an example (extract) of the full scoring calculation carried out for the ecological component of the Integrated Multi-Criteria Analysis Model for the Mvoti River system.

Chapter 12: Appendix D: Report Comments

2 INTEGRATED CONSEQUENCES EVALUATION APPROACH

2.1 OVERVIEW OF THE SCENARIOS EVALUATION PROCESS

Considering that the core purpose of the Classification process is to select the Water Resource Class (DWAF, 2007) for a water resource, the scenario evaluation process provides the information needed to assist in arriving at a recommendation that will be consideration by the Minister of the Department of Water Affairs or delegated authority to make the final decision.

The overarching aim of the scenario evaluation process is to find the appropriate balance between the level of environmental protection and the use of the water to sustain socio-economic activities. Once the preferred scenario has been selected the Water Resource Class is defined by the level of environmental protection embedded in that scenario.

There are three main elements (variables) to consider in this balance, namely the Ecology, Ecosystem Services and the Economic benefits obtained from the use of a portion of the water resource. The scenarios evaluation process therefore estimates the consequences that a plausible set of scenarios will have on these variables. The evaluation process uses the quantification of selected metrics to compare the scenarios on relative basis with one another.

During the evaluation process stakeholders are engaged at various stages, initially by providing their respective visions for the catchments (Integrated Units of Analysis - IUA), then defining and selecting the scenarios for evaluation and finally to assess the consequences with the aim to make a recommendation of which Water Resource Class should be implemented.

The scenario evaluation process entails a sequence of activities followed during the study and are illustrated schematically in Figure 2.1.

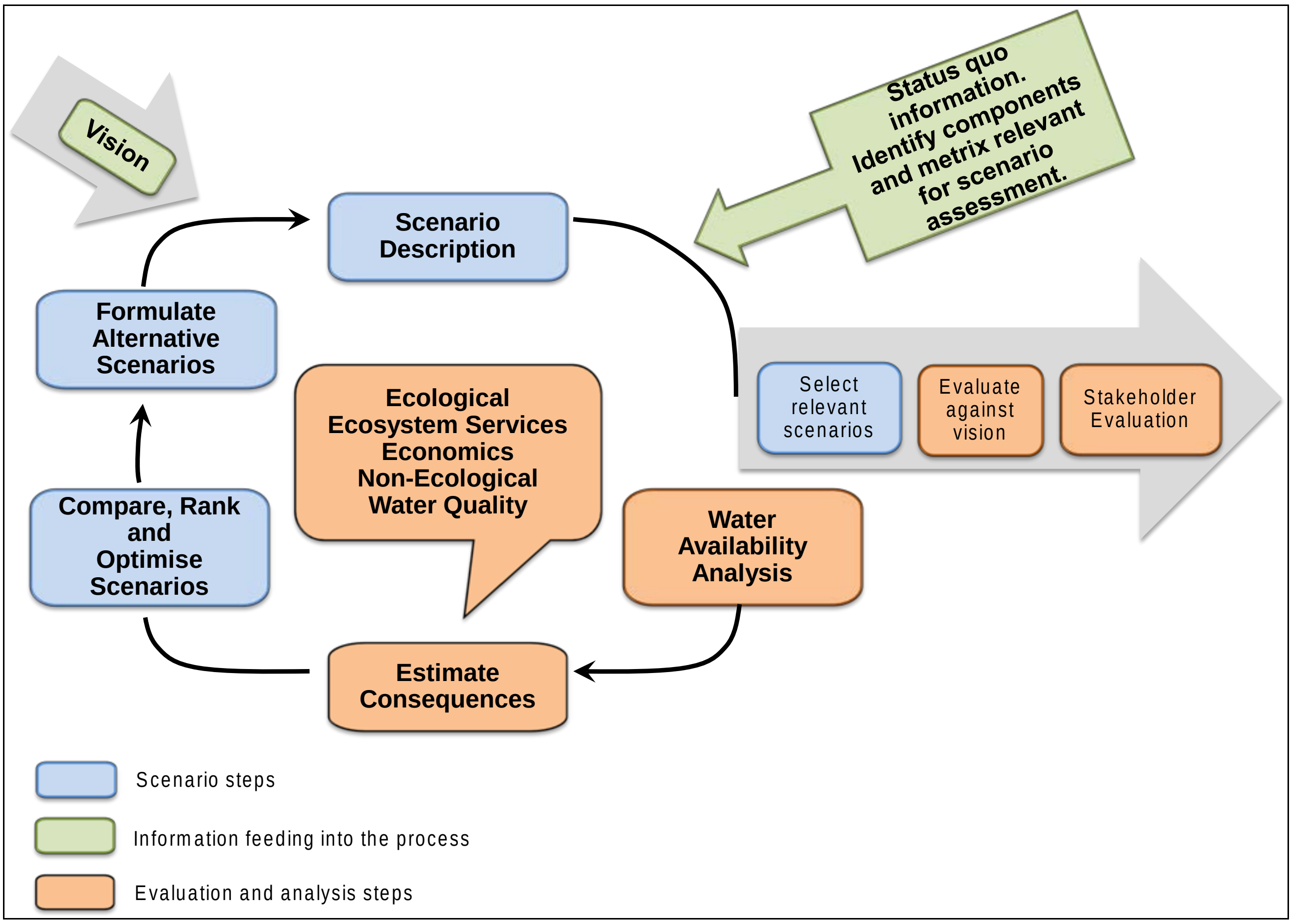


Figure 2.1 Schematic representation of the scenario evaluation process

Each activity presented in Figure 2.1 is briefly described in the following sections.

2.1.1 Vision

The visioning activity was carried out through interactive engagements with stakeholders where their respective views as to what the desired future state of the water resources should be were obtained. These visions were documented in the form of narrative descriptions and captured for the twelve delineated IUA.

2.1.2 Scenario description

The definition and evaluation of scenarios were undertaken in context of the prevailing and proposed water resource management activities in the study area. A scenario, in context of water resource management and planning, are plausible definitions (settings) of all the factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. While a workshop was held with stakeholders to identify scenarios, the development options were already well established as part of several previous studies (such as DWAF, 2008). This preliminary list was presented to stakeholders for their consideration after which a final list was compiled for evaluation (see Chapter 3 for a description of the scenarios that were evaluated).

2.1.3 Assign attributes to EWR nodes

Applying the Status Quo information (DWA, 2013) all the relevant properties (attributes) were defined for the biophysical nodes with respect to the Ecology, Ecosystem Services as well as the economic characteristics (in context of the IUA). A key aspect of this activity was to incorporate these nodes into the water resource simulation model to enable the generation of monthly time series of flow data for the scenarios where appropriate. At selected nodes (key biophysical nodes *or EWR sites) the flows required to achieve a particular ecological state were also defined, along with rules to make releases from upstream weirs and dams.*

2.1.4 Water availability analysis

This activity applied the water resource simulation model to determine the volume of water that is available for abstraction from the water resource for economic use, given that the flow regime in the river is maintained to achieve a certain ecological state. Appropriate discharges are also simulated as part of the volumetric analyses. The ecological state is defined by the particular EC specified for the scenario under consideration, which could be the Recommended Ecological Category (REC), Present Ecological State (PES) or any other appropriate EC.

2.1.5 Estimate consequences

The simulated flow regimes at the nodes and the water available for abstraction form the basis for evaluating and estimating the consequences of each scenario. The text box in the centre of Table 2.1 indicates the aspects that were evaluated. Table 2.1 lists these aspects and provides a brief description of the evaluation method and purpose as well as references to where further detail information are provided.

Table 2.1 Variables considered in the scenario comparison and evaluation process

Variable	Evaluation purpose and method	Reference to further detail information
Ecological	*Determine the EC and indicate the degree in which the scenario achieves the REC.*	*Report 8.1; Report 8.2 Chapter 5 Chapter 6*
Ecosystem Services	*Determine the extent that each scenario changes the Ecosystem Services relative to the PES conditions.*	*Chapter 7 Report 8.5*
Economy	*Determine the economic benefit of utilising the available water (abstractions) in terms of Gross Domestic Product (GDP) and Employment (Jobs).*	*Chapter 4 Report 8.4*
Non-ecological Water Quality	*Consider the consequences of having to achieve elevated water quality standards for users other than the ecology (fitness for use or Userspecs). This may involve determining the economic implications of such elevated standards.*	*Report 8.6 (to be produced during February 2015)*

2.1.6 Compare, rank and optimise

The consequences from the abovementioned activity are expressed numerically for the scenarios and compared separately for each variable and then the results are combined for all variables to derive overall scores which give effect to the ranking of scenarios. The methodology employed for this is based on Multi Criteria Analysis approach where weighting factors are applied, firstly to give effect that certain nodes are more important than others and secondly that the variables listed in Table 2.1 may differ in their relative importance (see Section 2.2) for further details on the Multi Criteria Analysis methodology).

All the scenarios are described in Chapter 3.

2.1.7 Formulate alternative scenarios

This activity involves the formulation of alternative scenarios, usually consisting of adjustment to the initial list (rather than completely different scenarios) for further consideration. The other steps *are then repeated as indicated by the circular arrows depicting the information flow from one activity to the next.*

2.1.8 Select scenario subset for stakeholder evaluation

The technical study team assessed several scenarios of which the results defined the boundaries of the variable settings and point to the aspects that are important to consider in the study area. A relevant subset of the full list of scenarios was selected for discussion with stakeholders.

2.2 MULTI CRITERIA ANALYSIS FOR SCENARIO EVALUATION AND COMPARISON

2.2.1 Evaluation variables

As explained in Section 2.1 there are three main aspects that are compared when determining the degree of achieving the appropriate balance between the ecological objectives on the one hand and the socio-economic benefits on the other.

The ecological state (or health) rating is expressed relative to how the scenario achieves the REC. This is quantified as a numerical ratio ranging usually between 1 and 0, where a score of 1 indicates the scenario achieves the REC and zero when the scenario is typically in an F Ecological Category.

The rating of the Ecosystem Services for a scenario is expressed numerically and relative to the baseline Ecosystem Services available under current conditions (2013). A score of 1 indicates the scenario will provide the same services as under present conditions where a score of 1.2 imply there is 20% more utility in terms of Ecosystem Services. A score of 0.8 indicates a reduction of 20% in the services provided by the scenario.

In terms of the socio-economic component, two aspects are evaluated, namely the GDP and employment (the number of jobs) that will be supported by the volume of water that is abstracted from or discharges into the system for the scenario. The GDP is expressed in monetary terms (Rand) and employment in the number of jobs supported.

The following sections provide an expanded description of how the metric for each of the three components presented above were derived.

2.2.2 Ecological Metric

a) Rivers

Deriving a single metric (one number), that reflects the ecological health relative to the REC for the river, requires several steps, sub-steps and the application of various tools. Broadly, the rationale to achieve this single rating is based on the following.

- *Scenarios at each EWR site are ranked on the basis of the degree to which the scenarios meet the REC.*
- *Comparing the impact of the scenarios at the different EWR sites to determine a ranking from a system context depends both on the degree to which the scenario meets the REC, as well as the relative ecological importance of the sites.*

To further explain this, if a scenario is ranked highest at a site of low importance, but lower at a site of high importance, this scenario will not carry the same weight as the scenario that scored the highest at the sites of high importance.

The steps and sub-steps to derive a single number are illustrated in Figure 2.2 and Figure 2.3 and described in the bulleted list below:

- *Step 1: Rank scenarios at each EWR site (Figure 2.2 and Figure 2.3).*
  - *Apply the EcoClassification (Kleynhans and Louw, 2007) process at each EWR site where the scenario influences the flow or water quality to determine the EC for each component[1].*
  - *Provide the associated percentage that represents the category.*
  - *Calculate the degree to which the scenario meets the ecological objectives which is represented by the REC. I.e., if the REC for a component is 62% and the scenario results in this component being at 62%, then the resulting score would be a 1 (or a 100% successful in meeting the REC). If a scenario's rating for the component is 48%, then the score would be 0.77 (or 77% successful in meeting the REC).*
  - *Average the score at each component to obtain a score for the scenario at the site.*
  - *Each site's score is then normalised to obtain a rating that is 1 if the REC is achieved, above one if the REC is exceeded (i.e. 1.1) or between 1 and zero if the score (EC) is below the REC.*
  - *Rank the scenarios in terms of a numerical scale with values zero and one (typically, where one (1) indicates the scenario achieves the REC and a zero (0) represents the situation where the scenario results in a "F").*

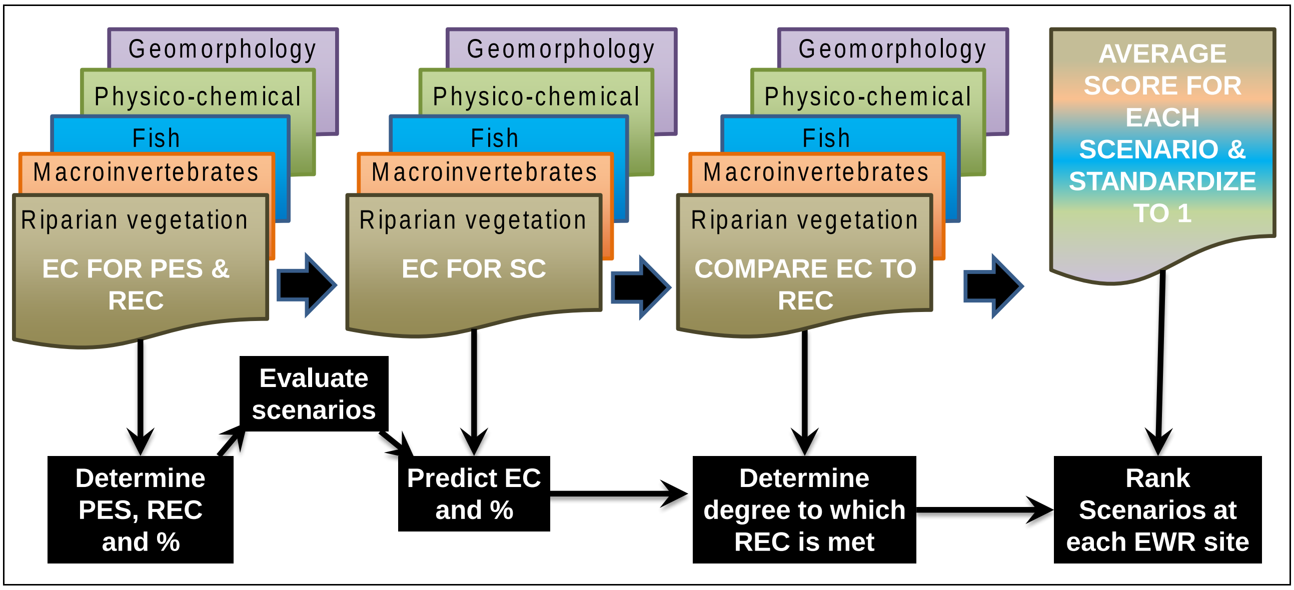


Figure 2.2 Process to rank scenarios at each EWR site

- *Step 2: Determine the relative importance of EWR sites to each other (Figure 2.3).*

The following aspects are considered when determining the relative importance of the EWR sites to each other:

  - *PES: The higher the PES the more important the EWR site. The PES percentage is used in this calculation.*
  - *Ecological Importance and Sensitivity (EIS): The higher the EIS rating, the more important the EWR site. The EIS score is used in this calculation.*

1 Component: Habitat drivers (geomorphology and water quality (hydrology is a given)); Biological responses (fish, macroinvertebrates, riparian vegetation).

- *Conservation importance: The locality of the site within a declared conservation area is highlighted. A site within a Trans-frontier park or a Wilderness Area will be more important than a National Park which in turn will be more important than a provincial nature reserve.*

The above metrics are averaged and the score is then normalised out of one.

- *Step 3: Rank the scenarios in a system context (Figure 2.3)*

All the scores from the EWR sites are then combined into a single score by accounting for the above site importance ranking. This is achieved by assigning different weights (factors) to each site to reflect the importance relative to the others.

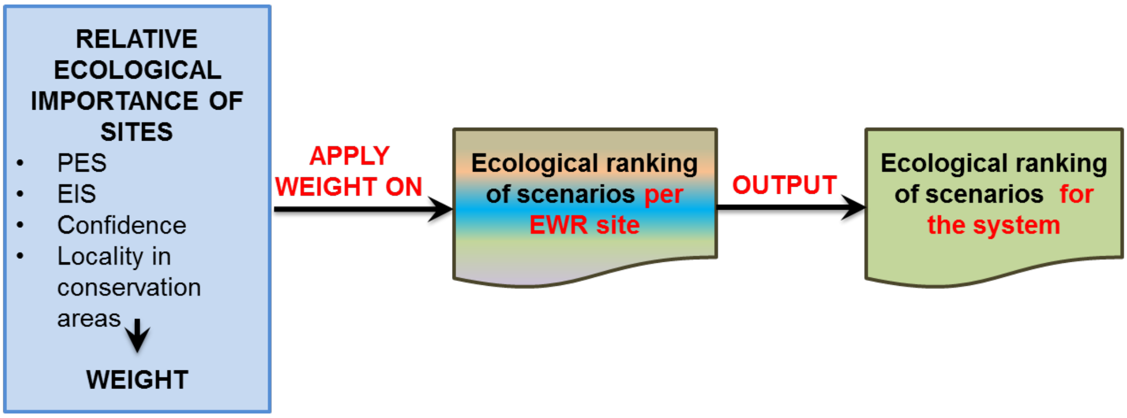


Figure 2.3 Process to achieve the ecological ranking of all scenarios on the river systems

The output of the application of these processes result in an ecological ranking of each scenario for the uMkhomazi, and Mvoti River systems. The individual ranking and consequences at each EWR site have therefore been integrated into one ranking and consequences applicable to the specific river system.

b) Estuary

Deriving a single metric (one number), that reflects the ecological health relative to the REC for the estuaries, requires a number of steps. Broadly, the rationale to achieve a single rating is that each scenario at each estuary is ranked on the basis of the degree to which the scenarios meet the REC. The following approach was applied:

- *Apply the Estuary Health Index (EHI) process to each scenario that influences the flow or water quality to determine the EC for each component.*
- *Provide the associated percentage that represents the category.*
- *Calculate the degree to which the scenario meets the ecological objectives which is represented by the REC.*
- *The score of each scenario is then normalised to obtain a rating that is 1 if the REC is achieved, above one if the REC is exceeded (i.e. 1.1) or between 1 and zero if the score (EC) is below the REC.*
- *Rank the scenarios in terms of a numerical scale with values zero and one (typically, where one (1) indicates the scenario achieves the REC and a zero (0) represents the situation where the scenario results in a "F").*

c) Integration of rivers and estuary

To produce a final ecological ranking, the rivers and estuary must be combined and inherently, the estuary is treated as an additional EWR site. This means that as the river EWR sites are weighted, the estuary must now also be weighted and all EWR site weights adjusted pro rata. Factors considered in the rating are ecological and conservation importance, the PES, the functionality of the estuary, the sensitivity of the estuary to scenario changes and the length or size (area) of the river and estuary respectively. At this stage, fixed rules have not been established and the weighting was decided through a specialist consultative process (considering the above issues), as well as a sensitivity analysis to test the different weight combinations.

2.2.3 Ecosystem Services metric

Natural habitats and ecosystems provide a range of environmental goods and services that contribute to human well-being. River systems and their associated use values are of particular importance in many instances. For operational purposes this study followed 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.

With this in mind an analysis of Mk_I_EWR1, 2 and 3 on the uMkhomazi and Mv_I_EWR2 on the Mvoti was undertaken. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. 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 categories of ecosystem services. Here the perceived vulnerability of households dependent on the provisioning aspect of Ecosystem Services played a major role.

The scenario impact on various ecosystem services (including botanical or fish species) were then amalgamated into overall categorisation of provisioning, regulating, cultural, and supporting services. The scenarios are also weighted with respect to the importance of the services at each EWR site. As such the score given to each of the services when the Sub Quaternary catchments (SQs) are evaluated is examined against the nature of the particular EWR site and associated area. In an instance where regulating services, for example are deemed to be important, then these services are given a higher weight. The same goes for the other services. All weightings are normalised against a base score of 1. Where all four services are deemed to be of equal importance then a score of 0.25 would be allocated to each.

2.2.4 Relationship between economic, environmental and social impact

None of the rivers in the specific WMA are still in the original virgin state, they are in different stages of utilisation by the local population, irrigation activities, commercial forestry, mining or other economic activities. Typically if the resource is not well looked after the volume and quality of the water will deteriorate over time and the current activities will decline with the resulting negative impacts on the environment and the population.

2.2.5 Gross Domestic Product and employment metric

The economic evaluation of the impact of the different scenarios, as evaluated, is based on the broad assumption that the utilisation of any additional, current or future water allocation is utilised at maximum efficiency.

Any economic evaluation takes place within the specific current situation, not a clear undeveloped river catchment, and it is necessary that the current situation be taken into consideration in the evaluation of all the operational scenarios.

Currently the following main water users are identified in a catchment or WMA, or are dependent on the water abstracted from or discharged into the river. The main users are:

- *Irrigation.*
- *Commercial forestry.*
- *Mining.*
- *Electricity Generation*
- *Industry – Wet and Dry processes.*
- *Urban and Domestic Household Use – certain water related activities are performed in the different domestic suburbs like plumbing, car washes and others.*
- *Tourism.*

The tourist activity depends on the availability and quality of the water in the river or estuary and the overall condition of the environment.

As the main aim of the classification process is to stabilise the river or estuary class, the possibility that the water in the river will be reduced is not always an acceptable option. Therefore, the tourist activities can only be positively impacted upon, the worst case option is that the sector will remain as it is at present.

The commercial forestry sector is regulated by a permit system, and we could not find any evidence that any reduction or increase in the commercial plantation area is considered. For this reason it was accepted that on the medium term the forestry sector will not be impacted on by any operational scenario.

The irrigation, mining and industry sectors will only be impacted on by scenarios which result in available volumes increasing or decreasing. However, currently no electricity generation takes place in the catchment and only quarrying as a mining activity takes place.

Measuring parameters

It was decided to use, in both the baseline as well as the different scenarios, two macro-economic indicators, namely Gross Domestic Product (GDP) and employment. Although the use of the GDP created is generally accepted as an economic growth indicator, it sometimes does not present the full picture. In the case of irrigation agriculture irrigated sugarcane provides a very large GDP contribution. If the area is highly rural and impoverished then job creation is perhaps more important than GDP creation.

The different linkages are also explained with by the following example illustration. In the case of irrigation agriculture irrigated maize is an important strategic product which makes a significant GDP contribution to the national food security, as well as to the rural household food security *situation. However, because of the high levels of mechanisation limited employment opportunities are created in the primary sector.*

A second factor to consider is the value added process in the production area, as an example, sugarcane mills create a service point in the primary area of production. Many social services start to concentrate around sugarcane mills, such as health clinics, pension pay points and police stations.

On the opposite side is, possibly, citrus production which creates a large number of jobs in the primary production activity, but very little value added takes place in the primary production area as most of the fruit is exported. This is not always the complete picture as juice facilities and other value added processes can be added. Related exports in whatever form has a positive impact on the Balance of Payments.

In the final instance it is necessary to take into consideration the current situation, a certain economic sector is in operation while some of the others are based on assumptions and projections. There is always the risk that the projected benefits will not materialise because of a number of reasons, e.g. government policy, economic circumstances or lack of entrepreneurial skills.

Cost benefit analysis approach

The identified operational scenarios involve water provision from the proposed Smithfield Dam in the uMkhomazi and the Imvutshane Dam in the Mvoti River as well as additional re-use volumes from the Darvill and the EThekwini Waste Water Treatment Works (WWTW). This necessitates an approach that takes into consideration the cost of the infrastructure to provide the additional water as well as the potential benefits that can be derived from the additional available water.

The evaluation of projects is often a difficult task since costs and benefits do not occur only once but materialise over time. Furthermore, costs and benefits are often hidden, making them hard to identify, and are also frequently difficult to measure. The same problems occur when the decision maker has to make a choice between numbers of mutually exclusive projects intended to achieve the same goal via a number of different routes. These problems are not limited to capital projects; they also occur when decisions have to be made regarding the merits of current expenditure programmes (Hoffman and Du Plessis, 2008). The Cost Benefit Analysis (CBA) method provides a logical framework by means of which projects can be evaluated, serving as an aid in the decision making process.

The approach followed in the evaluation process of the different scenarios is in line with Water Research Publication: A Manual for Cost Benefit Analysis in South Africa with Specific Reference to Water Resource Development – Third Edition (Updated and Revised) September 2014.

The construction of a CBA in the public sector is approached from the point of view of the total community and not only the shareholders as in the case of a private sector company. It is also necessary that it be highlighted that a CBA does not provide answers about affordability, tariffs and funding the responsible authority.

In general a CBA is aimed at decision-making in respect of projects to be undertaken in the future and therefore involves projections and assumptions regarding future developments. This implies that a boundary of uncertainty will necessarily exist, thereby affecting decisions in respect of the *future taken on the grounds based on of this methodology. It is therefore desirable that the CBA should, where necessary, be supplemented by the analysis of risk and uncertainty, as well as related information.*

The costs used are the cost estimates for the different proposed dams as well as the operational and management costs as sourced from the different reports made available.

The benefits derived from the water are calculated in terms of the estimated GDP and the number of new employment opportunities that can be created.

The GDP is expressed in terms of R/m^3 and the water in m^3, by multiplying the two an answer in Rand is provided. The GDP is available per catchment as it was calculated as part of the economic status quo.

The employment is expressed in terms of $Number/mm^3$ and the water in m^3; by multiplying the two an answer in employment numbers is provided. The employment is available per catchment as it was calculated as part of the economic status quo.

2.2.6 Overall ranking metric

The first aspect to consider in deriving the overall ranking for each scenario is the method employed to normalise each variable's results. This is necessary to remove the effect of the different dimensions (Rand for the economy, number of jobs for employment and the different rating scales for the ecology and Ecosystem Services) and make the scores of each variable comparable. The second aspect is to make provision to vary the importance each variable has in the overall ranking. Both these are described further below.

2.2.7 Relative importance among variables

The relative importance (among the variables) is defined by assigning relative weights to each of the four variables. Examples of how different weights would result in a preselected bias are presented in Table 2.2 for illustration purposes. The actual weight scheme applied in the study is discussed in Chapter 7.

Table 2.2 Explanation of the application of variable weights

Pre-selected Importance Bias	Weights assigned (Sum of weights for the four variables must add up to one)			
	Ecological Protection	Ecosystem Services	Economic Indicator (GDP)	Employment Indicator (Jobs)
Neutral[1]	0.5	0.1666	0.1666	0.1666
Preference for ecology	0.7	0.1	0.1	0.1
Preference for socio-economy	0.3	0.2333	0.2333	0.2333
Preference for socio-economy with emphasis on employment	0.3	0.2	0.2	0.3
Preference for socio-economy with emphasis on economy	0.3	0.2	0.3	0.2

1 This weight scheme is neutral because all the socio-economic variables together carry the same weight as the ecology variable. Note that Ecological Protection refers to rivers, wetlands and estuaries.

2.2.8 Normalising methods

The **first method** *normalises the score to a scale between 0 and 1, where the scenario with the best score is 1 and lowest score is 0. This is carried out for each variable respectively. The* **second method** *applies the rank order (1 for the one with the lowest score and 6 for the one with the highest score - given that there are six scenarios) of the scores of each variable. Both these methods were applied in the analysis and the results are described in Chapter 8.*

The overall rank for a scenario is therefore determined by the sum of the products of each variable's metric multiplied with importance weight of the variable.

2.3 WATER RESOURCE CLASS DETERMINATION

In accordance with the WRCS Guidelines (DWAF, 2007), the Water Resource Class for an IUA is defined by the distribution of the selected ECs for the biophysical nodes in an IUA. In general, if the nodes are in "A" or "B" ECs the IUA is in a Class I, a Class II will be assigned if most nodes are in a C EC and if the nodes mostly falls into a D EC the IUA is in a Class III.

The guidelines recommend the scheme presented in Table 2.3 as the criteria to determine the Water Resource Class. The "units" applied in the table is the percentage of river length (associated with a biophysical node) falling into each of the indicated ECs.

The following is an example interpretation to illustrate the application of the guideline scheme.

An IUA is in Water Resource Class I if the following applies:

- *40% or of the units must be greater than or equal to an A/B Ecological Category.*
- *60% of the units should be greater or equal to and B Ecological Category.*
- *80% of the units should be greater or equal to and C Ecological Category.*
- *99% of the units should be greater or equal to and D Ecological Category.*
- *Less than 1% of the units can be in an E EC.*

Table 2.3 Preliminary guidelines for the calculation of the IUA Class for a scenario (DWAF, 2007)

		% EC representation at units represented by biophysical nodes in an IUA				
		≥ A/B	≥ B	≥C	≥ D	< D
Class 1		*40*	*60*	*80*	*99*	-
Class 2			*40*	*70*	*95*	-
Class 3	**Either**			*30*	*80*	-
	Or				*100*	-

The results presented in Chapter 9 lists the IUA Water Resource Classes for the indicated scenarios. The specific scheme (adjusted from the guideline scheme presented here) are also presented and discussed in Chapter 9.

3 SCENARIO DESCRIPTION

3.1 INTRODUCTION

Scenarios were identified from different sources of information and ongoing planning processes undertaken by the Department of Water Affairs and Municipalities as described below.

The study "Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas" (DWAF, 2008) was undertaken by DWA with the main purpose to identify priority areas where shortfalls in water resource availability occur and confirm the intervention options required to reconcile the water requirements with the available water resources in the study area at current and future development levels. The study area extended from the Mvoti to the uMkhomazi River System. The following possible interventions defined in the strategy will be considered as scenarios.

- *Isithundu Dam on the Mvoti River to supply the North Coast and KwaDakuza areas.*
- *Raising of Hazelmere Dam on the uMdloti River.*
- *Mooi-Mgeni Transfer Scheme phases providing additional water into Midmar Dam.*
- *Development of the Smithfield Dam on the uMkhomazi River and conveyance infrastructure to augment the water supply of EThekwini.*
- *Ngwadini off-channel storage dam on the lower uMkhomazi River to augment water supply of the Middle South Coast Area.*
- *Re-use of treated wastewater in the EThekwini Municipality.*
- *Re-use of treated wastewater in Msunduzi Municipality (Darvill WWTW).*

Other relevant studies included:

- *uMkhomazi Feasibility Study.*
- *Southern KwaZulu-Natal Water Resources Pre-Feasibility Study.*
- *Ncwabeni Off-channel Storage Dam Feasibility Study (on the Umzimkulu River).*
- *Uzimkulu River Catchment Water Resource Study: Riverine Ecological Water Requirements.*
- *WRC: The resilience of South Africa's estuaries to future water resource development based on a provisional ecological classification of these systems.*
- *DWA All Towns Recon Study.*

The large portion of the river systems in the study area are impacted on by return flows generated from WWTW and this is most prominent in the EThekwini Municipal Area for which an Ultimate Waste Water Scenario (UWS) has been derived for the EThekwini WWTWs (projected waste water discharges for 2040) in accordance with the EThekwini Spatial Development Framework.

3.2 WATER MANAGEMENT SCENARIOS

The scenarios specific to the Mvoti and uMkhomazi River Systems are described in the subsequent sections.

3.2.1 uMkhomazi River System (U1)

The existing uMkhomazi catchment is relatively undeveloped. Three future development options, the uMkhomazi Water Project, Phase 1 (uMWP1) (proposed Smithfield Dam and its associated conveyance infrastructure), the Bulwer Water Supply Scheme and the Ngwadini Off-channel Dam (OCD), were included in the water resource analyses that were carried out with the Water Resource Yield Model (WRYM). The recently completed uMkhomazi Study was the primary *source of information for the simulation of this catchment. Additional nodes were added to the network configuration to accommodate the simulation of the biophysical nodes. The EWR at the EWR sites applied in the scenario analysis was determined based on the latest hydrology. There is only one industrial water user, SAPPI-SAICCOR, with an abstraction of 53 million m^3/s. The abstraction is from the Lower uMkhomazi at the inlet to the estuary. The uMkhomazi River is SAPPI-SAICCOR's only resource and for the purposes of the operational scenarios it was assumed that SAPPI-SAICCOR is supported from the proposed Smithfield Dam by means of river releases. A loss of 10% was associated with these releases. An estuary flow requirement of 1 m^3/s was also included in all the operation scenarios which are listed in Table 3.1 below and each scenario and its associated variables are described in the sub-sections that follow.*

Table 3.1 uMkhomazi: Summary of operational scenarios

Scenario	Scenario Variables				
	Update water demands	**Ultimate development demands and return flows (2040)**	**EWR**	**uMWP-1**	**Ngwadini OCD**
MK1	*Yes*	*No*	*No*	*No*	*No*
MK2	*Yes*	*Yes*	*No*	*Yes*	*Yes (no support)*
MK21	*Yes*	*Yes*	*REC tot[1] (EWR 2)*	*Yes*	*Yes (no support)*
MK22	*Yes*	*Yes*	*REC low[2] (EWR 2)*	*Yes*	*Yes (no support)*
MK23	*Yes*	*Yes*	*REC low+[3] (EWR 2)*	*Yes*	*Yes (no support)*
MK31	*Yes*	*Yes*	*REC tot[1] (EWR 3)*	*Yes*	*Yes (no support)*
MK32	*Yes*	*Yes*	*REC low[2] (EWR 3)*	*Yes*	*Yes (no support)*
MK33	*Yes*	*Yes*	*REC low+[3] (EWR 3)*	*Yes*	*Yes (no support)*
MK4	*Yes*	*Yes*	*No*	*Yes*	*Yes (with support)*
MK41	*Yes*	*Yes*	*REC tot[1] (EWR 2)*	*Yes*	*Yes (with support)*
MK42	*Yes*	*Yes*	*REC low[2] (EWR 2)*	*Yes*	*Yes (with support)*

1 REC (Total Flows).
2 REC (Low Flows).
3 REC (Total Flows for January, February, March and Low Flows remaining months).

3.2.1.1 Scenario MK1: Present Day

The latest WRYM configuration was sourced from the uMWP- 1: Module 1: Technical Feasibility Study Raw Water. The WRYM setup representing the 2008 development level was refined to include modelling of the desktop biophysical nodes. The adjusted WRYM configuration was used for analysing the present day scenario.

3.2.1.2 Scenario MK2: Ultimate Development, MWP and Ngwadini OCD (No MWP Support)

The purpose of this scenario is to determine the system yield prior to the implementation of the EWRs and to assess the flows at the selected two EWR sites (Mk_I_EWR2 and Mk_I_EWR3).

The Sc **MK2** *analysis was based on the following assumptions:*

- *Catchment development was set to reflect the ultimate development level (2040).*
- *The MWP was implemented with Smithfield Dam operated at its Historic Firm Yield (HFY).*

- *Ngwadini OCD implemented with no support from Smithfield Dam and operated at its HFY.*
- *EWRs not implemented.*
- *Modelling of Bulwer Water Supply and Sanitation (WSS), SAPPI-SAICCOR and main stem irrigators.*

The Ngwadini OCD was configured in the WRYM in such a way that no support was provided from Smithfield Dam. The strategy adopted for the assessment of Sc **MK2***, was firstly to determine the HFY for Smithfield Dam and secondly to determine the HFY for Ngwadini Dam whilst Smithfield is operated at its HFY. The system was finally run with both dams operated at their respective HFYs to get the final simulated flows for Sc* **MK2***. The HFYs for Smithfield and Ngwadini dams were found to be 196.0 million* m^3*/a and 11.99 million* m^3*/a respectively.*

3.2.1.3 Scenario MK21, MK22, MK23: Ultimate Development, REC EWR (Mk_I_EWR2), MWP and Ngwadini OCD (No MWP Support)

These scenarios were based on Sc **MK2** *where the flows at the EWR sites were assessed for the following EWR flows:*

- *Total flow EWRs (Mk_I_EWR2) set to achieve the REC (Sc* **MK21***).*
- *Low flow EWRs (Mk_I_EWR2) set to achieve the REC (Sc* **MK22***).*
- *Total Flows for January, February, March and Low Flows remaining months (Mk_I_EWR2) set to achieve the REC (Sc* **MK23***).*

*The purpose of these scenarios was to determine to what degree the total flow, low flow and the in between flow EWRs together with the dam spills and tributary inflows from the dam will achieve the REC at Mk_I_***EWR2***. The HFYs of Smithfield and Ngwadini were also assessed to determine the affect of implementing the EWR. The 'cost' of releasing an EWR from the future Smithfield Dam can then be determined as an impact on the current socio-economics.*

3.2.1.4 Scenario MK31, MK32, MK33: Ultimate Development, REC EWR (Mk_I_EWR3), MWP and Ngwadini OCD (No MWP Support))

These scenarios are based on Sc **MK2** *where the flows at the EWR sites will be assessed for the following EWR flows:*

- *Total flow EWRs (Mk_I_EWR3) set to achieve the REC (Sc* **MK31***).*
- *Low flow EWRs (Mk_I_EWR3) set to achieve the REC (Sc* **MK32***).*
- *Total flows for January, February, March and low flows remaining months (Mk_I_EWR3) set to achieve the REC (Sc* **MK33***).*

*The purpose of these scenarios is to determine to what degree the total flow, low flow and the in between flow EWRs together with the dam spills and tributary inflows from the dam will achieve the REC at Mk_I_***EWR3***. The HFYs of Smithfield and Ngwadini were also assessed to determine the affect of implementing the EWR. The 'cost' of releasing an EWR from the future Smithfield Dam can also be determined as an impact on the current socio-economics.*

3.2.1.5 Scenario MK4: Ultimate Development, MWP and Ngwadini OCD (No EWR releases)

This scenario is based on Sc **MK2** *with the only change being that the Ngwadini OCD was configured in the WRYM in such a way that support is provided from Smithfield Dam. The strategy adopted for the assessment of Sc* **MK4,** *was firstly to determine the HFY for Ngwadini Dam and secondly to determine the HFY for Smithfield Dam whilst Ngwadini is operated at its HFY. The system was finally run with both dams operated at their respective HFYs to get the final simulated flows for Sc* **MK4.**

*The purpose of this scenario is to assess the flows at the EWR sites for the ultimate development level with MWP and Ngwadini OCD (***with support provided from Smithfield Dam***) in place. The HFYs of Smithfield and Ngwadini were assessed to determine the affect of implementing the EWR. The 'cost' of releasing an EWR from the future Smithfield Dam can also be determined as an impact on the current socio-economics.*

3.2.1.6 Scenario MK41, MK42: Ultimate Development, REC EWR (Site 2), MWP and Ngwadini OCD (With MWP Support)

These scenarios are based on Sc **MK4** *and the flows at the EWR sites were assessed for the following EWR flows:*

- *Total flow EWRs (Site 2) set to achieve the REC (Sc* **MK41***)*
- *Low flow EWRs (Site 2) set to achieve the REC (Sc* **MK42***)*

The purpose of these scenarios is to determine to what degree the total flow and low flow EWRs (Mk_I_EWR2) together with the dam spills and tributary inflows from the dam will achieve the REC at the EWR sites.

3.2.1.7 Scenario MK21b: Ultimate Wastewater Scenario, discharge into the estuary

This scenario is based on Sc **MK21,** *with 20Ml/day of treated wastewater discharge into the estuary. The assumption was that nutrient removal is in accordance with conventional treatment methods.*

A further discharge scenario was proposed, where an additional 30Ml/day of wastewater is transferred and treated from the Kingsburgh Works.

3.2.2 Mvoti River System (U4)

The Mvoti River system's operational scenarios included the modelling of the proposed Isithundu Dam as well as the new Imvutshane Dam (situated on a tributary of the Hlimbtiwa River) which is currently in construction. Analyses were undertaken with the WRYM. The proposed scenarios for the Mvoti system are summarised in Table 3.2 and each scenario and its associated variables are described in the sub-sections that follow. The impact of implementing the EWR at Mv_I_EWR2 was assessed within context of the available system yield.

Table 3.2 Mvoti: Summarised description of Scenarios

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	MRDP[1]	Imvutshane Dam
MV1	*Yes*	*No*	*No*	*No*	*No*
MV21	*Yes*	*No*	*REC tot[2]*	*No*	*No*
MV22	*Yes*	*No*	*REC low[3]*	*No*	*No*
MV3	*Yes*	*Yes*	*No*	*Yes*	*Yes*
MV41	*Yes*	*Yes*	*REC tot[2]*	*Yes*	*Yes*
MV42	*Yes*	*Yes*	*REC low[3]*	*Yes*	*Yes*
MV43	*Yes*	*Yes*	*REC low+[4]*	*Yes*	*Yes*

1 Mvoti River Development Project (Isithundu Dam). *2 REC (Total Flows)*
3 REC (Low Flows).
4 REC (Total Flows for January, February, March and Low Flows for remaining months).

3.2.2.1 Scenario MV1: Present Day

The WRYM from the original DWS Mvoti River Dam Feasibility Study was updated with the latest information available to produce the best possible estimate of present day flow. Information from the DWS All Towns Reconciliation Strategies and the Water Reconciliation Strategy Study for the Kwazulu Natal Coastal Metropolitan Areas was used to define the urban and industrial water requirements and return flows to present day levels.

3.2.2.2 Scenarios MV21 and MV22: Present Day and REC EWR

Scenario MV21 and MV22 were formulated to determine what reduction in the present day water use would have to be implemented if the REC is set to be an improvement to the PES. The outcome from the ecological assessment indicated that no improvement in flow related aspects were needed (compared to the PES) and therefore no reduction in the present water use is necessary to achieve the REC. These scenarios were therefore not assessed further as part of the integrated multi-criteria analysis.

3.2.2.3 Scenario MV3: Ultimate Development, Mvoti River Development Project and Imvutshane Dam

This scenario included estimates of increased water use and return flows for the domestic sector (Greytown and KwaDukuza). The increase was due to population growth and improved service delivery for the ultimate development scenario. Information on estimated increase in domestic use was sourced from the DWA's All Towns Strategies. Since Greytown's PD water use already exceeded the yield of Lake Merthley, it was assumed that the town's increased water use will be supplied from groundwater resources as a long term options in addition to the current planning to augment the water resources of the town from Craigie Burn Dam. To this end, adjustments were made to the natural surface runoff from the incremental catchment affected by the increased groundwater use. The runoff from simulation catchment Sc MV3 was subsequently reduced by 2.1%. The projected 2040 return flows included for Greytown and Kwadukuza amounted to 1.578 and 7.26 million m^3/a respectively.

This scenario also included the implementation of the Mvoti River Development Project (Isithundu Dam with a gross storage capacity of 51.8 million m^3) and the Imvutshane Dam (located on a tributary of the Hlimbitwa River just above the Mvoti and Hlimbitwa confluence).

The following information relating to the Imvutshane WSS was adopted for inclusion in the WRYM configuration:

- *Imvutshane Dam catchment area: 42.86 km^2.*
- *Imvutshane Dam Natural MAR: 8.80 million m^3/a.*
- *Full Supply Capacity (FSC) of dam: 3.11 million m^3.*
- *Buffer storage reserved for environmental releases: 0.311 million m^3 (10% of FSC).*
- *Abstraction from dam in 2040: 12Ml/d (4.38 million m^3/a).*
- *Maximum capacity for diversion from Hlimbitwa: 0.1 m^3/s.*
- *Environmental releases: 0.054 m^3/s May – October; 0.069 m^3/s November – April.*

Scenario **MV3** *excluded the Mvoti EWRs and to be consistent no environmental releases were made from Imvutshane Dam for this scenario as well. The purpose of this scenario was to determine the Excess Firm Yield (EFY) at Isithundu Dam for the 2040 development conditions and to assess the modelled flows at the EWR sites with the system operated at the EFY (i.e. the EFY is imposed as a direct abstraction from Isithundu Dam. All downstream water users were supported* *from the proposed Isithundu Dam which means that the water resources of the Mvoti were fully utilised for this scenario.*

3.2.2.4 Scenario MV41, MV42 and MV43: Ultimate Development, REC EWR and MRDP

These scenarios are based on Sc **MV3** *but the flows at the EWR sites are assessed for the implementation of the following alternative EWRs:*

- *Total flow EWRs set to achieve the REC (Sc* **MV41***).*
- *Low flow EWRs set to achieve the REC (Sc* **MV42***).*
- *Total Flows for January, February and March and Low Flows for the remaining months set to achieve the REC (Sc* **MV43***).*

The purpose of these scenarios is to determine to what degree the total flow, low flow and the in between flow (low+) EWRs together with the dam spills and tributary inflows will achieve the REC EWRs. It is important to note that the Imvutshane environmental releases were implemented for all three of these scenarios.

4 ECONOMIC CONSEQUENCES

The results of the different scenarios of each catchment, as it impacts on the different economic sectors, are presented in this Chapter. The impact on GDP and then on labour is provided to be integrated in the final results.

4.1 RESULTS PRESENTATION

The results are displayed in the format of the discounted total GDP which also reflects the cost of the water resource developments and employment calculated.

Discounted Values

As already explained the total capital cost of the proposed project is entered together with the annual operational and maintenance costs to provide a total annual cost for the future - 40 years. The total GDP from the different benefits are calculated over the period. The two sets of values are subtracted to provide a Present Value, this value is then discounted over the period to provide a GDP Net Present Value expressed in Rand. This is then presented as the GDP benefit from the additional water.

The total estimated number of jobs is also calculated, then discounted and presented as the employment benefit of the additional water. The discount rate used is 8% as recommended by the CBA manual.

4.2 MVOTI RIVER SYSTEM

In the following table the results of the different operational scenarios for the Mvoti catchment are presented.

Table 4.1 Results of the operational scenarios in the Mvoti Catchment

Scenario	Projected GDP growth (R million)	Projected additional labour
MV3	R 39 637.65	21 661
MV41	R 15 808.43	6 427
MV42	R 25 713.48	11 360
MV43	R 23 996.70	10 412

The following table presents the results in terms of economic preference.

Table 4.2 Mvoti results ranked

Position	Projected GDP	Projected Employment
1	MV3	MV3
2	MV42	MV42
3	MV43	MV43
4	MV41	MV41

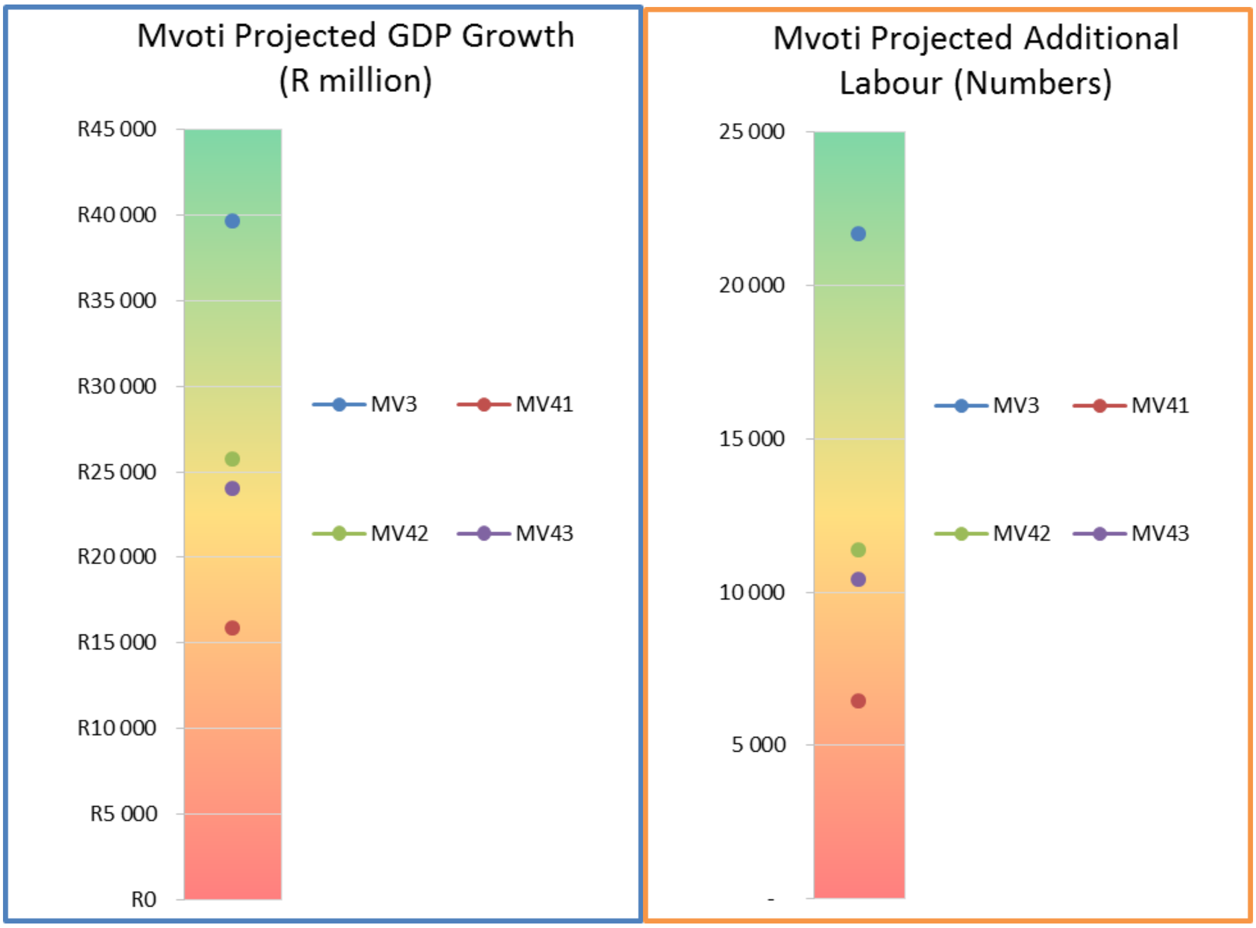


Figure 4.1 Mvoti projected GDP growth and additional labour

The above table together with the figure indicates that in economic terms Sc MV3 is the most preferable option with Sc MV41 the worst option.

4.3 uMKHOMAZI RIVER SYSTEM

In the following table the results of the different operational scenarios for the Lovu catchment are presented. The results represent not only the possible impact in the uMkhomazi but also the impact of the different volumes that can be transferred.

Table 4.3 Results of the operational scenarios in the uMkhomazi Catchment

Scenario	Smithfield HFY	Ngwadini HFY	Projected GDP growth (R million)	Projected additional labour
MK2	196.00	11.99	R 386 158	402 685
MK21	142.20	8.03	R 348 392	342 577
MK22	150.60	8.03	R 354 093	353 837
MK23	150.60	8.03	R 354 093	353 837
MK31	150.10	5.98	R 351 204	351 777
MK32	161.00	6.63	R 358 397	365 594
MK33	161.00	6.63	R 358 397	365 594
MK4	142.50	54.80	R 357 056	346 582
MK41	84.10	54.80	R 290 228	243 680
MK42	92.50	54.80	R 303 646	261 266

The following table presents the results in term of economic preference.

Table 4.4 uMkhomazi results ranked

Position	Projected GDP	Projected Employment
1	*MK2*	*MK2*
2	*MK 32 and MK 33*	*MK 32 and MK 33*
3	*MK 4*	*MK22 and MK33*
4	*MK 22 and MK 33*	*MK31*
5	*MK 31*	*MK4*
6	*MK 21*	*MK21*
7	*MK 42*	*MK42*
8	*MK 41*	*MK41*

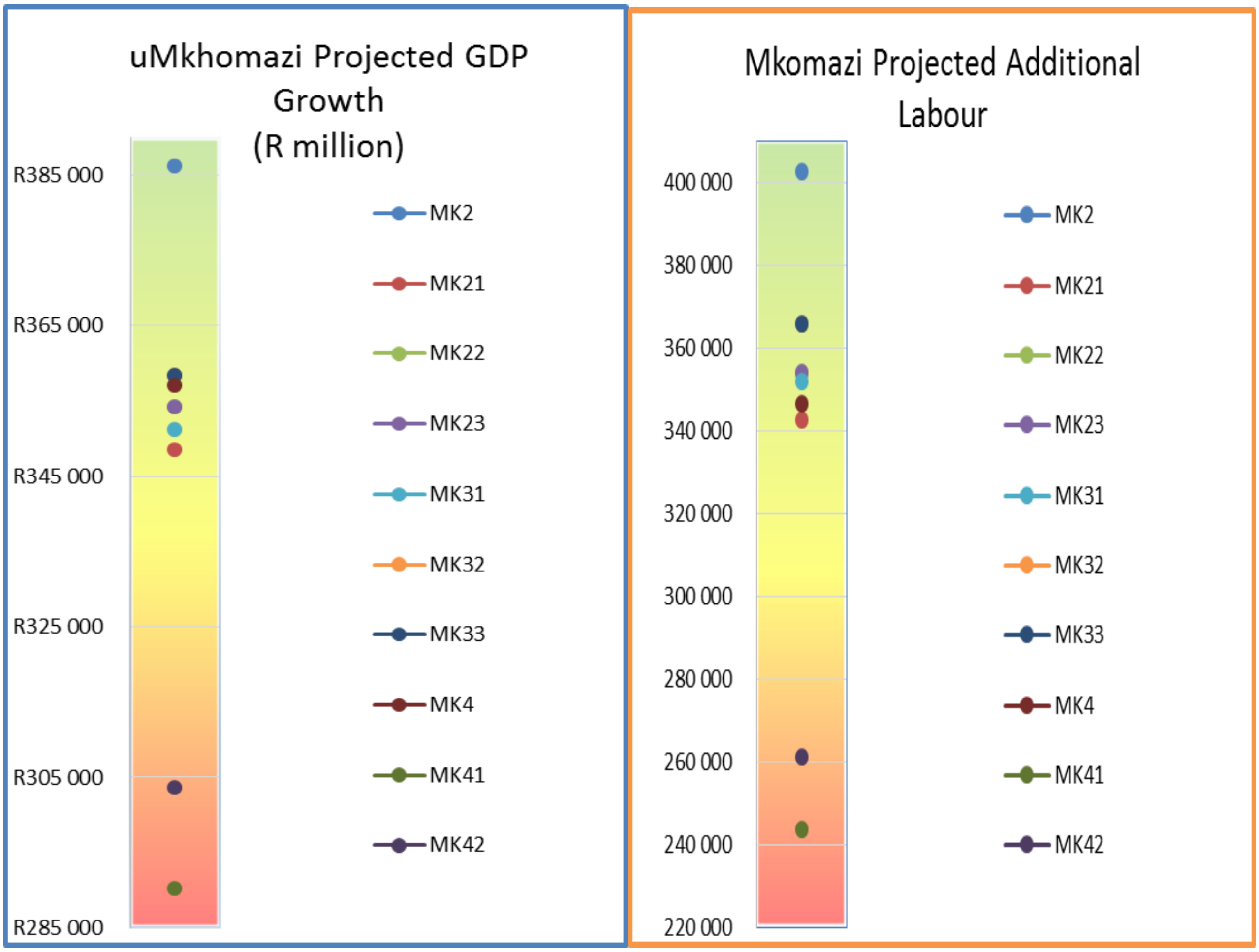


Figure 4.2 uMkhomazi projected GDP growth and additional labour

All the scenarios provide positive results, but differ in the lower rankings. For both measuring instruments Sc MK2 is the preferable option. Scenario MK42 is economically the least preferred option.

4.4 CONCLUSION

The various operational scenarios all present positive answers and should all make a positive contribution to the economic growth and employment creation in the four catchments. The final preferred option will depend on the interaction between the economic values, the goods and services and the environmental impacts.

5 ECOLOGICAL CONSEQUENCES (RIVERS)

This Chapter focuses on the results of the evaluation of the various scenarios. The integration into a single ecological ranking for the uMkhomazi and Mvoti River systems are provided in Sections 5.1 and 5.2 respectively. Detailed consequences are provided in the supporting document, Report 8.1(DWS, 2014).

5.1 uMKHOMAZI RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS AT THE EWR SITES

The scenarios are described in Table 3.1. The ecological consequences are summarised in Table 5.1. The first column provides the ECs for each component at the EWR site. The second column provides a summary of the ecological consequences. The third column provides the ranking of the scenarios. The fourth column includes a short explanation of the consequences and ranking. A summary of the ranking is provided in Figure 5.1

MK_I_EWR1: *The ranking shows that Sc MK2 and MK4 are the lowest in the ranking order at all sites and significantly lower than the other scenarios. This is because Sc MK2 and MK4 includes Smithfield Dam with no EWRs. All the rest of the scenarios still maintain the EcoStatus of a C at Mk_I_EWR1 but do not achieve the REC (PES). The major problem at Mk_I_EWR 1 is that the site is close to the dam and therefore only received the water being released from the dam or spills. As the river acts as a conduit to convey water from the dam down the system, the main reasons for not achieving the REC (PES) is the increased (above natural) and unseasonal base flows as well as the decrease in floods.*

MK_I_EWR2: *As one moves further downstream of the dam, the impacts become less pronounced. At Mk_I_EWR 2, tributary inflows mitigate some of the impacts of the unseasonal flows and the lack of floods. However the main users are downstream of Mk_I_EWR 2, and therefore the impacts are still felt to some degree. Sc MK 21, MK41 and MK42 still maintain the EcoStatus of a B with Sc MK41 being the better scenario.*

MK_I_EWR3: *Sc MK 21 and MK41 are the best options as they are the closest to meeting the ecological objectives. Both these scenarios include the total EWR flows and the impacts are mostly due to the impacts on the dam itself, such as the barrier effect, impact on larger frequency of floods and largely due to the increased (above natural) base flows.*

Table 5.1 uMkhomazi River System: Summary of ecological consequences at the EWR sites

Ecological consequences as ECs	Ecological consequences	Ranked scenarios	Ranking rationale

MK_I_EWR1 (uMKHOMAZI RIVER)

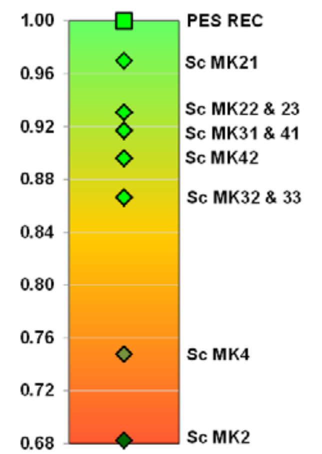
Ecological consequences as ECs

Component	PES & REC	Sc MK2	Sc MK21	Sc MK22, 23	Sc MK31	Sc MK32, 33	Sc MK4	Sc MK41	Sc MK42
Physico chemical	A/B	C	A/B	A/B	B	B	B	A/B	A/B
Geom	A/B	C/D	B/C	C	B/C	C	C	B/C	C
Fish	B	D	B/C	C	C	C	D	C	C
Invertebrates	B/C	D	B/C	C	C	C	C/D	C	C
Riparian vegetation	C	D	C	C	C	C	C/D	C/D	C/D
EcoStatus	C	D	C	C	C	C	C/D	C	C

Ecological consequences

Geomorphology is reduced to different degrees under all scenarios due to the impact of the dam on sedimentation and possible erosion and accumulation of fines. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and 4 as they do not include EWR releases. This results in a lack of fast flowing habitats and possible reduction and/or eradication of Amphilius natalensis and Barbus natalensis. Scenarios that include EWR releases are an improvement, but the unseasonal releases and at times higher flows than natural are problematic.

Ranked scenarios



Ranking rationale

The results illustrate that most of the scenarios meet the ecological objectives in terms of EcoStatus except for Sc MK4 and MK2. These two scenarios do not cater for EWR requirements and are similar, however under Sc MK2 lower flows occur in all months and zero flows occur during drought periods in Oct – Dec and therefore Sc MK2 has the greatest impact. None of the scenarios meet the ecological objectives for all the components. Sc Mk 21 are the best of the options overall and is therefore ranked the highest.

MK_I_EWR2 (uMKHOMAZI RIVER)

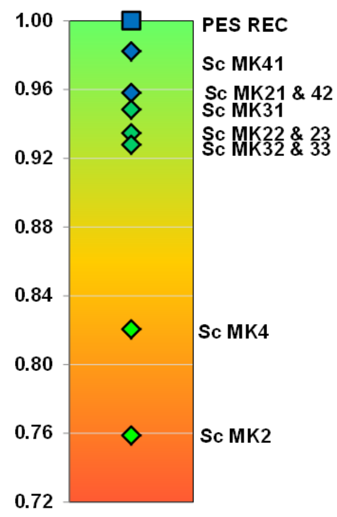
Ecological consequences as ECs

Component	PES & REC	Sc MK2	Sc MK21	Sc MK22, 23, 32, 33	Sc MK31	Sc MK4	Sc MK41	Sc MK42
Physico chemical	A/B	C	A/B	A/B	A/B	B	A	A
Geom	B	C	C	C	C	C	C	C
Fish	B	D	C	C	C	C/D	B/C	B/C
Invertebrates	B	D	B/C	B/C	B/C	C	B	B/C
Riparian vegetation	B	C	B	B/C	B	C	B	B
EcoStatus	B	C	B	B/C	B/C	C	B	B

Ecological consequences

Geomorphology is reduced to a C under all scenarios due to the impact of the dam on sedimentation, channel narrowing and an increase in embeddedness. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and MK4 as they do not include EWR releases. The other scenarios include increased high flows in the dry season with a loss of slow habitats which impact on Barbus anoplus and Barbus viviparus.

Ranked scenarios



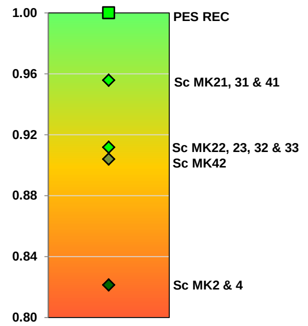
Ranking rationale

None of the scenarios meet the ecological objectives. Although Sc MK21, 41 and 42 results in the same EcoStatus, the instream biota are impacted by the reduced wet season base flows and reduced floods. Sc MK41 is the best scenario of these three scenarios because it provides more flows during wet season. Scenario MK2 and MK4 has the worst impact due to reductions in baseflows during dry and wet seasons.

MK_I_EWR3 (uMKHOMAZI RIVER)

Component	PES & REC	Sc MK2	Sc MK21, 31, 41	Sc MK22, 23, 32, 33	Sc MK4	Sc MK42
Physico chemical	A/B	B/C	A/B	B	B/C	B
Geom	B	C	B/C	C	C	C
Fish	B	C	B/C	C	C	C
Invertebrates	B	C/D	B/C	C	C/D	C
Riparian vegetation	D	D	D	D	D	D
EcoStatus	C	D	C	C	D	C/D

Geomorphology impacts are not as severe as at EWR 1 and 2 due to the distance of the dam. The reduction of large flood and delayed early wet season floods still cause impacts. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and 4 as they do not include EWR releases. The deterioration in fish and inverts, albeit mostly small, is related to the low flows for drought in wet months and impact on spawning. There is no impact on the riparian vegetation.



The results illustrate that none of the scenarios meet the ecological objectives. Sc MK 21, MK31 and MK41 results in the same EcoStatus and has the least impact with a slight deterioration in geomorphology and instream biota. Sc MK22, MK23, MK32 and MK33 also has the same EcoStatus as the PES/REC but there is further deterioration in the instream biota as well as geomorphology and water quality. Scenario MK2 and MK4 have the biggest impact as overall they drop a category for while Sc MK42 only caters for the low flow EWR and the impact is therefore slightly less, i.e. it drops half a category

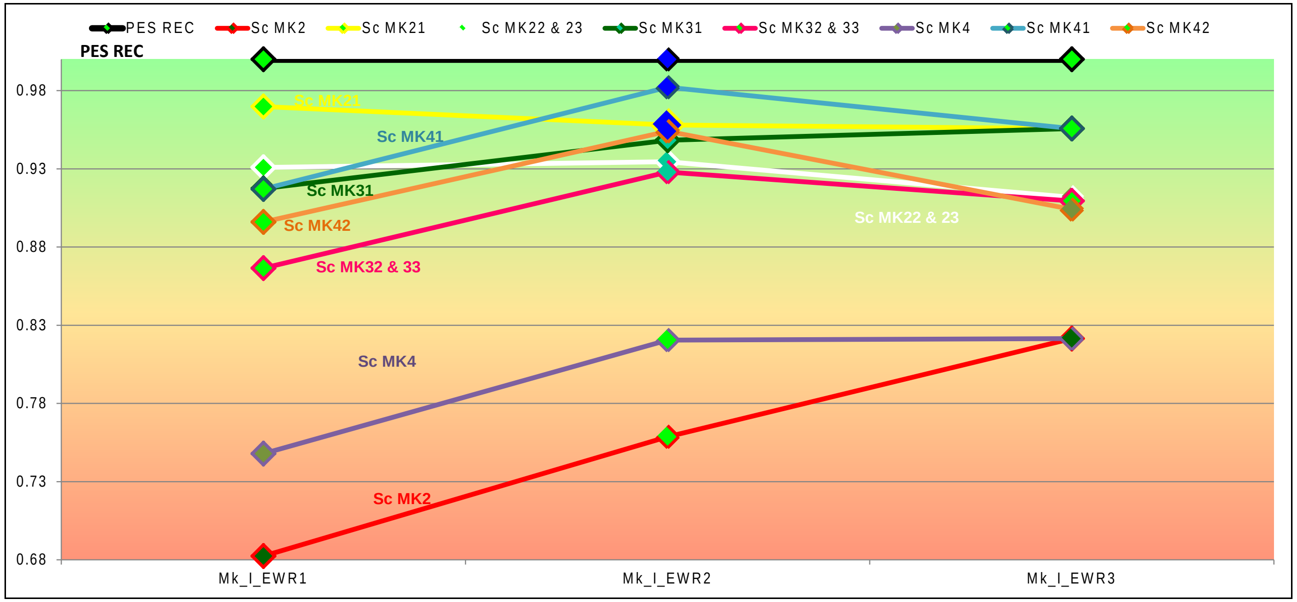


Figure 5.1 uMkhomazi River System: Ranking of scenarios at each EWR site

As there are three sites on the uMkhomazi River, these need to be integrated based on a system of weighting the importance of the sites. MK_I_EWR3 is the most important site due largely to the long river distance which the site represents (Table 5.2). The integrated ranking is showing in the Figure 5.2.

Table 5.2 Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas (0 - 5)	Distance	Normalised Weight
EWR 1	C	*Moderate*	*1*	*0.08*	**0.22**
EWR 2	B	*High*	*3*	*0.32*	**0.37**
EWR 3	C	*Moderate*	*1*	*0.6*	**0.41**

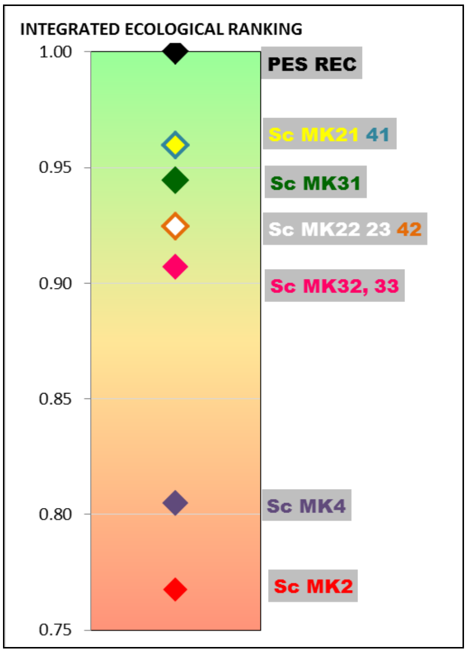


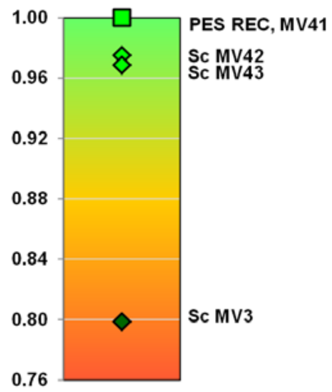
Figure 5.2 uMkhomazi River System: Integrated ecological ranking of the scenarios

5.2 MVOTI RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS AT THE EWR SITES

The scenarios are described in Table 3.1. The ecological consequences are summarised in Table 5.3 and an integrated ranking illustrated in Figure 5.2.

Scenario MV41 which includes the dam and releases the full EWR will meet the ecological objectives. Scenario MV42 and MV43 are very similar, still maintain the REC EcoStatus but overall do not comply with all the objectives. Scenario MV3 is the least acceptable as it drops a category overall (D EC) and for most of the components.

Table 5.3 Mvoti River System: Summary of ecological consequences at the EWR sites

<table>
<tr><th>Ecological consequences as ECs</th><th>Ecological consequences</th><th>Ranked scenarios</th><th>Ranking rationale</th></tr>
<tr><th colspan="4">MV_I_EWR2 (MVOTI RIVER)</th></tr>
<tr>
<td>
<table>
<tr><th>Component</th><th>PES & REC</th><th>Sc MV3</th><th>Sc MV41</th><th>Sc MV42, 43</th></tr>
<tr><td>Physico chemical</td><td>C</td><td>C/D</td><td>C</td><td>B/C</td></tr>
<tr><td>Geom</td><td>C</td><td>C/D</td><td>C</td><td>C/D</td></tr>
<tr><td>Fish</td><td>B/C</td><td>C/D</td><td>B/C</td><td>C</td></tr>
<tr><td>Invertebrates</td><td>B/C</td><td>C/D</td><td>B/C</td><td>B/C</td></tr>
<tr><td>Riparian vegetation</td><td>C/D</td><td>D</td><td>C/D</td><td>C/D</td></tr>
<tr><td>EcoStatus</td><td>C</td><td>D</td><td>C</td><td>C</td></tr>
</table>
</td>
<td>Scenario MV3 is the worst case as it does not include EWR releases. The channel will narrow with vegetation encroachment. An overall loss of fast habitats will impact on the instream biota. Impacts associated with Sc MV42 and MV43 are less pronounced as it includes EWR releases to some degree. Scenario MV 41 supplied the total EWR and therefore meets the ecological objectives.</td>
<td>
</td>
<td>The results illustrate that Sc MV41 meet the ecological objectives. Although Sc MV42 and MV43 results in the same EcoStatus the ecological objectives are not met due to a slight deterioration in geomorphology and fish. Scenario MV3 has the biggest impact with deterioration in all components as the EWR are not provided.</td>
</tr>
</table>

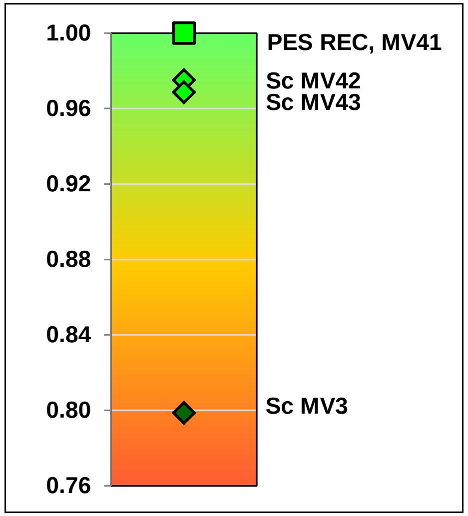


Figure 5.3 Ecological ranking of operational scenarios at MV_I_EWR2

6 ECOLOGICAL CONSEQUENCES: (ESTUARIES)

6.1 MVOTI ESTUARY

6.1.1 Present Ecological State

The Estuarine Health Index (EHI) scores allocated to the various abiotic and biotic health parameters for the Mvoti Estuary and the overall PES for the system are calculated using the index (see below) (DWAF 2008). The Mvoti Estuary present state is estimated to be 55 (i.e. 55% similar to natural condition), which translates into D. The Mvoti Estuary is therefore presently in a D Category, which is mostly attributed to the following factors:

- *The high organic load in the effluent from the Sappi Stanger mill just upstream of the estuary head, which is associated with low oxygen events (< 4 mg/l);*
- *Increased nutrient input as a result of poor catchments practises, causing excessive growth of reeds and aquatic invasive plants in intertidal and subtidal habitats;*
- *Significant loss of habitat in the Estuary Functional Zone as a result of sugarcane farming;*
- *Changes in sediment structure due to sand mining; and*
- *The loss of resetting floods which otherwise assist in removing excess vegetation growth from intertidal, subtidal and supratidal areas (important bird habitat).*

Estimates of the contribution of non-flow related impacts on the level of degradation suggests that non-flow impacts have played a significant role in the degradation of the estuary to a D, but that flow-related impacts are also one of the main causes of its degradation. **The highest priority is to address the quality of the estuary water***. Water quality degradation, resulting from the high organic load in the Sappi discharge and poor catchment management, was found to be the most important non-flow-related factor that influenced the health of the estuary. The occurrence of low oxygen events in the estuary reduced invertebrate abundance to 25% of Reference Conditions and prevents the system from functioning as a fish nursery, which in turn reduces food availability to birds. Excess nutrients in the inflowing river water increased plant growth and in so doing contributed to loss of open intertidal, subtidal and riparian habitat. This has had biological consequences (e.g. loss of sandbanks that were previously important bird habitats). Another key non-flow related pressure was the loss of riparian area due to sugarcane farming in the Estuary Functional Zone, causing a loss the habitat and loss of a buffer area against human disturbance.*

6.1.2 Estuary Importance

The Estuary Importance Score takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account. Biodiversity importance, in turn is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. The scores have been determined for all South African estuaries, apart from functional importance, which was scored by the specialists in the workshop (DWAF, 2008; Turpie and Clarke, 2007).

Even though the Mvoti Estuary tends to recruit high numbers of estuarine associated fish in spring and summer, it is of low nursery value as river flow is high for most of the year and there are few backwater areas for fish to take refuge in from the main currents. However the Mvoti Estuary is an important movement corridor for eels. This places significance on ecological flow and water quality requirements for the estuary (and the river).

In the 1980s Mvoti Estuary was noted for its high species richness of waterbirds, as well as a high density of waterbirds relative to the length of available shoreline. The Mvoti Estuary is classified as a sub-regional Important Bird Area. Large numbers of terns, up to 10 000 individual birds, have been recorded regularly roosting at the estuary on expansive and exposed islands in the main water channel. Another key waterbird species is the Collared Pratincole, a Red Data species, which has been found breeding on the exposed sandbanks in the river. Other noteworthy Red Data waterbirds recorded at the estuary include African Marsh Harrier, Woolly-necked Stork and Chestnut-banded Plover. Mvoti Estuary has also boasted the regular presence of a large number of vagrant waterbirds over the years, making it a popular spot for bird-watching and bird-watchers. A recent investigation into the current IBA status of the Mvoti Estuary, however, reported that the aquatic avifauna of the site has deteriorated sharply since about the mid-2000s and recommended that the site be de-listed as an IBA. Since that time, large numbers of terns no longer roost at the estuary and nor do Collared Pratincoles nest there. The aquatic avifauna of the estuary is now a mere remnant of what it once was and the site is no longer attractive as a bird-watching locality.

The functional importance of Mvoti Estuary is also very high for the nearshore marine environment. It is one of small number key systems that supply sediment, nutrients and detritus to the coasts. The sediment load from the Mvoti is especially important as it is habitat forming and plays an important role in maintaining the beaches and nearshore habitat along this coast. The impact of further dam development on the nearshore marine environment was not assessed as part of this study, but should be to ensure that all ecological processes and related ecosystem services (e.g. beaches, coastal buffers against stoorms, the KwaZulu-Natal prawn fishery) are considered.

The Estuary Importance for the Mvoti Estuary was estimated to be 69, i.e. the estuary is rated as "Important".

6.1.3 Recommended Ecological Category

The REC represents the level of protection assigned to an estuary. The PES sets the minimum REC. The degree to which the REC needs to be elevated above the PES depends on the level of importance and degree of protection or desired protection for a particular estuary.

Table 6.1 Estuary protection status and importance, and the basis for assigning a REC

Protection status and importance	REC	Policy basis
Protected area	*A or BAS**	*Protected and desired protected areas should be restored to and maintained in the best possible state of health.*
Desired Protected Area		
Highly important	*PES + 1, min B*	*Highly important estuaries should be in an A or B category.*
Important	*PES + 1, min C*	*Important estuaries should be in an A, B or C category.*
Of low to average importance	*PES, min D*	*Estuaries to remain in a D category.*

** BAS = Best Attainable State*

The PES for the Mvoti Estuary is a D. The Mvoti Estuary is rated as "Important" from a biodiversity perspective and should therefore be in a C Category.

The system also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan for the National Biodiversity Assessment (Turpie et al., 2012). The NBA 2011 (Van Niekerk and Turpie 2012) recommended that the minimum Category for the Mvoti be a D, that it be granted full no-take protection, and that 75% of the estuary margin be undeveloped.

Based on the above and the reversibility of impacts, the REC for the Mvoti Estuary is a C Category.

6.1.4 Ecological Categories associated with scenarios

The individual EHI scores, as well as the corresponding ecological category under different scenarios are provided below. The estuary is currently in a D Category. Under Scenario Group A (Sc MV21, 22 and 41) and C (Sc MV42 and 43) the Mvoti Estuary will improve slightly in health, but is expected to remain in a D Category as a result of reduced frequency and duration of mouth closure from Reference. Under Scenario Group B (Sc MV3) the estuary will deteriorate further in health (by about 5%) as a result of increased closed mouth conditions.

None of the Scenarios Groups A to C achieved the REC for the Mvoti Estuary. Therefore a sensitivity test, Scenario Group E, was conducted. Scenario Group E is based on the freshwater inflow simulated for Scenario Group A (Sc MV 21, MV22 and MV41) in conjunction with the following management interventions:

- *Improvement of oxygen levels in the estuary, through for example, removal of the high organic content from the Sappi Stanger effluent;*
- *Reduce the nutrient input from the catchment by 20% to control growth of reeds and aquatic invasive plants; and*
- *Remove the sugarcane from the Estuary Functional Zone (below 5 m contour) to allow for a buffer against human disturbance and the development of a transitional vegetation ecotone between estuarine and terrestrial ecosystems.*

Scenario Group E (Sc MV21, 22 and 41 – Anthropogenic Impacts) achieved the REC of a C. Scenario Group C (Sc MV42 and MV43) with the same management intervention will also achieve the REC (Table 6.2). Since these scenarios include the construction of a new dam, this is seen as a medium to long term recommendation. In the short term, a combination of the PES and the REC (in the same category) will be recommended. The improvements required to meet the REC are mostly non-flow related measures. The non-flow related (or anthropogenic) measures required to improve the estuary can be applied and should improve the estuary to a B.

Table 6.2 provides the scoring and results and Figure 6.1 summarises the ranking of the scenarios.

Table 6.2 Mvoti Estuary Health Index score and corresponding ECs under the different runoff scenarios

Variable	Scenario Group				
	Present	A (MV 21, 22, 41)	B (MV3)	C (MV42 & 43)	E (MV21, 22 & MV 41 with ANT reduced)
Hydrology	*53.4*	*59*	*42*	*55*	*59*
Hydrodynamics	*95*	*99*	*95*	*99*	*99*
Water quality	*58.4*	*59*	*54*	*59*	*65*
Physical habitat alteration	*73*	*73*	*69*	*70*	*73*
Habitat health score	**70**	**72**	**65**	**71**	**74**
Microalgae	*80*	*80*	*65*	*80*	*85*
Macrophytes	*32*	*33*	*33*	*33*	*50*
Invertebrates	*25*	*25*	*15*	*25*	*60*
Fish	*55*	*55*	*55*	*55*	*75*
Birds	*10*	*10*	*10*	*10*	*45*
Biotic health score	**40**	**41**	**36**	**14**	**63**
ESTUARY HEALTH SCORE	**55**	**56**	**50**	**56**	**68**
ECOLOGICAL STATUS	**D**	**D**	**D**	**D**	**C**

The **'recommended Ecological Water Requirement' scenario** *is defined as the flow scenario (or a slight modification thereof to address low-scoring components) that represents the highest change in river inflow that will still maintain the estuary in the REC. Where any component of the health score is less than 40 modifications to flow and measures to address anthropogenic impacts must be found that will rectify this. Based on this assessment, the REC for the Mvoti Estuary is a Category C.*

The flow requirements for the estuary are the same as those described for Scenario Group A – Scenarios Sc MV21, MV22 and MV41, but Scenario Group C – Sc MV42 and MV43 will also achieve the REC.

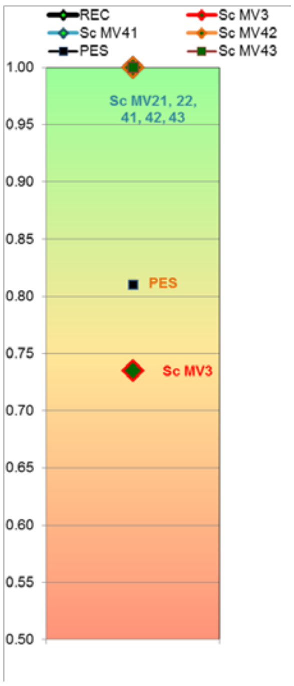


Figure 6.1 Mvoti Estuary: Ranking of scenarios

6.2 uMKHOMAZI ESTUARY

The uMkhomazi Estuary is situated 50 km south-west of Durban and is one of only two estuarine systems within the eThekwini Municipal boundary classified as Permanently Open and only one of five between uThukela and uMtamvuna. With a catchment of ca. 4 300 km^2 it is one of Kwazulu-Natal's largest rivers. The Sappi weir above the old metal bridge and 6 km from the mouth sets an artificial and absolute limit on tidal and to some extent saline penetration.

6.2.1 Present Ecological State

The uMkhomazi Estuary in its present state is estimated to be 69% similar to the natural condition, which translates into a PES of a C Category. This is attributed to the following factors:

- *The weir in the upper reaches reducing the connectivity between the river and estuary;*
- *Sandmining that has taken away the sandbanks in the upper reaches (Zone C), resulting in loss of intertidal areas and back-water refuge areas. It has also impacted on access to grazing areas as the river cannot be crossed in this section anymore;*
- *Recreational activities (e.g. boat launching) in the lower reaches affecting bird abundance;*
- *Over exploitation of living resources (e.g. cast netting and line fishing); and*
- *Agricultural activities and disturbance in the Estuary Functional Zone causing loss of estuarine habitat.*

Estimates of the contribution of non-flow related impacts on the level of degradation suggests that non-flow related impacts have played a role in the degradation of the estuary to a C, but that flow-related impacts are also driving degradation. **The highest priority from a flow related perspective is to address the quality of influent water***. Of the non-flow-related impacts, loss of open water areas as a result of the weir, habitat loss within the 5m contour and the related vegetation integrity along with water quality problems as a result of the high nutrient load associated with the WWTWs were the most important factors influencing ecological health of the system. The excess nutrients in the inflowing water are considered to be an important factor to consider with increased abstraction from the system. Increased retention (further reduction in flow) of these high concentrations of nutrients will lead to nuisance algal growth, low dissolved oxygens and reduced habitat quality.*

6.2.2 Estuary Importance

The Estuary Importance Score takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account. Biodiversity importance, in turn is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. Estuary Importance was estimated at 85, i.e. the estuary is rated as "Highly Important" (DWAF, 2008; Turpie and Clarke, 2007).

The functional Importance of the uMkhomazi Estuary is very high. It serves as an important nursery for exploited fish stock and plays a very important role from a fish egg production perspective. In addition, it is also an important movement corridor for eels (CITES listed species).

Similar to the Mvoti Estuary, the functional importance is also very high for the nearshore marine environment. It is one of a number key systems that supply sediment, nutrients and detritus to the coasts. The impact of further dam development on the nearshore marine environment was not assessed as part of this study, but should be done to ensure that all ecological processes and related ecosystem services (e.g. nearshore pelagic and prawn fishery) are addressed.

uMkhomazi forms part of the core set of priority estuaries identified in the National Estuary Biodiversity Plan in need of protections to meet biodiversity targets under the Biodiversity Act and National Estuarine Management Protocol promulgated under the Integrated Coastal Management Act. The National Estuary Biodiversity Plan requires that the uMkhomazi Estuary be partially protected (e.g. no-take fishing zone and 25% of riverine area left untransformed) with a REC of B.

6.2.3 Recommended Ecological Category

The PES for the uMkhomazi Estuary is a C, but the Estuary is rated as "Very Important" from a biodiversity perspective and should therefore be in a B Category. In addition, the system also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan for the National Biodiversity Assessment (Turpie et al., 2012). Taking the current conditions (PES = C), the reversibility of the impacts, the ecological importance and the conservation requirements of the uMkhomazi Estuary the REC for the system is a B Category.

6.2.4 Ecological Categories associated with scenarios

The individual EHI scores, as well as the corresponding ECs under different scenarios are provided below. The estuary is currently in a C Category. Under Scenario Group B (Sc MK21 and MK42) and Group C (Sc MK22, MK23, MK43) the uMkhomazi Estuary will decline slightly in health, as a result of more closed mouth conditions, but is expected to remain in a C Category. While, under Scenario Group A (Sc MK2,4), D (Sc MK31) and E (Sc MK32, MK33) the estuary will deteriorate further in health by about 14%, 8% and 9% respectively as a result of increase closed mouth conditions.

To test the sensitivity of the estuary to the increased nutrient load associated with a 20 ML/d Waste Water Treatment Works, Scenario Group F (based on Scenario Group B) was evaluated in more detail. Under this scenario, the uMkhomazi Estuary declines in health by 13% (Sc 21b). Similar responses are expected for any of the future scenarios with this high level of nutrient input (It should be noted that this is a low confidence assessment as no numerical modelling was done to test the tidal effects on lateral discharges or the effect of entrainment).

Table 6.3 uMkhomazi Estuary Health Index score and corresponding ECs under the different runoff scenarios

Variable	Scenario Group								
	Present	A (MK2, 4)	B (MK21, 42)	C (MK22, 23, 43)	D (MK31)	E (MK32, 33)	F (MK21, 42) + WWTW	G MK21, 42 –Anth but with weir	H MK21, 42 – Anth & remove the Weir
Hydrology	*66.8*	**45**	*63*	*62*	*59*	*57*	*63*	*63*	*63*
Hydrodynamics and mouth condition	*95*	**75**	*95*	*95*	*38*	*38*	*95*	*95*	*97*
Water quality	*66.6*	**61**	*66*	*67*	*66*	*67*	*34*	*66*	*66*
Physical habitat alteration	*78*	**70**	*75*	*75*	*75*	*75*	*75*	*84*	*90*
Habitat health score	**76**	**63**	**75**	**75**	**60**	**59**	**67**	**77**	**79**

Variable	Scenario Group								
	Present	**A (MK2, 4)**	**B (MK21, 42)**	**C (MK22, 23, 43)**	**D (MK31)**	**E (MK32, 33)**	**F (MK21, 42) + WWTW**	**G MK21, 42 –Anth but with weir**	**H MK21, 42 – Anth & remove the Weir**
Microalgae	*80*	**65**	*80*	*80*	*80*	*80*	*50*	*80*	*90*
Macrophytes	*21*	**20**	*26*	*31*	*33*	*34*	*15*	*46*	*46*
Invertebrates	*75*	**60**	*75*	*75*	*70*	*70*	*50*	*85*	*90*
Fish	*60*	**35**	*60*	*60*	*60*	*55*	*50*	*70*	*75*
Birds	*60*	**50**	*55*	*55*	*55*	*55*	*50*	*57*	*65*
Biotic health score	**59**	**46**	**59**	**60**	**60**	**59**	**43**	**68**	**73**
ESTUARY HEALTH SCORE	**68**	**54**	**67**	**67**	**60**	**59**	**55**	**72**	**76**
ECOLOGICAL STATUS	**C**	**D**	**C**	**C**	**D**	**D**	**D**	**C**	**B**

For the uMkhomazi Estuary, none of the scenarios achieved the REC of a B Category. Therefore, Scenario H (Group B (Sc MK21 and MK42)) in conjunction with a number of management interventions) is the recommended ecological flow scenario. Scenario Group C (Sc MK22, MK23 and MK43) will also achieve the REC. The following management interventions are required to achieve the uMkhomazi REC:

- *Remove sandmining from the upper reaches below the Sappi Weir to increase natural function, i.e. restore intertidal area;*
- *Restoration of vegetation in the upper reaches and along the northern bank in the middle and lower reaches, e.g. remove alien vegetation and allow disturbed land to revert to natural land cover (is already on upwards trajectory);*
- *Curb recreational activities in the lower reaches through zonation and improved compliance;*
- *Reduce/remove castnetting in the mouth area through estuary zonation or increased compliance; and*
- *Relocate upstream, or remove, the Sappi Weir to restore upper 15% of the estuary.*

Since these scenarios include the construction of a new dam, this is seen as a medium to long term recommendation. In the short term, a combination of the PES and the REC will be recommended. The improvements required to meet the REC are mostly non-flow related measures. **The non-flow related (or anthropogenic) measures required to improve the estuary (apart from the removal or changing of the SAPPI weir location) can be applied and should improve the estuary to a B/C – this is recommended as the target ecological health status as discussed further in Section 9.2.2.**

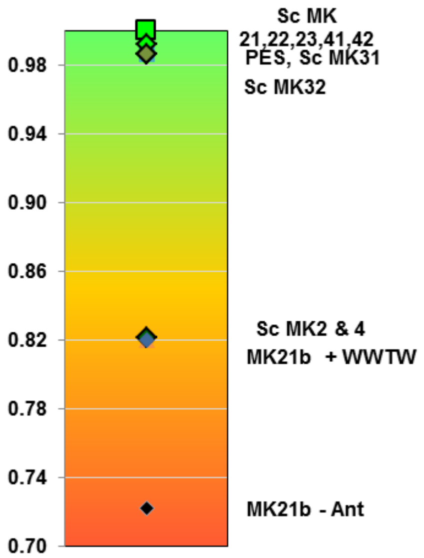


Figure 6.2 uMkhomazi Estuary: Ranking of scenarios

7 ECOSYSTEM SERVICES CONSEQUENCES

7.1 uMKHOMAZI RIVER SYSTEM

7.1.1 MK_I_EWR1: uMkhomazi River

The site provides a relatively moderate to high abundance of provisioning resources (specifically fish and riparian vegetation) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.4, while cultural services are given a weighting of 0.3. Regulating and supporting services are weighted as 0.2 and 0.1 respectively.

Scenarios that were assessed generally result in low to moderate decreases in ecosystem provision, and no appreciable improvements (Table 7.1). Scenario MK2 and MK31 show the highest reduction in ecosystem services with a weighted scope of 0.78 and 0.79 respectively – or a 20% reduction in function. The highest reductions include the abundance in terms of fish and riparian vegetation and noticeably a significant decrease in waste assimilation/dilution capability, while more moderate reductions are noted for flood regulation, bank protection, stream flow regulation and groundwater recharge.

Scenario MK4, MK32, MK41 and MK42 show moderate reductions in ecosystem function with an average weighted score of 0.86 – or 14% reduction in ecosystem function. The reduction in ecosystem functions is the same of Sc MK2 and MK31, however the reduction is not considered as significant.

Scenario MK21 and MK22 show the lowest reduction in ecosystem function, although there remain no likely improvements. Reduction in services is largely related to reduction in fish abundance, flood regulation, bank protection and stream flow regulation.

Table 7.1 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MK_I_EWR1

Service	Sc MK2	Sc MK4	Sc MK21	Sc MK22	Sc MK31	Sc MK32	Sc MK41	Sc MK42	Weight
Provisioning services	*0.65*	*0.70*	*0.88*	*0.87*	*0.84*	*0.79*	*0.77*	*0.77*	*0.40*
Regulating services	*0.74*	*0.84*	*0.97*	*0.95*	*0.92*	*0.91*	*1.00*	*0.99*	*0.20*
Cultural services	*0.90*	*0.90*	*0.90*	*0.90*	*0.57*	*0.90*	*0.90*	*0.90*	*0.30*
Supporting services	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*0.10*
Score	*0.78*	*0.82*	*0.92*	*0.91*	*0.79*	*0.87*	*0.88*	*0.87*	*1.00*

7.1.2 MK_I_EWR2: uMkhomazi River

The site provides a relatively low to moderate abundance of provisioning resources (specifically natural riparian vegetation) which is utilised by people to a moderate degree. Provisioning services are provided the highest weighting of 0.35. However, the site also provides for relatively high cultural services related to recreation, and is thus this service is provided with a weighting of 0.25. Regulating services with respect to water assimilation and dilution as well as stream-flow regulation is moderate with a weighting of 0.25, while supporting services is weighted as 0.15.

Scenarios that were assessed generally result in low to moderate decreases in ecosystem provision, and no appreciable improvements (Table 7.2). Scenario MK2 shows the highest *reduction in Ecosystem Services with a weighted scope of 0.89, which is specifically related to reductions in fish abundance, as well as reduction in waste assimilation and dilution services.*

The remaining scenarios are largely consistent with equivalent reductions in Ecosystem Services. All scenarios results in the reduction of provisioning services (especially around certain fish and riparian vegetation species). Scenario MK41 and MK42 shows slight improvement in regulating services, while the remaining scenarios show reductions. This is generally attributed to improvements in waste assimilation and dilution services. Flood control related to scenarios MK2, MK4, MK21, MK22, MK31 and MK32 show sight improvements in terms of supporting cultivation along the river banks.

Table 7.2 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MK_I_EWR2

Service	Sc MK2	Sc MK4	Sc MK21	Sc MK22	Sc MK31	Sc MK32	Sc MK41	Sc MK42	Weight
Provisioning services	*0.79*	*0.81*	*0.90*	*0.89*	*0.90*	*0.89*	*0.94*	*0.94*	*0.35*
Regulating services	*0.92*	*0.98*	*1.00*	*1.01*	*1.00*	*0.99*	*1.03*	*1.03*	*0.25*
Cultural services	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.25*
Supporting services	*1.10*	*1.05*	*1.05*	*1.05*	*1.05*	*1.05*	*1.00*	*1.00*	*0.15*
Score	*0.89*	*0.91*	*0.95*	*0.95*	*0.95*	*0.94*	*0.96*	*0.96*	*1.00*

7.1.3 MK_I_EWR3: uMkhomazi River

The site provides a relatively moderate abundance of provisioning resources (specifically natural riparian vegetation) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.35. Cultural and regulating services are provided an equal weighting of 0.25, while supporting services is weighted as 0.15.

Scenarios that were assessed generally result in negligible overall changes (Table 7.3). Scenario MK2 shows the highest reduction in Ecosystem Services of all the scenarios, although the overall weighted score is only 0.95; related to reduced provisioning services of fish and riparian vegetation and changes in stream-flow. Scenario MK21 shows slight improvements in provisioning and regulating services, although this is considered to be minor and related to improvement in tree abundance due to improved flood attenuation. Scenarios MK22, MK32 and MK42 are considered to be largely static in terms of any potential changes in Ecosystem Services. Only very slight reductions in provisioning services (reduced provisioning services of fish) are noted.

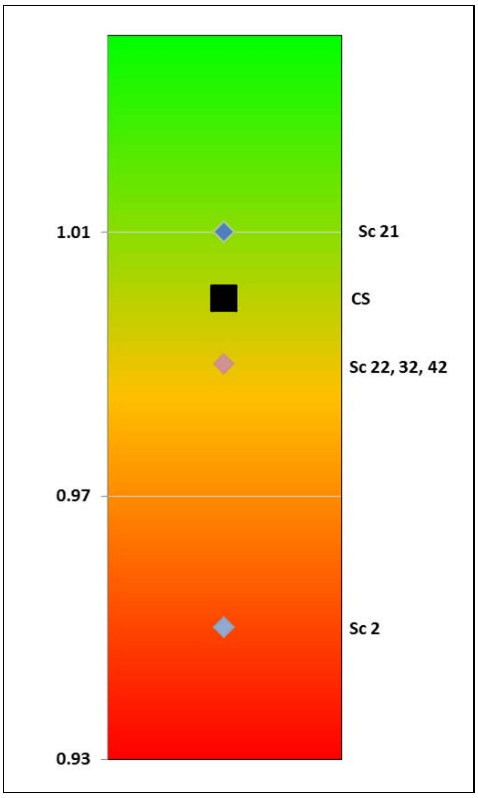
Table 7.3 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MK_I_EWR3

Service	Sc MK2	Sc MK21	Sc MK22	Sc MK32	Sc MK42	Weight
Provisioning services	*0.92*	*1.01*	*0.98*	*0.98*	*0.98*	*0.35*
Regulating services	*0.95*	*1.01*	*1.00*	*1.00*	*1.00*	*0.25*
Cultural services	*0.97*	*1.00*	*1.00*	*1.00*	*1.00*	*0.25*
Supporting services	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*0.15*
Score	*0.95*	*1.01*	*0.99*	*0.99*	*0.99*	*1.00*

7.1.4 uMkhomazi River: Overall Scenario Ranking

The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites was undertaken for the uMkhomazi where multiple sites were considered. Here the perceived vulnerability of households dependent on the *provisioning aspect of ecosystem services played a major role. Overall the results of the scenarios for the uMkhomazi River were ranked with the EWR sites weighted.*

Again all scores are normalised against a base score of one. Results are presented in Figure 7.1 below.



CS = Current state

Figure 7.1 Integrated scenario results for EWR sites in the uMkhomazi River

7.1.5 uMkhomazi Estuary

The uMkhomazi Estuary provides a relatively moderate abundance of provisioning resources (specifically natural riparian vegetation and fish species) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.4. Cultural and regulating services are provided a weighting of 0.3 and 0.2 respectively, while supporting services is weighted as 0.1.

Scenarios that were assessed generally result in variable changes (Table 7.4). Scenario Group A and Scenario Group F show the greatest reduction in service provision. This is attributed to the reduction in fish abundance, waste dilution potential as well as increases in water-borne diseases.

Scenario Group C, as well as Group D and Group E are considered to be largely static in terms of any potential changes in ecosystem services. Only very slight reductions in provisioning services (reduced fish abundance) and regulating services are noted.

Scenarios Sc MK21 and MK41 + anth, Scenario Group G and Scenario Group H are the only that show positive trends in service provision. This is largely related to improved fish abundance, cultural use and improvement in human health.

Table 7.4 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at the uMkhomazi Estuary

Service	A	Sc 21 + 41 + anth	C	D	E	F	G	H	Weight
Provisioning services	*0.79*	*1.02*	*0.97*	*0.98*	*0.90*	*0.81*	*1.17*	*1.32*	*0.4*
Regulating services	*0.67*	*0.95*	*0.95*	*0.95*	*0.95*	*0.76*	*0.99*	*1.03*	*0.2*
Cultural services	*0.96*	*1.04*	*1.00*	*1.04*	*1.00*	*0.86*	*1.22*	*1.32*	*0.3*
Supporting services	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*0.1*
Score	*0.84*	*1.01*	*0.98*	*0.99*	*0.95*	*0.83*	*1.13*	*1.23*	*1*

7.2 MVOTI RIVER SYSTEM

7.2.1 MV_I_EWR 2: Mvoti River

Given the relatively high abundance of natural resources and the moderate and high utilisation of these resources, the provisioning services are given the highest weighting of 0.35. Both regulating and cultural services are provided an equal weighting of 0.25. Supporting services are given the lowest weighting of 0.15.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (See Table 7.5). Scenario MV42 and MV43 are considered as equivalent in terms of the impact on Ecosystem Services including an improvement in riparian vegetation growth, water quality, waste dilution and groundwater recharge. Scenario MV3 shows some potential reduction in provisioning services, but an improvement in regulating services around flood regulation from stabilised baseflows.

Table 7.5 Mvoti River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MV_I_EWR2

Service	Sc MV3	Sc MV42	Sc MV43	Weight
Provisioning services	*0.97*	*1.02*	*1.02*	*0.35*
Regulating services	*1.02*	*1.22*	*1.22*	*0.25*
Cultural services	*1.00*	*1.00*	*1.00*	*0.25*
Supporting services	*1.10*	*1.05*	*1.05*	*0.15*
Score	**1.01**	**1.07**	**1.07**	**1.00**

7.2.2 Mvoti Estuary

The Mvoti Estuary provides limited provisioning services with respect to fish but has a moderate abundance of riparian vegetation which is underutilised. Hence, provisioning services is given a value of 0.2. The estuary provides moderate levels of regulating services, specifically flood attenuation, storm control, sediment supply to beach; but also have elevated levels of water-borne diseases (bilharzia and cholera). Hence regulating services are given the highest weighting of 0.4. The estuary provides limited cultural services with the exception of ritual uses. Recreational fishing and birding is limited. Hence cultural services are given a weighting of 0.3.

Scenarios, where the PES EWRs are reduced by 5 and 15% show a commensurate drop in Ecosystem Services (Table 7.6). The reduction is likely in provisioning, regulating and cultural services. Provisioning services are likely impacted by the reduction in fish abundance, while there is likely to be reductions in regulating services associated with flood attenuation and increases in *water-borne diseases. Cultural services, related to aesthetic value, ritual use and birding is likely to be reduced.*

The maintenance of the PES with a reduction in organics will see improvements in provisioning, regulating and cultural services (Table 7.6). This includes greater abundance of fish species, reduction in water-borne diseases and improved cultural services.

Table 7.6 Mvoti River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at the Mvoti Estuary

Service	PES (A+C)[1]	B (-5%)[2]	A+C-Organics[4]	Weight
Provisioning services	*1.00*	*0.98*	*1.16*	*0.2*
Regulating services	*1.00*	*0.89*	*1.16*	*0.4*
Cultural services	*1.00*	*0.88*	*1.55*	*0.3*
Supporting services	*1.00*	*1.00*	*1.00*	*0.1*
Score	**1.00**	**0.92**	**1.26**	**1.0**

1 Refer to Section 2.2.3 for outline of scenario grouping.
2 PES EWRs are reduced by 5%.
3 PES EWRs are reduced by 15%.
4 The maintenance of the PES with a reduction in organics undr Scenario Group A and C.

8 INTEGRATED MULTI-CRITERIA RESULTS

The results of the rating, weighting and scoring for the four variables, Economy, Employment, Ecology and Ecosystem Services presented in the previous chapters were integrated to obtain the overall ranking of the scenarios as described in this chapter. Provision was made in this process to incorporate all the biophysical nodes in each of the IUAs.

Integrated multi-criteria analysis models were compiled respectively for the uMkhomazi and Mvoti River systems.

8.1 ECOLOGICAL SCORING MATRIX RESULTS

Table 11.1 (Appendix A) provides an example (extract) of the full scoring calculation carried out for the ecological component of the Mvoti River system. The elements of the table are described below in accordance with the respective column alphabetic labels:

Column *a*: *National biophysical node label identifier, where the first 4 characters "U40A" refers to the quaternary catchment in which the node is located. The remaining numbers represent the SQ reach number. The SQ river reaches as indicated in http://www.dwa.gov.za/iwqs/gis_data /river/rivs500k.html and http://www.dwa.gov.za/iwqs/gis_data/river/River_Report_01.pdf, forms the basis of the Desktop Present Ecological State (PES) and Ecological Importance (EI) - Ecological Sensitivity (ES) (DWS, 2014b) assessment (referred to PES (11)). A SQ changes when a significant tributary joins it. This means that a SQ may potentially be subdivided into various EcoRegions, geomorphic zones (slope zones) resource units (natural or management), etc. Such subdivisions are not addressed on a desktop level, and may be required when higher confidence assessments are done. The version of the 1:500 000 coverage that was used for the PES (11) (DWS, 2014b), was a version used during the determination of the Status Quo (DWA, 2013).*

The EWR sites are indicated as "Mv_I_EWR_1" where the numerical number refers to the particulate site. These are the river sites where high confidence Reserve determination studies were undertaken and serve as the drivers for the water resource modelling and availability analysis.

Column *b*: *River or stream name.*

Columns *c* and *d*: *These columns are the weights assigned to each node. Column c reflects the relative ecological importance of each node and* **Column *d*** *is the length of river reach the node represents. The length of river is a measure of the extent of the ecological habitat of the river reach (associated with the nodes) relative to each other. These two weights are combined into one weight, see description of* **Column *g*** *below.*

Columns *e, f* and *g*: *The weights of* **Columns *c*** *and* ***d*** *are respectively normalised in these columns.*

Columns *e* and *f* *(divide each nodes weight by the sum of the weights)***:** *The combined weight in* **Column g** *is determined by the sum of the product of the normalised values with the factors given in grey shading above the column labels. These factors must add up to one and represents the relative contribution of the "Importance" and the "Length" in the combined weight.*

Columns *h* to *k*: *This is the rating of the ecological status of each node as it is influenced by the scenario. Since most of the biophysical nodes are in tributary catchment and not affected by the scenarios their ratings are one, indicating the REC is achieved.*

Columns *l* to *o*: *This is the score, the product of the weight in* **Column *g*** *and respective ratings in* **Columns h** *to* **k:** *The sum of the scores of all the nodes for a scenario is listed at the bottom of each column. This is the metric representing the ecology for the scenario and taken into account when determining the integrated ranking of scenarios.*

Similar calculations were carried out for the uMkhomazi River system.

8.2 ECOSYSTEM SERVICES SCORING MATRIX RESULTS

The same calculation methodology as described in Section 8.1 is applied for the Ecosystem Services component for all four river systems.

8.3 INTEGRATED SCENARIO RANKING RESULTS

The summarised integrated results for the two river system are presented respectively in the following sections.

8.3.1 Mvoti River System

The scenario scores for the four variables, Ecology, Ecosystem Services, Economy and Employment are presented graphically in Figure 8.1. The scenarios presented are identified in accordance with their labels presented in Chapter 3. Note that only the scenarios that are relevant for the discussion and decision making process are listed. The scenarios not shown provided intermediate perspectives for evaluation purposes and were superseded by other scenarios during the analysis process.

The four individual graphs shown in Figure 8.1 have the following interpretation:

- **Ecological Status relative to REC:** *This is the measure of how each scenario's ecological status is ranked relative to the REC. As indicated* **Sc MV3** *(no releases for the EWR) has the lowest ecological score while* **Sc MV41** *the highest.*
- **Ecosystem Services:** *The score indicates to what extent each scenario changes the Ecosystem Services relative to the Present Day or PES conditions. The ranking follows largely the same ranking order as that for the ecological status.*
- **Economic Indicator (GDP):** *This metric represents GDP in Rand with* **Sc MV3** *ranking the highest and* **Sc MV41** *the lowest.*
- **Employment:** *The number of people employed follow the same relative ranking position as the economic indicator.*

The lines depicted in Figure 8.1 connect the variable points for a scenario and when opposing consequences are observed (among the variables) the lines cross. This indicates opposing outcomes and a compromise between ecological protection and socio economic benefits will most likely result in the optimum solution – "the desired balance between protection and use".

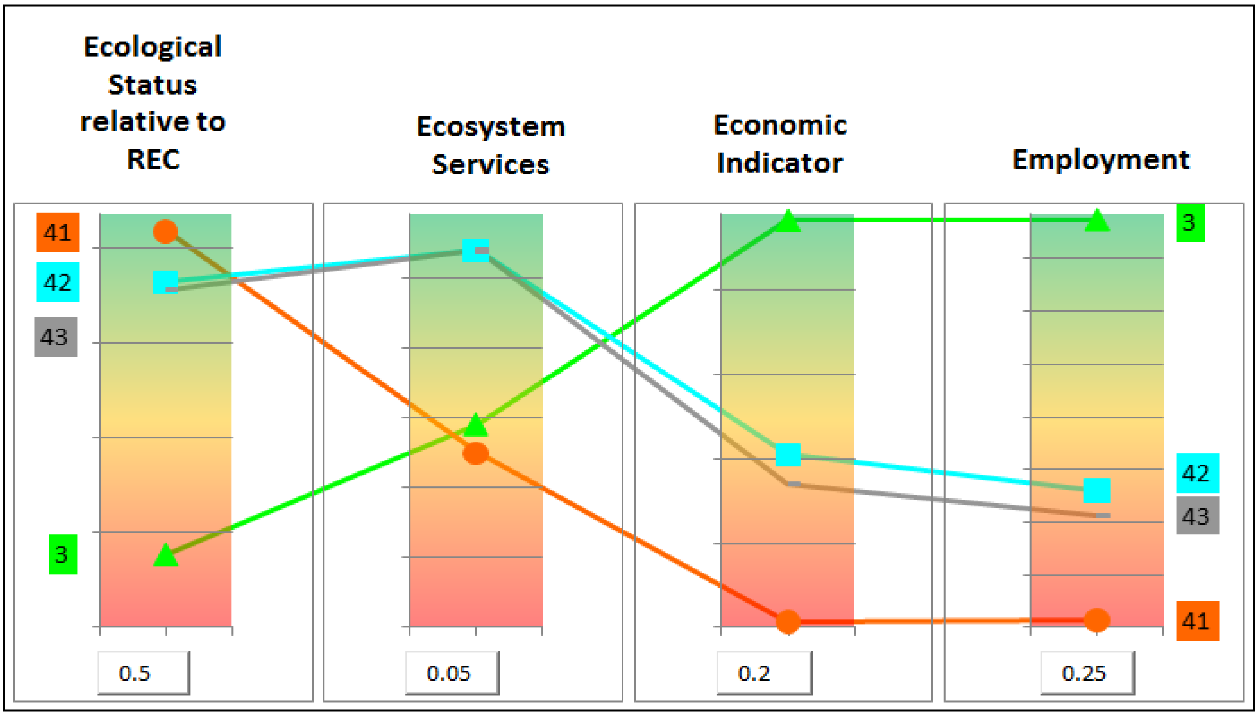


Figure 8.1 Mvoti River System: Graphical results of individual variables and all scenarios

The final step in the multi-criteria analysis was to determine the integrated and overall rank of the scenarios and this is depicted in Figure 8.2a and Figure 8.2b for the two ranking methods

The relative weight applied to each variable for calculating the overall ranking is indicated numerically at the bottom of each bar graph. Each weight has a value between zero and one and a set of selected weights for all four variables must add up to one. The rationale for the weights selected is to assess what the balance is between the ecological health and the socio-economic benefits, therefore a weight of 0.5 (or 50%) is assigned to the ecology and the remaining 50% is divided among the other three variables; Ecosystem Services (5%), economy (20%) and employment (25%).

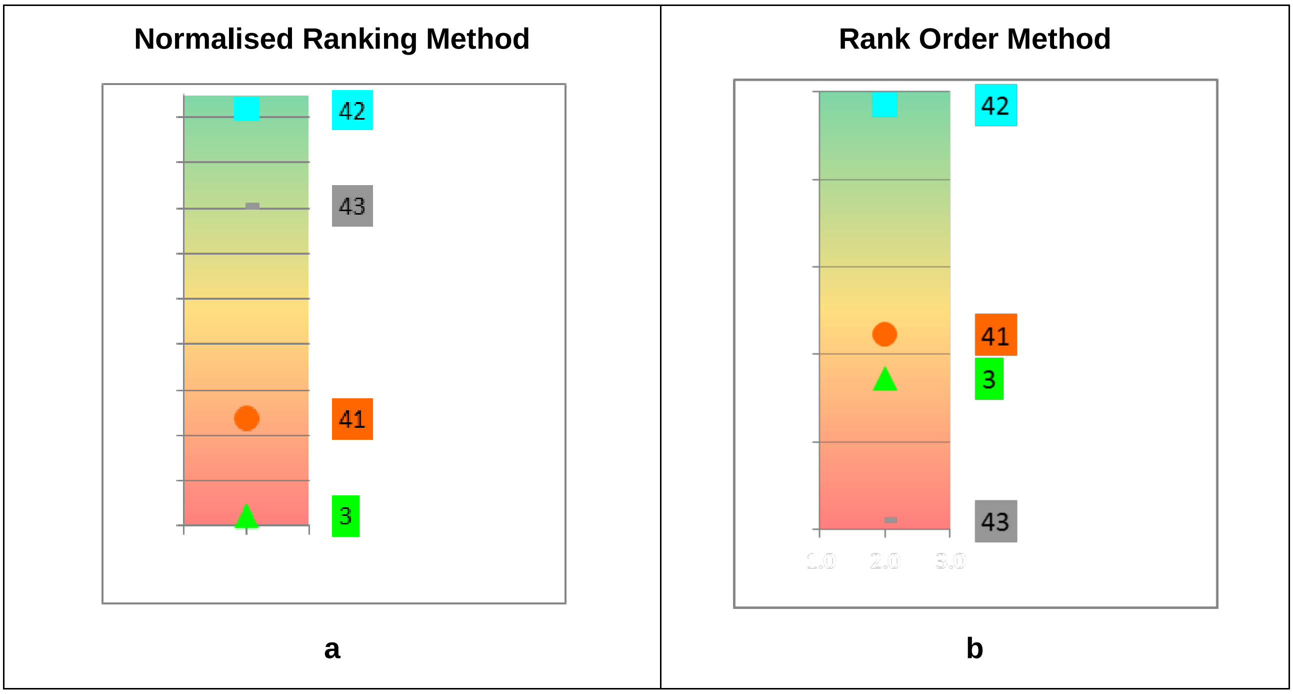


Figure 8.2 Mvoti River System: Graphical results of overall ranking from the multi-criteria analysis

Scenario MV42 *has overall the highest rank for both ranking methods.*

The integrated ranking calculations which give rise to the ranking order shown in Figure 8.2 are presented in Table 8.1 and is explained below by using the column and row labels.

Column *a*: *This column contains headings describing the different sections in the table as well as labelling the variables for which the calculated data of the scenarios are provided in the subsequent columns.*

Columns *b* and *c*: *Contain parameters applied in the calculations, either the best and highest and lowest scores of the weights associated with each variable. The application of these parameters in the calculations is described below.*

Columns *d* to g: *Represent the values calculated for each of the scenarios.*

Rows *A* to *D*: *This is the numerical results (scores) of the scenarios.*

Row *A* *is the Ecological Scores for the scenarios, which originate from the calculations in Table 11.1 (Appendix A) and is obtained from the last row in that table.*

Row *B* *is the Ecosystem Services score which is calculated following the same procedure as above.*

Rows *C* and *D*: *Contains the Economic Indicator (GDP in Rand) and the Employment numbers for each scenario respectively. The calculations to derive these variables were described in Chapter 4.*

Rows *E* to *O*: *This section of the table shows the calculation results for the Rank Order method of determining the overall scenario rank.*

Rows *E* to *H*: *Contains the rank order position of each variable's score derived from the scored in* **Rows *A* to *D*.**

Row *I*: *This is the sum of the rank positions of the scenario (note this is before the variable weight are applied.* **Row *J*** *is the ranked position of* **Row *I*.** *Note that both* **Rows *I*** *and* ***J*** *are before the variables weights are applied.*

Rows *K* to *N*: *These rows show the scores where the Weights indicated in* **Column *b*** *are multiplied with the respective rank positions given in* **Rows *E*** *to* ***H*.**

Row *O*: *This is the sum of the scenario values of* **Rows *K*** *to* ***N*** *– the overall score of the scenarios for the Rank Order method.*

Row *P*: *This is the rank order of the scenarios for the Rank Order method, indicating Sc MV42 is the best (rank if one) and Sc MV42 ranks the lowest with a rank of four.*

Rows Q to *AB*: *The results for the normalisation calculation are presented in these rows.*

Rows *Q* to *T*: *Shows the normalised values for the variables determined from* **Rows *A* to *D*** *respectively.*

Rows *Q* to *T*: *This is the normalised values calculated by assuming the worst scenario will have a normalised value of zero and the best scenario a value of one. All the other values then transposed to fit the zero to one normalised scale.*

Rows *U* and *V*: *This is the sum of the scores for the normalised values for each scenario and the rank order of the scores. Note that both* **Rows *U*** *and* ***V*** *are before the variables weights are applied.*

Rows *W* to *Z*: *These rows show the scores where the Weights indicated in Column b are multiplied with the respective rank positions given in* **Rows *Q*** *to* ***T****.*

Row *AA*: *This is the sum of the scenario values of* **Rows *W*** *to* ***Z*** *– the overall score of the scenarios for the Normalisation Method.*

Row *AB*: *This is the rank order of the scenarios for the Normalisation Method, indicating* **Sc MV42** *is the best (rank if one) and Scenario 3 ranks the lowest with a rank of four.*

Rows *AC* to *AF*: *This is the respective results (integrated scores and rank positions) of the two ranking methods repeated for easy comparison.*

In order to determine how sensitive the ranking results are for alternative weight settings, Table 8.2 provides scenario ranking results for a range of variable weights. Scenario MV41 is ranked first for most of the alternatives and only differs where weight for the ecology is less than 0.25. The analysis result is therefore not sensitive for different variable weights.

Table 8.1 Mvoti River System: Integrated ranking calculations for the two ranking methods

Row	Description	Parameters		Scenarios: 3	41	42	43
	a	*b*	*c*	*d*	*e*	*f*	*g*
	Variable Scores:						
		Highest	*Lowest*				
A	Ecological Status	0.96	0.77	0.77	0.96	0.93	0.92
B	Ecosystem Services	1.00	1.00	1.00	1.00	1.00	1.00
C	Economic Indicator (GDP) (R Millions)	39638	15808	39637.7	15808.4	25713.5	23996.7
D	Employment	21661	6427	21661	6427	11360	10412
	Rank Order Method:						
	Ranked order of variables (6 = higest, 1 = lowest, equals = average):						
E	Ecological Status			1.0	4.0	3.0	2.0
F	Ecosystem Services			2.0	1.0	3.5	3.5
G	Economic Indicator (GDP) (R Millions)			4.0	1.0	3.0	2.0
H	Employment			4.0	1.0	3.0	2.0
I	Total:			**11.0**	**7.0**	**12.5**	**9.5**
J	Rank (1 = best, 4 = worsed)			**2**	**4**	**1**	**3**
	Rank order x Weights:	Weights					
K	Ecological Status	0.50		0.50	2.00	1.50	1.00
L	Ecosystem Services	0.05		0.10	0.05	0.18	0.18
M	Economic Indicator (GDP) (R Millions)	0.20		0.80	0.20	0.60	0.40
N	Employment	0.25		1.00	0.25	0.75	0.50
O	**Total:**			**2.400**	**2.500**	**3.025**	**2.075**
P	**Rank (1 = best, 4 = worsed)**			**3**	**2**	**1**	**4**
	Normalisation Method:						
	Normilized (0 = minimum, 1 = maximum):						
Q	Ecological Status			0.000	1.000	0.842	0.816
R	Ecosystem Services			0.143	0.000	1.000	1.000
S	(R Millions)			1.000	0.000	0.416	0.344
T	Employment			1.000	0.000	0.324	0.262
U	Total:			**2.143**	**1.000**	**2.582**	**2.421**
V	Rank (1 = best, 4 = worsed)			3	4	1	2
	Normiliaed x Weights:	Weights					
W	Ecological Status	0.50		0.000	0.500	0.421	0.408
X	Ecosystem Services	0.05		0.007	0.000	0.050	0.050
Y	Economic Indicator (GDP) (R Millions)	0.20		0.200	0.000	0.083	0.069
Z	Employment	0.25		0.250	0.000	0.081	0.065
AA	Total:			**0.457**	**0.500**	**0.635**	**0.592**
AB	**Rank (1 = best, 4 = worsed)**			**4**	**3**	**1**	**2**
AC	**Overall Score (Rank Order method)**			2.40	2.50	3.03	2.08
AD	Rank (1 = best, 4 = worsed)			**3**	**2**	**1**	**4**
AE	**Overall Score (Normalisation Method)**			0.457	0.500	0.635	0.592
AF	Rank (1 = best, 4 = worsed)			**4**	**3**	**1**	**2**

Table 8.2 Mvoti River System: Sensitivity analysis of scenario ranking for alternative variable weights

Weights					Rank Position of Scenario Normalisation Ranking Method) (1 = Best, 4 = Worst)			
Alternative	**Ecology**	**EcoSystem Services**	**GDP**	**Jobs**	**MV3**	**MV41**	**MV42**	**MV43**
1	*0.50*	*0.15*	*0.15*	*0.20*	*4*	*3*	**1**	*2*
2	*0.50*	*0.10*	*0.20*	*0.20*	*4*	*3*	**1**	*2*
3	*0.50*	*0.05*	*0.20*	*0.25*	*4*	*3*	**1**	*2*
4	*0.50*	*0.05*	*0.15*	*0.30*	*4*	*3*	**1**	*2*
5	*0.50*	*0.05*	*0.30*	*0.15*	*4*	*3*	**1**	*2*
6	*0.50*	*0.05*	*0.20*	*0.25*	*4*	*3*	**1**	*2*
7	*0.47*	*0.11*	*0.21*	*0.21*	*4*	*3*	**1**	*2*
8	*0.44*	*0.06*	*0.22*	*0.28*	*3*	*4*	**1**	*2*
9	*0.41*	*0.06*	*0.24*	*0.29*	*3*	*4*	**1**	*2*
10	*0.38*	*0.06*	*0.25*	*0.31*	*2*	*4*	**1**	*3*
11	*0.25*	*0.25*	*0.25*	*0.25*	*3*	*4*	**1**	*2*
12	*0.33*	*0.07*	*0.27*	*0.33*	**1**	*4*	*2*	*3*
13	*0.20*	*0.10*	*0.40*	*0.30*	**1**	*4*	*2*	*3*
14	*0.29*	*0.07*	*0.29*	*0.36*	**1**	*4*	*2*	*3*
15	*0.15*	*0.10*	*0.45*	*0.30*	**1**	*4*	*2*	*3*

Note that since the calculation methods are the same for both systems; the detail calculation descriptions provided in Section 8.3.1 are not repeated for the multi criteria analysis of the uMkhomazi River system. The descriptions for the uMkhomazi focus on the discussion and interpretation of the results.

8.3.2 uMkhomazi River System

The scenario scores for the four variables, Ecology, Ecosystem Services, Economy and Employment are presented graphically in Figure 8.3.

The four individual graphs shown in Figure 8.3 have the following interpretation:

- **Ecological Status relative to REC:** *This is the measure of how each scenario's ecological status is ranked relative to the REC. As indicated* **Sc MK2** *and* **MK4** *(no releases towards the EWR) has the lowest ecological score while* **Sc MK21** *and* **MK41** *the highest.*
- **Ecosystem Services:** *The score indicates to what extent each scenario changes the Ecosystem Services relative to the Present Day or PES conditions. The ranking follows largely the same ranking order as that for the ecological status.*
- **Economic Indicator (GDP):** *This metric represents GDP in Rand with* **Sc MK2** *ranking the highest and* **Sc MK41** *the lowest.*
- **Employment:** *The number of people employed follow the same relative ranking position as the economic indicator.*

The relative weight applied to each variable for calculating the overall ranking is indicated numerically at the bottom of each bar graph. Each weight has a value between zero and one and a set of selected weights for all four variables must add up to one.

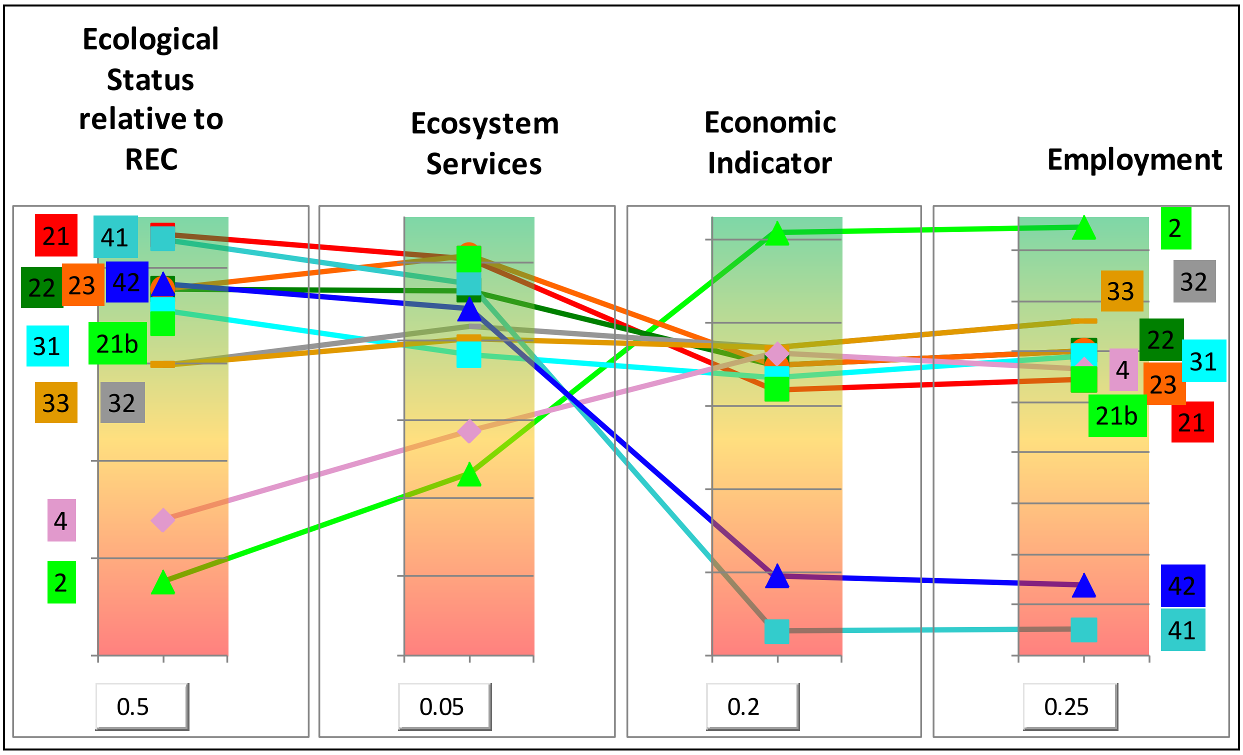


Figure 8.3 uMkhomazi River System: Graphical results of individual variables and all scenarios

The final step in the multi-criteria analysis was to determine the integrated and overall rank of the scenarios and this is depicted in Figure 8.4a and Figure 8.4b for the two ranking methods.

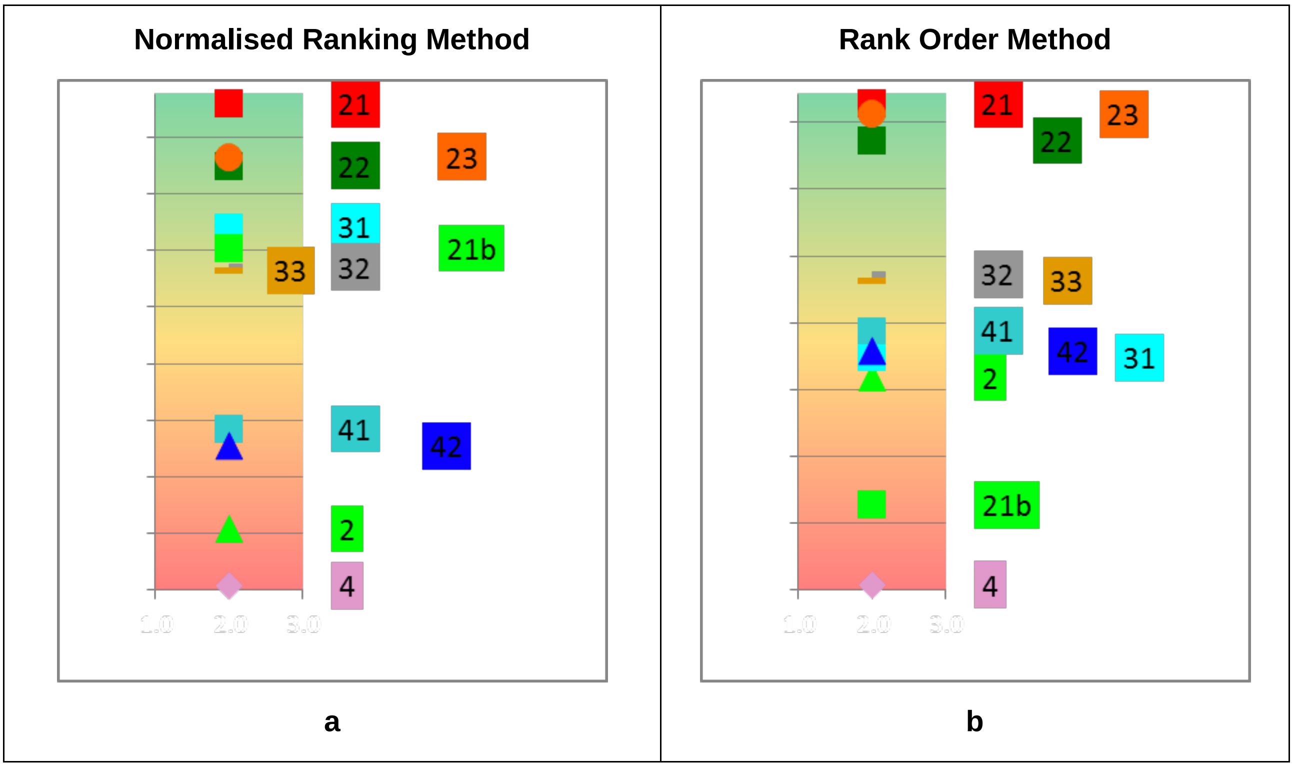


Figure 8.4 uMkhomazi River System: Graphical results of overall ranking from the multi-criteria analysis

Scenario MK21 *has overall the highest rank for both ranking methods.*

In order to determine how sensitive the ranking results are for alternative weight settings, Table 8.4 provides scenario ranking results for a range of variable weights. **Scenario MK21** *is ranked first for most of the alternatives and only differs where weight for the ecology is less than 0.25. The analysis result is therefore not sensitive for different variable weights.*

Table 8.3 uMkhomazi River System: Sensitivity analysis of scenario ranking for alternative variable weights

Weights					Rank Position of Scenario Normalisation Ranking Method) (1 = Best, 11 = Worst)										
Alt.	Ecology	EcoSystem Services	GDP	Jobs	MK 2	MK 21	MK 22	MK 23	MK 31	MK 32	MK 33	MK 4	MK 41	MK 42	MK21b
1	0.50	0.15	0.15	0.20	11	1	3	2	5	6	7	10	8	9	4
2	0.50	0.10	0.20	0.20	10	1	3	2	5	6	7	11	8	9	4
3	0.50	0.05	0.20	0.25	10	1	3	2	4	6	7	11	8	9	5
4	0.50	0.05	0.15	0.30	10	1	3	2	4	6	7	11	8	9	5
5	0.50	0.05	0.30	0.15	10	1	3	2	4	6	7	11	8	9	5
6	0.50	0.05	0.20	0.25	10	1	3	2	4	6	7	11	8	9	5
7	0.47	0.11	0.21	0.21	10	1	3	2	5	6	7	11	8	9	4
8	0.44	0.06	0.22	0.28	8	1	3	2	4	6	7	11	9	10	5
9	0.41	0.06	0.24	0.29	8	1	3	2	4	5	7	11	10	9	6
10	0.38	0.06	0.25	0.31	8	1	3	2	4	5	6	9	11	10	7
11	0.25	0.25	0.25	0.25	8	1	3	2	7	5	6	11	10	9	4
12	0.33	0.07	0.27	0.33	8	1	3	2	6	4	5	9	11	10	7
13	0.20	0.10	0.40	0.30	6	2	3	1	8	4	5	9	11	10	7
14	0.29	0.07	0.29	0.36	8	1	3	2	6	4	5	9	11	10	7
15	0.15	0.10	0.45	0.30	1	5	3	2	8	4	6	9	11	10	7

Scenario MK21b *is based on* **Sc MK21***, with the addition that the ultimate wastewater volume of 20 Ml/day is treated and discharged into the estuary. The estuary Ecological Health Score for* **Sc MK21b** *is 12 points lower than* **Sc MK21***, indicating that alternative discharge options and the associated costs implications should also be formulated for further analysis and comparison. It can however be concluded that based on the other variables (excluding the implication of alternative wastewater management)* **Sc MK21** *is the preferred scenario.*

9 WATER RESOURCE CLASS AND CATCHMENT CONFIGURATION

9.1 WATER RESOURCE CLASS CRITERIA TABLE

A range of alternative water resource criteria settings (alternative to the guideline criteria presented in Table 2.3) were evaluated by the study team leading to the recommended criteria parameters presented in Table 9.1.

Table 9.1 Recommended Water Resource Class criteria table

		% EC representation at units represented by biophysical nodes in an IUA				
		≥ A/B	≥ B	≥C	≥ D	< D
Class 1		*0*	*60*	*80*	*95*	*5*
Class 2			*0*	*70*	*90*	*10*
Class 3	**Either**			*0*	*80*	*20*
	Or				*100*	

The above table was applied to both systems and the resulting Water Resource Classes and catchment configuration are provided in the next sections.

These Water Resource Classes and catchment configuration results are the recommendations that were presented at the Project Steering Committee Meeting held in November 2014 for comments after which the final scenario and results will be prepared for gazetting.

9.2 uMKHOMAZI RIVER SYSTEM

9.2.1 uMkhomazi River System Water Resource Class

When applying the criteria presented in Table 8.1 to the resulting ECs for each scenario, the Water Resource Classes for the 5 IUAs in the uMkhomazi River system are as listed in Table 9.2.

Table 9.2 uMkhomazi River System: Resulting IUA Water Resource Classes for each scenario

IUA	Scenarios and Water Resource Class												
	PES	REC	MK2	MK21	MK22	MK23	MK31	MK32	MK33	MK4	MK41	MK42	MK21b
U1-1	**I**	**I**	*I*	*I*	*I*	*I*	*I*	*I*	*I*	*I*	*I*	*I*	*I*
U1-2	**II**	**II**	*II*	*II*	*II*	*II*	*II*	*II*	*II*	*II*	*II*	*II*	*II*
U1-3	**II**	**I**	*II*	*I*	*II*	*II*	*II*	*II*	*II*	*II*	*I*	*I*	*I*
U1-4	**II**	**II**	*III*	*II*	*III*	*III*	*II*	*II*	*II*	*III*	*II*	*III*	*II*
U1-5	**II**	*I*	*III*	*II*	*II*	*II*	*III*	*III*	*III*	*III*	*II*	*II*	*III*

Following on from the preliminary selection of **Sc MK21** *as the preferred scenario for the uMkhomazi River system, the embossed column in Table 9.2 represents the recommended Water Resource Classes for the indicated IUAs. This scenario does not include a wastewater option.*

*The wastewater option evaluated (***Sc MK21b***) results in the estuary dropping a Water Resource Class. Alternative wastewater options that maintain the estuary class can still be investigated. However, it must be noted that this estuary is important and under the current state, and with* **Scenario 21***, improvements can actually be achieved with addressing some anthropogenic issues.*

Since **Sc MK21** *includes the construction of a new dam, this is seen as a medium to long term recommendation. In the short term, a combination of the PES and the REC (which is the same classes as for* **Sc MK21***) will be recommended and the RQOs determined for these Water Resource Classes and catchment configuration. The REC is set to largely maintain the PES apart from specific desktop biophysical nodes where improvements which require mostly to non-flow related measures to be applied (see 9.1.2 below). The non-flow related (or anthropogenic) measures required to improve the estuary (apart from the removal or changing of the SAPPI weir location) can be applied and should improve the estuary to a B/C. Further investigations are required as well as the input of other legislative organisations and a socio-economic impact assessment to address the issue of the SAPPI weir.*

9.2.2 uMkhomazi River System Catchment Configuration

Given the results and scenario selections presented in the section above, Table 8.4 provides respectively the proposed Water Resource Class and ECs for the IUAs and biophysical nodes for the uMkhomazi River system.

It must be noted that various nodes require improvements (Table 9.4) based on non flow-related/anthropogenic issues that have to be addressed. Where it is deemed that the REC is attainable, it has been included in the catchment configuration (Table 9.4).

Table 9.3 uMkhomazi River System nodes requiring improvements

IUA	Node	River	PES	REC	REC Comment	Target EC
U1-1	*U10D-04298*	*Nzinga*	**B/C**	**B**	*Difficult to achieve the REC as catchment management would be required to amongst others manage sedimentation.*	**B**
U1-1	*U10D-04349*	*uMkhomazi*	**B/C**	**B**	*Difficult to achieve the REC as catchment management would be required to amongst others manage sedimentation.*	**B**
U1-1	*U10D-04434*	*uMkhomazi*	**B/C**	**B**	*Difficult to achieve the REC as catchment management would be required to amongst others manage sedimentation.*	**B**
U1-2	*U10G-04388*	*Elands*	**C**	**B**	*Target improvement especially in the lower reach. Buffer zone, alien removal, water quality practices. As none of the scenarios are relevant to this SQ, the improvement is valid irrespective of the recommended scenario.*	**B**
U1-2	*U10G-04473*	*Elands*	**C**	**B**	*Target improvement especially in the upper reach. Buffer zone, alien removal, water quality practices. Also flow improvements but should be able to reach at least a B/C without any improvement in flow.*	**B**
U1-3	*U10H-04666*	*Ngudwini*	**B/C**	**B**	*Address erosion to reduce sedimentation (overgrazing, forestry, informal agriculture). As none of the scenarios are relevant to this SQ, the improvement is valid irrespective of the recommended scenario.*	**B**
U1-4	*U10J-04713*	*Mkobeni*	**C**	**B**	*Riparian buffer zone in forestry and agricultural areas. Also alien removal. As none of the scenarios are relevant to this SQ, the improvement is valid irrespective of the recommended scenario.*	**B**
U1-4	*U10J-04820*	*Lufafa*	**B/C**	**B**	*Erosion control, riparian buffer. Due to the catchment scale of the problem, this is deemed to be difficult and the PES must be maintained.*	**B/C**
U1-5	*U10M-04746*	*uMkhomazi Estuary*	**C**	**B**	*Remove sand mining from the upper reaches to increase natural function, i.e. restore intertidal area.*	**B/C**

IUA	Node	River	PES	REC	REC Comment	Target EC
					Restoration of vegetation in the upper reaches and along the northern bank in the middle and lower reaches, e.g. remove alien vegetation and allow disturbed land to revert to natural land cover (is already on upwards trajectory). Curb recreational activities in the lower reaches through zonation and improved compliance. Reduce/remove cast netting in the mouth area through estuary zonation or increased compliance.	

The catchment configuration associated with the PES/REC combination and Sc MK21 is provided below. The target ECs associated with the REC requires no new infrastructure development and is therefore immediately applicable.

Table 9.4 uMkhomazi River System: Recommended ECs and Water Resource Classes

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC for:	
					Short term	Sc MK21
U1-1	I	U10A-04115	Lotheni	27.0	A/B	A/B
		U10A-04202	Nhlathimbe	25.7	B	B
		U10A-04301	Lotheni	18.9	B	B
		U10B-04239	uMkhomazi	18.3	B	B
		U10B-04251	uMkhomazi	8.3	A	A
		U10B-04274	Nhlangeni	9.7	A	A
		U10B-04337	uMkhomazi	28.1	B	B
		U10B-04343	Mqatsheni	25.1	B	B
		U10C-04347	Mkhomazana	68.4	B	B
		U10D-04199	Nzinga	19.3	A	A
		U10D-04222	Rooidraai	13.0	B	B
		U10D-04298	Nzinga	27.1	B	B
		U10D-04349	uMkhomazi	17.2	B	B
		U10D-04434	uMkhomazi	1.4	B	B
U1-2	II	U10E-04380	uMkhomazi	39.5	C	C
		U10F-04528	uMkhomazi	7.0	C	C
		Mk_I_EWR1	uMkhomazi	14.0	C	C
		U10G-04388	Elands	26.5	B	B
		U10G-04405		12.2	C	C
		U10G-04473	Elands	44.5	B	B
U1-3	I	U10H-04576	Tholeni	15.8	B	B
		U10H-04666	Ngudwini	36.1	B/C	B
		U10H-04708	Ngudwini	7.5	B	B
		U10H-04729	Mzalanyoni	24.4	C	C
		Mk_I_EWR2	uMkhomazi	49.0	B	B
		U10J-04721	Pateni	13.8	B	B
U1-4	II	U10J-04713	Mkobeni	24.2	B	B
		U10J-04820	Lufafa	43.2	B	B
		U10J-04837		4.0	A/B	A/B
		U10K-04842	Nhlavini	26.2	B	B
		U10K-04899	Xobho	44.3	C/D	C/D
		U10K-04946	Nhlavini	21.8	B/C	B/C
		Mk_I_EWR3	uMkhomazi	113.0	C	C
U1-5	II	MK_Est	Estuary	-	B/C	B/C

It is proposed to gazette the WRCs and catchment configuration as in bold above as for the short term ECs. RQOs will be set for the short term ECs in detail with reference to expected changes under Sc MK21.

9.3 MVOTI RIVER SYSTEM

9.3.1 Mvoti River System Water Resource Class

When applying the criteria presented in Table 8.1 to the resulting ECs for each scenario, the Water Resource Classes for the 4 IUAs in the Mvoti River system are as listed in Table 9.5.

Table 9.5 Mvoti River System: Resulting IUA Water Resource Classes for each scenario

IUA	Scenarios and Water Resource Class					
	PES	REC	MV3	MV41	MV42	MV43
U4-1	II	II	II	II	II	II
U4-2	II	I	I	I	I	I
U4-3	II	II	III	II	II	II
U4-4	III	II*	III	III	II*	III

** Note, these improvements are based on addressing the anthropogenic issues.*

Following on from the selection of **Sc MV42** *as the preferred scenario for the Mvoti River system, the embossed column in the adjacent table gives the recommended Water Resource Classes for the IUAs. Since* **Sc MV42** *includes the construction of a new dam, this is seen as a medium to long term recommendation. In the short term, the REC (which results in the same classes as for Sc MV42) will be recommended and the RQOs determined for these Water Resource Classes and catchment configuration. Where the catchment configuration differs due to improved requirements, reference will be made to the expected changes in RQOs.*

The REC is set to largely maintain the PES apart from specific desktop biophysical nodes where improvements which require mostly to non-flow related measures to be applied (see 9.2.2 below). The non-flow related (or anthropogenic) measures required to improve the estuary can be applied and should improve the estuary to a C.

9.3.2 Mvoti River System Catchment Configuration

Given the results and scenario selections presented in the section above, Table 9.8 provides respectively the proposed Water Resource Class and ECs for the IUAs and biophysical nodes for the Mvoti River system.

It must be noted that various nodes require improvements based on non flow-related/anthropogenic issues that have to be addressed. Where it is deemed that the REC is attainable, it has been included in the scenario configuration (Table 9.6).

Table 9.6 Mvoti River System nodes requiring improvements

IUA	Node	River	PES	REC	REC Comment	Target EC
U4-1	*U40A-03869*	*Mvoti*	**B/C**	**B**	*Improve riparian buffer in forestry and agriculture areas.*	**B**
U4-1	*U40C-03982*	*Khamanzi*	**B/C**	**B**	*Improve riparian buffer in forestry and agriculture areas.*	**B**
U4-3	*U40H-04091*	*Pambela*	**B/C**	**B**	*Reinstate riparian zone.*	**B**

IUA	Node	River	PES	REC	REC Comment	Target EC
U4-3	U40H-04117	Nsuze	B/C	B	Reinstate riparian zone.	B
U4-3	U40H-04133	Nsuze	B/C	B	Reinstate riparian zone, erosion control.	B
U4-4	U40J-03998	Mvoti Estuary	D	C	Improvement of oxygen levels in the estuary, through for example, removal of the high organic content from the Sappi Stanger effluent. Reduce the nutrient input from the catchment by 20%. Remove the sugarcane from the Estuary Functional Zone.*	C

* This recommendation may require economic analysis and it is recommended that this be investigated.

Table 9.7 Mvoti River System: Recommended ECs and Water Resource Classes

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC for:	
					Short term	Sc MV42
U4-1	II	U40A-03869	Mvoti	54.5	B	B
		U40B-03708	Intinda	18.7	C	C
		U40B-03740	Mvozana	11.0	C	C
		Mv_I_EWR_1	Heinespruit	27.8	C	C
		U40B-03832	Mvozana	16.7	C/D	C/D
		U40B-03896	Mvoti	9.7	C	C
		U40C-03982	Khamanzi	40.2	B	B
		U40D-03867	Mvoti	18.6	B	B
U4-2	I	U40D-03908	Mtize	18.9	B	B
		U40D-03957	Mvoti	27.7	B	B
		U40E-03967	Mvoti	8.4	B/C	B/C
		U40E-03985	Mvoti	27.7	B	B
		U40E-04079	Faye	21.2	B	B
		U40E-04082	Sikoto	8.0	B	B
		U40E-04137	Sikoto	23.1	B	B
		U40F-03690	Potspruit	17.3	C	C
		U40F-03694	Hlimbitwa	11.0	C	C
		U40F-03730	Cubhu	24.3	C	C
		U40F-03769	Hlimbitwa	13.3	C	C
		U40F-03790	Nseleni	5.9	B/C	B/C
		U40F-03806	Hlimbitwa	6.1	B	B
		U40G-03843	Hlimbitwa	42.5	B	B
U4-3	II?	Mv_I_EWR_2	Mvoti	62.9	C	C
		U40H-04091	Pambela	17.5	B	B
		U40H-04117	Nsuze	2.7	B	B
		U40H-04133	Nsuze	27.9	B	B
U4-4	II	Mv_Est	Mv_Est	-	C	C

It is proposed to gazette the Water Resource Classes and catchment configuration as for the short term ECs.

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11 APPENDIX A: EXAMPLE OF RATING, WEIGHTING AND SCORING

Table 11.1 Mvoti River System: Example extract of the rating, weights and scoring table for the ecological component)

Nodes	River	Weights:		Normalisation:			Scenario Rating:				Scenario Score:			
		Importance	Length (km)	Importance	Length	Combined								
				1	0		3	41	42	43	3	41	42	43
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*	*o*
U40A-03869	Mvoti	1.0	54.5	0.0007	0.0967	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40B-03708	Intinda	1.0	18.7	0.0007	0.0332	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40B-03740	Mvozana	1.0	11.0	0.0007	0.0196	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
Mv_I_EWR_1	Heinespruit	1.0	27.8	0.0007	0.0493	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40B-03832	Mvozana	1.0	16.7	0.0007	0.0296	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40C-03982	Khamanzi	1.0	40.2	0.0007	0.0713	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40D-03908	Mtize	1.0	18.9	0.0007	0.0335	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40E-04079	Faye	1.0	21.2	0.0007	0.0376	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40E-04082	Sikoto	1.0	8.0	0.0007	0.0142	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40E-04137	Sikoto	1.0	23.1	0.0007	0.0410	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40F-03690	Potspruit	1.0	17.3	0.0007	0.0307	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
U40F-03694	Hlimbitwa	1.0	11.0	0.0007	0.0196	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
U40F-03730	Cubhu	1.0	24.3	0.0007	0.0432	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40F-03769	Hlimbitwa	1.0	13.3	0.0007	0.0235	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40F-03790	Nseleni	1.0	5.9	0.0007	0.0105	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40F-03806	Hlimbitwa	1.0	6.1	0.0007	0.0108	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40G-03843	Hlimbitwa	1.0	42.5	0.0007	0.0754	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
Mv_I_EWR_2	Mvoti	1000.0	155.1	0.7389	0.2750	0.7389	0.7837	1.0000	0.9649	0.9584	0.5791	0.7389	0.7130	0.7082
U40H-04091	Pambela	1.0	17.5	0.0007	0.0310	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40H-04117	Nsuze	1.0	2.7	0.0007	0.0048	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
U40H-04133	Nsuze	1.0	27.9	0.0007	0.0494	0.0007	1.0000	1.0000	1.0000	1.0000	0.0007	0.0007	0.0007	0.0007
Mv_Est	Mv_Est	333.3	0.0	0.2463	0.0000	0.2463	0.7400	0.8300	0.8188	0.8188	0.1823	0.2044	0.2017	0.2017
							Ecological Scores:				**0.775**	**0.957**	**0.928**	**0.923**

12 APPENDIX B: REPORT COMMENTS

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Comments from: Mmaphefo Thwala – 4 March 2015				
Page ix paragraph 3, third sentence:		*I think that should be scenarios for MK 4 and not MK31 since MK4 is the scenario with the second lowest ranking on the diagram.*	*Yes*	
Page 3-1 first bullet:		*Spelling of Kwadukuza (confirm with gazette as well)*	*Yes*	
Section 4.3		*Spelling of Umkhomazi on the heading and in figure 4.2*	*Yes*	
Section 6.2		*The reference to scenarios in terms of groups for estuaries, not consistent with the rest of the report.*	*No*	*The grouping of scenarios for the Mvoti and Mkomazi are different.*
Comments from: Mr Bill Pfaff by e-mail dated 11 March 2015				
		In considering the report itself it is noted that the purpose of the report is to recommend operational scenarios and draft Water Resource Classes for the uMkhomazi and Mvoti . *The comments below are made in respect of the uMkomazi only, but some may be applicable to the Mvoti.* *The overarching aim of the scenario evaluation process as stated is to find the appropriate balance between the level of environmental protection and the use of the water resource in providing economic and social benefits.* *In this respect the "balance " model has been queried previously in the following respects :* • *The model only considers the economic benefits of water abstracted from the river. In this methodology , for a river system where there is no abstraction , there would be no macro-economic benefit (and thus the economic equation is zero) and yet there will be considerable macro-economic advantage to eThekwini in the development of that catchment (as per the "visioning " submission.)*	*No*	*The economic quantification methods applied in the study account for both the relevant costs and benefits related to what the particular scenario's consequences require. Therefore, scenarios where there are no abstraction but discharges of treated wastewater (for example), the method accounts for the alternative discharge mitigation measures costs. In this case the main economic driver is the difference in costs between the scenarios. In this way the economic result can be negative.*

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		The statement is made that the cost benefit analysis method, which has been adopted, does not address issues of affordability, tariffs and funding. These are all important considerations which do need to be addressed.	*No*	*The economic methods applied is suitable for the level of investigations where macro-economic implications are determined as a variable that represents the detail financial implication such as tariff which in turn relates to affordability. The method accounts for the correct direction of change and the relative differences between the scenarios. As long as the relative change between the scenarios are representative the comparison will be valid.*
		In an effort to partly address the social component omitted from the current "balance " model, eThekwini has proposed an additional metric be added as a further variable in the multi-criteria analysis and scenario comparison method. The additional metric would consider the quantification of the possible positive impact on social services that can be lost if money is spend on more costly wastewater disposal infrastructure projects rather than on the needs of the people of Ethekwini. This proposal is being pursued under the EWS R4A commission (and in full liaison with DWS) and the study on the uMkomazi river will need to be re-visited once this has been finalised.	*No*	*The analysis method applied in the classification study estimate the socio-economic implication two fold, (a) As GDP generated (also incorporating costs in the form of a discounted Cost Benefit Analysis) and (b) the number of jobs that is being affected by the scenario in questions. The latter is an indicator of relative socio-economic status between scenarios. A scenarios where more jobs are created (more households can be economically sustained) are therefore rated to have a larger socio-economic benefit compared to a scenarios where fewer jobs will be generated. The method is considered to be appropriate for Classification.* *It is view of DWS that the intended additional analysis referred to above should form part of the evaluations carried out for the planning by eThekwini to compare the alternative wastewater options.*
		A further outstanding issue relates to the whole issue of the level of "confidence" around the various conclusions which are now being drawn from the Classification Study. This concern is described more fully in the attached e mail dated 1 Dec 2014. I can find no record of a response to this e mail.	*No*	*Responses were provided in the comments and response sheet of the study as well as the report.* *In addition, a presentation was given by Prof Hughes on the 24th of March on how to deal with uncertainty and level of confidence as informed by the research he lead over the past four years.*
		I can find no explanation of how a volume of water abstracted from the uMkomazi is translated into GDP and additional employment. Also, as the benefit of the water supply is distributed across a very large area	*No*	*(a) A macro-econometric approach has been used which is based on the Ethekwini Social Accounting Matrix (SAM). The approach is based on the assumption that the volume of water transferred*

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		presumably the associated water distribution infrastructure cost in totality is included but this again is not explained. *Is it clear how the cost of releasing the EWR from the future Smithfield dam impacts on the economic assessment ??*		*from the uMkhomazi will be utilised by the consumers in the same ratio as current consumption and current GDP. The second assumption is that the economic and population growth of Ethikweni will be at least on the same level as the past 5 to 10 years. However kept in mind that this study is not aimed at any projections of the future economic and population growth of the area. The econometric model is using the water usage per activity applying macro-economic multipliers to provide comparative answers for the different scenarios. However this is balanced by a Cost Benefit Analysis (CBA) where relevant costs are taken into consideration and the GDP as the benefit of the model. The net discounted benefit of the analysis (NPV) which in effect is based on the GDP and is then used in the MCDA.* *(b) The method being applied is to compare scenarios based on the implication on macro-economic focussing only on the elements that differentiate one scenario from the next. Aspects that are common to the scenarios, such as distribution infrastructure, are therefore not quantified.* *(c) The scenarios evaluated include the proposed Smithfield Dam and each alternative EWR release option gives a different abstractable yield. In turn the available yield was used to quantify the socio-economic benefits in terms of GDP and employment.*
		I can find no reference to the uMkomazi estuary report having been issued to stakeholders for information and comment. Thus it is almost impossible to fully understand the 10 scenarios listed which have been considered.	*No*	*The uMkomazi estuary report was send to the PSC members in 10 December 2015.*
		One scenario, however, set out to test the sensitivity of the estuary to the increased nutrient load associated with a 20 Ml/day WWTWks ,(but with the resulting nutrient load added to a scenario which was already indicating a negative trend.).	*No*	*As part of evaluating the sensitivity of the estuary to flow changes, the referred scenario first evaluated the impact of the flow regime on the estuary (isolating flow related impacts from water quality related impacts). Then to provide further additional*

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				information, it was assumed that the proposed increased discharge from the WWTW makes out a fraction of simulated flows to the estuary, which required the evaluation of the increase nutrient load to the estuary in addition to flow related impacts.
		This is noted in the report as a low confidence assessment as significant issues (tidal effect etc) were not taken into account. *In addition – and although not stated in the report – we have been advised that the effluent quality was assumed as being at 'general standard'. Advice had been provided at the time of the study that a reduced nutrient standard was being proposed by EWS and the consultant team were well aware of these details. This situation, and the resulting wasteful expenditure, could have been avoided had there been better liaison between the two study groups.* *A further scenario, which was also not considered, is for the effluent from the Kingburgh WWTWs (an additional 30 Ml/day) to discharge to the uMkomaas river. The necessary re-run of a set of alternative estuarine reserve scenarios will now be carried out as part of the EWS study.*	*No*	*Further scenarios evaluations will be carried out to accommodate the specified alternatives*
		It is further noted that the impact of the dam development on the nearshore marine environment was not assessed and that this should be done to ensure all ecological processes and related ecosystem services are addressed.	*No*	*The near shore environment is excluded from Classification process since it is governed by the National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008) . The ICM Act set out specific requirements for the National Estuarine Management Protocol (NEMP) for South Africa, as well as the development of individual Estuarine Management Plans. The ICM Act also requires indicate that DWS and the Department of Environment Affairs (DEA) beis jointly responsible for permitting of the allocation of effluent discharges licenses into estuaries (seein the "National Guideline for the Discharge of Effluent Discharges From Land-based Sources into the Coastal Environment (2014)"). The impact of the dam development will therefore not be addressed as*

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				part of this study. The implications will have to be addressed as part of further the detail feasibility investigations of each project.
		The determining factors leading to the present state of the estuary (category C) is the SAPPI weir, sandmining (legality of this??) , habitat loss, plus plus , with the highest priority from a flow related perspective being the quality of influent water. Of this it needs to be noted that the Municipal WWTWks contributes some 500 kls per day, (discharging very low down in the estuary) the remainder being (presumably) from the SAPPI plant, and this situation is exacerbated once abstraction from the proposed dams is in place. There is some reference to the SAPPI weir being moved upstream (is this a practical option, has this weir got a WUL??) but no recommendation made in respect of improving the effluent quality.	*No*	*The report recommends that the nutrient input from the catchment be reduced by 20% to control growth of reeds and aquatic invasive plants. The report do not go into detail on how much of this reduction should come from the river versus improving the quality of the discharge.*
		A final comment relates to Table 8.3. - the sensitivity analysis of scenario ranking for alternative variable weights - alternative 15 , and scenario 2. Scenario 2 scores very highly in terms of GDP and Jobs, and comparatively lowly for ecosystems services and ecological status, and alternative 15 allocates 75% of the weighting to GDP and Jobs. And yet the ranking position of scenario 2 changes little for alternative 15 when compared to the other 14 alternatives?? Is this correct?? It is also noted that the weighting in not every alternative adds up to 1. (eg 7,8,9, 10 , 12 and 14)	*Yes*	*Tables were corrected and changed.*
		In conclusion the request from eThekwini is that the report (perhaps updated in the light of the above comments) remains in draft until the practical and affordable means for the treatment and disposal of wastewater in the catchment is agreed.	*No*	*Classification is not the process by which recommendations are made or approved regarding any future development, including treatment and disposal of wastewater. During the classification process all these factors are considered, to make informed decisions. However it is likely that unless a future development is a high certainty in the short term, classification will not cater for developments that still have to go through all the channels of approval and legislation. In the classification*

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				documents it will be stated that it is unlikely that the WRC will cater for these scenarios and that if these have to go forward, a revision in the class may be required. The logic behind this is that if one had to cater for all possible future developments in the far future, the classification process becomes obsolete as all Classes would be a III. And one certainly cannot determine the Class to be a III when it is for example currently a II on the chance that some future scenarios will come into being in 40 years time.